7-P11

CHOLESTEROL OXIDATION PRODUCTS(COP) IN CHICKEN MEAT WITH ELECTRON-BEAM IRRADIATION

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Background:
Some of the cholesterol oxidation products(COP) have been reported to have a wide range of adverse biological effects such as atherogenesis, cytotoxicity, mutagenesis and carcinogenesis(Guardiola et al., 1996). The oxidation of cholesterol occurs easily in various foods including meat and poultry, and their products as cholesterol oxidation occurrs through the chemical process similar to that of unsaturated fatty acid oxidation. In addition, the oxidation of cholesterol in food is affected by the environment surrounding cholesterol, especially nearby unsaturated lipids(Gray et al., 1996). Accordingly, prolonged storage, application of heat, and exposure to light or irradiation promote the oxidation of cholesterol (Paniangvait et al., 1995). With the growing concern about food safety, the use of irradiation has been well accepted as the one of the best methods for production of safe meat and poultry (Lee et al., 1996). However, the problems of the irradiation of meat and poultry are the occurrence of off-flavor and the increased lipid oxidation of which the intensity is affected by processing conditions.

Objectives:
The objective of this study was to investigate the effects of electron-beam irradiation on the oxidation of cholesterol in chicken meat and how the processing conditions affect the oxidation products.

Methods:
Sample preparation & irradiation
Ground fresh chicken meats without skin were made into patties and packaged in air or in vacuum with PVDC. For the cooked samples, samples were heated in an electric oven until the internal temperature of 70° C was reached and then packaged. After packaging, the samples were irradiated on both sides of packages by electron-beam using a Samsung electron-beam accelerator at Central Lab of Samsung Heavy Industry Co., Inc.

Analysis
Analysis of cholesterol oxides was done on Hewlett Packard 5890 Plus GC with capillary column injection and FID detection. Helium was carrier gas at a head pressure of 14.0 psi. Initial injector temperature was set at 260° C. The initial oven temperature of 70° C was held for 0.5 min and then increased to 275° C at 40° C/min and held at 275° C for 0.5 min. The temperature increased again to 280° C at 2° C/min. The temperature of injector and detector was 300° C. GC column of 0.32 mm i.d. x 30 m with 0.33 μm film thickness(Supelcowax 10 column) was prepared according to Zubillaga and Maerker(1991), and Park and Addis(1985). The statistical analysis was done by ANOVA and the significance of the differences was tested with Duncan's Multiple test at 5% level.

Results and Discussions:
Table 1 illustrates the different kind and amount of cholesterol oxides produced during the storage time of raw chicken meat packaged in air or in vacuum and then irradiated. Regardless of treatment, the COP detected shortly after sample preparation were 7α-hydroxycholesterol, 7β-hydroxycholesterol and 7-ketocholesterol. The COP detected below 0.5 μg were β-epoxide, cholestanetriol and α-epoxide. COP content increased significantly($P<0.05$) with the level of irradiation regardless of packaging type. As for 7α-hydroxycholesterol and 7-ketocholesterol, the vacuum packaging prevented their formation during the irradiation. It has been suggested that the hydroperoxides of polyunsaturated fatty acids formed during lipid oxidation may be necessary to initiate cholesterol oxidation. That may be the reason why vacuum packaging lowered the content of COP significantly($P<0.05$) as shown in this study. It was reported that γ-irradiation increased 7-ketocholesterol, α- and β-epoxide in beef and pork packaged in an oxygen-permeable bag(Hwang and Maerker, 1993). The level of COP increased during storage time($P<0.05$) regardless of whether being irradiated or not. The COP increased considerably during storage in both irradiated and unirradiated meat, with the irradiated one being higher than the unirradiated one(Hwang and Maerker, 1993). The results of cooked chicken meat are shown in Table 2. It shows that cooking increased the cholesterol oxidation significantly($P<0.05$). The kind of COP in cooked samples were same but the levels were higher than in raw ones. Notable changes in the amount were observed in β-epoxide and 7-ketocholesterol of cooked samples. Total COP increased in meat cooked in an oven, pork having the greatest increase(Pie et al., 1991). Monahan et al.(1992) demonstrated that the rate of cholesterol oxidation in pork was greatly accelerated during storage following cooking. A similar trend was shown in this study.

