Effect of Dietary Vitamin E and Irradiation on Lipid Oxidation, Color, and Volatiles of Fresh and Previously Frozen Turkey Breast Patties

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Summary and Implications

When dietary TA was increased from 0 to 200 IU/kg diet, plasma and muscle vitamin E levels increased by 5- and 4-fold, respectively. Dietary TA at 100 IU/kg diet significantly improved the storage stability of turkey breast, and it was more distinct in irradiated than nonirradiated meats. Both irradiation and dietary TA increased a*-values of turkey breast meat, but irradiation had a stronger impact. The redness of meat decreased during the 7-d storage, but irradiated meat maintained redder color than nonirradiated. Irradiated meat produced more sulfur volatiles and aldehydes than nonirradiated meats, and dietary TA effectively reduced these compounds during storage. The effects of dietary TA on the reduction of off-odor volatiles were more distinct in previously frozen-stored meats than in fresh meats.

Introduction

The beneficial effect of dietary vitamin E on meat quality has been reported by many researchers. The benefit of dietary vitamin E is related to the increased vitamin E concentration in muscle tissues, which improves color stability and diminishes lipid oxidation and off-flavor development. The muscle vitamin E may not only retard lipid oxidation but also reduce production of sulfur volatiles responsible for the characteristic irradiation off-odor. The objective of this study was to determine the effectiveness of dietary vitamin E on lipid oxidation, color, and volatiles development in irradiated turkey breast meat during refrigerated storage.

Materials and methods

A total of 120 12-week-old male Large White turkeys raised on a corn-soybean meal-based diet were assigned to diets containing 0, 50, 100, or 200 IU of dl-α-tocopheryl acetate (TA)/kg diet. Then each of the diet was fed to turkeys from 12 to 16 weeks of age. Turkeys were slaughtered, breast muscles were deboned , and patties were prepared. The breast were packaged in oxygen-permeable bags and irradiated. To determine the effects of freezing on the volatile profiles, the whole breast muscles were frozen at -40 °C for 3 mo and thawed for 3 d at 4°C before use. The thawed breast meats were used to prepare patties.

Results and Discussion

The supplementation of tocopheryl acetate (TA) to turkeys increased the vitamin E levels of plasma and muscle tissues, but had no effect on the weight gains of turkeys. The TBARS values of breast meat from turkeys fed diets supplemented with TA were lower than that of the control at Day 0 and Day 7, but the antioxidant effects of dietary TA were highly significant when the meats were irradiated and stored (Table 2). At Day 0, the amounts of carbon disulfide, butanal, and total volatiles in turkey meat irradiated at 2.5 kGy decreased as the amount of dietary TA increased. Among the dietary TA treatments, 200 IU TA/kg diet was the most effective in reducing the amounts of both sulfur-volatiles and aldehydes (Table 3). Irradiation increased the color a*-values of turkey breast meat irrespective of dietary TA, and the degree of color increase was irradiation dose-dependent (Table 4).

A greater number of hydrocarbons and aldehydes were detected in previously frozen than in fresh turkey meats, and the effect of dietary TA on volatile production became more distinct in previously frozen than in fresh meat (Tables 5). The production of sulfur-volatiles, hydrocarbons, and aldehydes in turkey breast meat was irradiation dose-dependent (Table 5): dimethyl disulfide was produced the most with 2.5 kGy irradiation at 0 d, and hexanal and pentane were produced the most in 2.5 kGy meat after 7 d of aerobic storage. More distinct effect of dietary TA was found in 2.5 kGy-irradiated turkey meat than in nonirradiated meat. Supplementing a 200 IU of TA/kg diet reduced the amounts of hexanal by 60% of the control. Therefore, dietary TA was effective in reducing both irradiation-dependent and lipid oxidation-dependent off-odor volatiles from previously frozen turkey meat.

Conclusion

Dietary vitamin E protected turkey breast meat from oxidative changes, and its effect was prominent when the meat was structurally damaged by a freezing and thawing cycle, then irradiated and stored under aerobic conditions. The effects of dietary vitamin E were highly dependent upon the TA levels, and at least 100 IU/kg of dietary TA was needed to significantly reduce lipid oxidation and off-odor volatiles in irradiated turkey breast patties.

Table 1. **TBARS values of aerobically packaged turkey breast patties affected by dietary vitamin E and irradiation during storage at 4 °C**

	Dietary vitamin E			
Irradiation	0 IU	50 IU	100 IU	200 IU
	------- (mg MDA/kg meat) --------			
Day 0				
0 kGy	0.15^{ay}	0.13^{aby}	0.10^{by}	0.12^{ab}
1.5 kGy	0.19^{y}	0.18^{x}	0.15^{xy}	0.17
2.5 kGy	0.28^{ax}	0.19^{bx}	0.18^{bx}	0.14^{b}
Day 7				
0 kGy	0.46^{az}	0.32^{by}	0.22^{by}	0.22^{by}
1.5 kGy	1.12^{ay}	0.64^{bx}	0.29^{cy}	0.28^{cx}
2.5 kGy	1.24^{ax}	0.63^{bx}	0.37^{bx}	0.32^{bx}

Table 2. **Volatile profiles of nonirradiated, aerobically packaged raw turkey breast affected by dietary vitamin E during storage at 4 °C**

	Dietary vitamin E			
Volatiles	0 IU	50 IU	100 IU	200 IU
	------ (Total ion counts $\times 10^4$) -----			
Day 0				
Pentane	1238	1004	1225	1001
2-Pentene	99	93	108	61
2-Propanone	6214^{c}	7478^{b}	11236^{a}	10506^{a}
Dimethyl sulfide	328^{b}	322^{b}	507^{a}	288^{b}
Carbon disulfide	7406^{a}	2566^{b}	1100^{b}	1027^{b}
Total	15300^{a}	11465^{c}	14177^{ab}	12883^{bc}
Day 7				
Pentane	2314^{b}	4913^{a}	1931^{b}	851^{b}
Propanal	0^{b}	84^{a}	142^{a}	0^{b}
2-Propanone	11742	10617	11880	10240
Dimethyl sulfide	243^{a}	0^{b}	0^{b}	0^{b}
Carbon disulfide	1460^{a}	477^{b}	284^{b}	280^{b}
Hexane	99	180	127	105
Butanal	111^{a}	118^{a}	90^{a}	0^{b}
Octane	71^{a}	104^{a}	12^{b}	0^{b}
Total	16172^{a}	16782^{a}	14542^{a}	11476^{b}

Table 3. **CIE color values of aerobically packaged turkey breast patties affected by dietary vitamin E and irradiation during storage at 4 °C**

	Dietary vitamin E							
	Day 0				Day 7			
Irradiation	0 IU	50 IU	100 IU	200 IU	0 IU	50 IU	100 IU	200 IU
L value*								
0 kGy	46.1	45.8	42.7	45.3	49.2	48.8	48.3	48.0
1.5 kGy	45.9	45.1	44.1	46.5	49.6	50.8	49.6	49.2
2.5 kGy	44.2	43.8	43.2	44.6	49.6	49.4	50.0	50.0
a value*								
0 kGy	7.0^{bz}	6.9^{bz}	8.1^{az}	7.9^{az}	3.2^{bz}	3.7^{ay}	4.2^{ay}	4.3^{az}
1.5 kGy	8.1^{by}	8.4^{by}	9.3^{ay}	8.8^{aby}	4.5^{y}	4.0^{y}	4.4^{y}	5.0^{y}
2.5 kGy	9.5^{cx}	9.9^{bcx}	10.9^{ax}	10.5^{ax}	5.3^{bx}	4.9^{bx}	6.3^{ax}	6.4^{ax}

Table 4. Volatile profiles of 2.5 kGy-irradiated, aerobically packaged raw turkey breast patties affected by dietary vitamin E during storage at 4 °C

	Dietary vitamin E							
	Day 0				Day 7			
Volatiles	0 IU	50 IU	100 IU	200 IU	0 IU	50 IU	100 IU	200 IU
	------------------------------ (Total ion counts × 10^4) ------------------------------							
2-Methyl-1-propene	164^{b}	124^{c}	141^{bc}	191^{a}	36	14	0	16
1-Butene	187^{ab}	147^{b}	163^{b}	218^{a}	0	82	31	19
Pentane	1566	903	877	1115	1433	2153	1387	1092
2-Pentene	144^{a}	77^{b}	76^{b}	101^{ab}	0	0	0	0
Propanal	0^{b}	85^{a}	0^{b}	0^{b}	930^{b}	1676^{a}	707^{b}	768^{b}
2-Propanone	9318^{b}	9717^{ab}	10078^{a}	9945^{ab}	11788	11106	12527	12168
Dimethyl sulfide	1333^{b}	1295^{b}	1491^{ab}	1678^{a}	140	147	136	145
Carbon disulfide	13084^{a}	1411^{b}	831^{b}	1023^{b}	405^{a}	192^{b}	90^{b}	42^{b}
Hexane	71^{ab}	16^{b}	34^{ab}	97^{a}	268	248	227	266
Butanal	95^{a}	0^{b}	0^{b}	0^{b}	163	177	164	164
1-Heptene	17	17	15	56	82	110	100	93
Dimethyl disulfide	62	18	0	0	16	87	0	65
Toluene	581	570	565	501	171	172	200	182
Octane	77^{a}	14^{b}	14^{b}	68^{a}	25^{a}	53^{a}	30^{a}	0^{b}
Total	26761^{a}	14432^{b}	14318^{b}	15041^{b}	15461	16221	15604	15025