Conclusions:
The detected COP in both irradiated and unirradiated chicken meat were 7α-hydroxycholsterol, β-epoxide, 7β-hydroxycholesterol, cholestanetriol, α-epoxide and 7-ketocholesterol. The kind of COP was similar in raw and cooked chicken meats but the amount detected was

different. Packaging brought about different effects of irradiation on cholesterol oxidation. The cooking resulted in the difference in the amount of β-epoxide and 7-ketocholesterol. All detected COP increased during storage regardless of treatment.

References:

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Table 1. Effect of irradiation on cholesterol oxidation products in raw chicken meat packaged in air and vacuum (Unit: μg/g oil)

Cold storage(day)	0						7						14					
Irradiation	0kGy		1kGy		2kGy		0kGy		1kGy		2kGy		0kGy		1kGy		2kGy	
Packaging	Air*	Vac**	Air	Vac	Air	Vac	Air	Vac	Air	Vac	Air	Vac	Air	Vac	Air	Vac	Air	Vac
7α-hydroxycholesterol	0.88	tr***	0.831	tr	1.05	tr	4.75	tr	2.57	tr	3.01	tr	3.70	tr	3.01	tr	2.91	tr
β-epoxide	tr	tr	tr	tr	tr	tr	1.24	tr	0.98	tr	1.09	tr	4.18	2.49	2.42	3.01	2.22	2.80
19-hydroxycholesterol	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7β-hydroxycholesterol	14.24	3.47	16.23	4.05	20.35	10.72	12.50	8.59	19.07	14.33	27.21	18.01	34.50	12.66	69.03	18.28	78.84	24.46
6-ketocholesterol	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20α-hydroxycholesterol	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
25-hydroxycholesterol	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cholestanetriol	tr	tr	tr	tr	tr	tr	tr	tr	tr	tr	tr	tr	tr	tr	tr	tr	tr	tr
α-epoxide	tr	tr	tr	tr	tr	tr	tr	tr	tr	tr	tr	tr	tr	tr	tr	tr	tr	tr
22-ketocholesterol	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7-ketocholesterol	tr	tr	2.78	tr	2.78	tr	tr	tr	2.86	tr	3.302	tr	tr	tr	5.82	tr	5.33	tr
Total amounts	16.29	4.78	20.68	5.43	25.02	12.12	18.66	10.33	26.06	15.99	35.27	19.39	43.44	16.40	80.90	22.65	89.92	28.54

*Packaging in air; ** packaging in vacuum ; *** trace(below 0.5μg/g).

Table 2. Effect of irradiation on cholesterol oxidation products in cooked chicken meat packaged in air and vacuum(Unit: μg/g oil)

Cold storage(day)	0						7						14					
Irradiation	0kGy		1kGy		2kGy		0kGy		1kGy		2kGy		0kGy		1kGy		2kGy	
Packaging	Air*	Vac**	Air	Vac	Air	Vac	Air	Vac	Air	Vac	Air	Vac	Air	Vac	Air	Vac	Air	Vac
7α-hydroxycholesterol	4.50	1.44	6.58	1.91	8.13	2.29	10.19	2.98	21.45	2.38	19.97	2.64	32.90	1.74	33.76	1.55	26.07	2.15
β-epoxide	1.02	0.87	1.06	1.34	1.05	1.59	0.92	1.42	1.58	1.35	1.58	1.68	3.29	1.62	3.57	3.92	3.64	3.89
19-hydroxycholesterol	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7β-hydroxycholesterol	18.28	10.10	47.20	12.52	61.69	15.64	23.70	19.23	72.36	23.05	135.16	25.25	141.32	18.73	147.64	38.43	174.16	53.88
6-ketocholesterol	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20α-hydroxycholesterol	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
25-hydroxycholesterol	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cholestanetriol	tr***	tr	tr	tr	tr	tr	tr	tr	tr	tr	tr	tr	tr	tr	tr	tr	tr	tr
α-epoxide	tr	tr	tr	tr	tr	tr	tr	tr	tr	tr	tr	tr	tr	tr	tr	tr	tr	tr
22-ketocholesterol	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7-ketocholesterol	6.80	2.89	9.26	2.86	9.58	2.99	9.07	3.57	21.85	3.11	20.37	3.37	18.14	7.38	29.86	8.47	39.66	8.04
Total amounts*	31.23	15.88	64.75	19.21	80.98	23.11	44.52	27.91	117.93	30.52	177.76	33.50	196.31	30.13	215.16	53.04	244.19	68.62

*~***: see Table 1.

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