Table 5. Volatiles of aerobically packaged turkey breast (frozen for 3 mo) patties affected by dietary vitamin E during the storage at 4 °C

	Day 0				Day 7			
Volatiles	0 IU	50 IU	100 IU	200 IU	0 IU	50 IU	100 IU	200 IU
nonirradiated	(Total ion counts $\times 10^4$)							
Pentane	3353^{a}	2223^{b}	1463^{c}	0^{d}	5219^{a}	3100^{b}	1636^{c}	452d
Propanal	0	0^{b}	0	0^{b}	56	62	0	0
Dimethyl sulfide	571	646	518	278	0	0	0	0
Carbon disulfide	988^{a}	331^{b}	91^{b}	0^{b}	1749	1858	1015	1441
Hexane	237^{a}	131^{b}	47^{c}	0^{c}	268	248	227	266
Heptane	265^{a}	118^{b}	45^{c}	0^{c}	545^{a}	363^{ab}	372^{ab}	211^{b}
Pentanal	13	0	0	27	148	122	176	101
4-Octene	378^{a}	285^{a}	92^{b}	0^{b}	0	0	0	0
Octane	867^{a}	608^{ab}	309^{b}	0^{c}	554^{a}	529^{a}	466^{a}	95^{b}
2-Octene	239^{a}	161^{ab}	96^{b}	0^{c}	0	0	0	0
3-Methyl-2-heptene	340^{a}	268^{a}	75^{b}	0^{b}	0	0	0	0
Hexanal	1142^{a}	225^{b}	115^{b}	0^{b}	5102^{a}	4891^{a}	2658^{b}	1654^{b}
Total	8526^{a}	5000^{b}	2855^{c}	616d	13641^{a}	11173^{a}	6550^{bc}	4220^{c}
Irradiated at 2.5 kGy								
Methanethiol	490^{a}	380^{ab}	357^{ab}	73^{b}	0	0	0	0
Pentane	4651^{a}	2432^{b}	1251^{bc}	585^{c}	9955^{a}	6043^{b}	4692^{b}	2438^{c}
Propanal	0	0	0	0	350	290	240	154
Dimethyl sulfide	895^{a}	281^{b}	471^{b}	323^{b}	0	0	0	0
Carbon disulfide	672^{a}	240^{b}	0^{b}	92^{b}	0	0	0	0
Hexane	310^{a}	354^{a}	264^{a}	157^{b}	362^{a}	275^{b}	213^{b}	213^{b}
Benzene	258	236	384	294	142	132	116	133
3-Methyl butanal	59	0	0	0	0	0	0	0
1-Heptene	211^{a}	174^{a}	127^{ab}	62^{b}	196	175	113	120
Heptane	239^{ab}	270^{a}	110^{ab}	81^{b}	484^{a}	379^{a}	232^{b}	156^{b}
Pentanal	52^{a}	0^{b}	0^{b}	0^{b}	233	199	281	108
Dimethyl disulfide	653^{a}	29^{b}	18^{b}	0^{b}	0	0	0	0
Toluene	427	355	399	242	213	207	129	207
4-Octene	124	251	170	119	0	0	0	0
Octane	466^{b}	784^{a}	479^{b}	302^{b}	455^{a}	329^{b}	204^{c}	168^{c}
2-Octene	94^{ab}	148^{a}	127^{ab}	71^{b}	251^{a}	116^{b}	98^{b}	46^{c}
3-Methyl-2-heptene	50^{b}	213^{a}	178^{ab}	63^{b}	0	0	0	0
Hexanal	861^{a}	52^{b}	28^{b}	17^{b}	7117^{ab}	8180^{a}	5050^{ab}	2851^{b}
Total	10566^{a}	6268^{b}	4419^{bc}	2486^{c}	19761^{a}	16328^{b}	11371^{c}	6597^{d}

$^{a\text{-}c}$Different letters within a row with same storage day are significantly different ($P < 0.05$), n = 4.