Lipid and Protein Oxidation of Chicken Breast Rolls as Affected by Dietary Oxidation Levels and Packaging

A.S. Leaflet R2763

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Summary and Implications

The objective of this study was to determine the effects of dietary treatment and packaging on the oxidative stability of breast rolls. Dietary supplementation of antioxidants significantly reduced lipid oxidation (TBARS) and protein oxidation (carbonyls) in breast rolls, and the effect of dietary antioxidants on lipid oxidation was more pronounced than protein oxidation. However, dietary oxidized oil did not increase lipid and protein oxidation in breast rolls. Vacuum-packaging significantly delayed the onset of lipid oxidation and protein oxidation in chicken rolls during 7-day refrigerated storage ($P < 0.05$). The results suggested that appropriate use of dietary supplementation of antioxidants in combination with packaging could minimize lipid oxidation in chicken breast rolls.

Introduction

The consumer demands and popularity of ready-to-eat cooked meat products are increasing rapidly in recent years. However, processed meats are more vulnerable to oxidative changes than raw meat. Also, cooked chicken meat was more susceptible to oxidation than cooked beef and pork. It has been postulated that the amounts of polyunsaturated fatty acids (PUFA) and antioxidants are critical determinants of lipid oxidation occurring in processed meat. For many years, butylated hydroxytoluene (BHT), butylated hydroxyanisole

Materials and Methods

One hundred and twenty, 1-day-old commercial broiler chicks were fed with a standard broiler corn-soybean diet for 28 d. On 29th day, 10 broilers were assigned to each of 12 floor pens. Four floor pens were randomly allotted to one of the 3 experimental diets including control, oxidized diet, and antioxidants-fortified diet. Control diet was prepared with fresh animal-vegetable fat (AV fat) blend (5%) with 25 IU vitamin E, oxidized diet was prepared after oxidizing the same AV fat by exposing to room temperature for a long time until attaining peroxide value (PV) of 100, and the antioxidants-fortified diet was prepared with the fresh AV fat supplemented with BHA (200 ppm) and vitamin E (500 IU) per kilogram of feed. Each of the diet was fed to the broilers for 2 wk with free access to water and diet. At the end of the feeding trial, the birds were slaughtered following USDA guidelines. The breast muscles were ground through a 3-mm plate, mixed with 1.5% NaCl and 0.25% phosphate, 1.5% transglutaminase, 0.5% sodium caseinate, 0.5% dextrose, and 6.25% water for 5 min, stuffed, and cooked at 85 ◦C until the center temperature reached 74 ◦C. After cooling, the rolls were cut into 2-cm thick slices and individually packaged in vacuum bags (nylon/polyethylene, 9.3 mL O2/m2 per 24 h at 0 ◦C) or oxygen-permeable bags (polyethylene, 2,300 mL/m2 per 24 h). Samples were stored in a 4 ◦C cold room for 7 d. Lipid, protein oxidation and volatiles were determined after 1, 4 and 7 d of storage. Lipid oxidation was determined by a TBARS method and protein oxidation by DNPH method. Data were analyzed by the procedure of generalized linear model using SAS 9.1 software. Mean values and standard error of the means (SEM) were reported.

Result and Discussion

No significant difference on TBARS was found between the rolls produced from the chickens fed oxidized and control diets during whole storage period (Table 1). Adding 5% oxidized oil (PV = 100) to chicken diet before slaughter had no negative effect on lipid oxidation of chicken breast rolls during storage, probably because the level of oxidized oil supplemented in diet was relatively low and the duration of feeding was relative short. Feeding broilers with a diet containing 500 IU vitamin E/kg diet for 2 wk before slaughter significantly improved the storage stability of chicken breast rolls evidenced by lower TBARS level during the whole storage period (Table 1). The TBARS value of chicken breast rolls produced from antioxidants diet increased from 0.30 to 0.48 mg MDA/kg meat while that from control diet increased from 1.36 to 3.56 mg MDA/kg after 7 d of storage indicating that dietary addition of vitamin E improved the oxidative stability of breast rolls.

Vacuum-packaging significantly delayed the onset of lipid oxidation in chicken breast rolls during the 7-d refrigerated storage ($P < 0.001$) (Table 1). The TBARS value of chicken rolls treated with vacuum-packaging were lower than those with oxygen-permeable packaging. Packaging can reduce lipid oxidation in meat and meat products by controlling oxygen interactions at the meat surface. Significant interactive effects between diet and packaging on lipid oxidation were found ($P < 0.01$) (Table 1). Lipid oxidation in chicken breast rolls increased as the oxidation of oils in diet increased. However, vacuum-packaging of cooked breast rolls reduced the oxidative

changes during storage. Therefore, it is suggested that appropriate use of dietary supplementation of antioxidants in combination with packaging could minimize lipid oxidation in chicken rolls.

No significant difference in carbonyls levels between rolls produced from the chickens fed oxidized diet and control diet during 7-d storage period was detected (Table 2). Protein oxidation of chicken rolls produced from the birds treated with different diets, monitored by carbonyls content, was ranged from3.71 to 6.31 nmol/mg protein (Table 2), which much higher than those in raw meats. The rolls manufactured from the chickens fed a diet containing 500 IU vitamin E/kg feed for 2 wk before slaughter had a significantly lower level of protein oxidation than those from the control diet at 1-, 4-, and 7-d storage point ($P < 0.05$) (Table 2). The initial level of protein oxidation in vitamin E supplemented group was approximately 3.71 nmol/mg of protein. The content of carbonyls increased to 5.06 nmol/mg protein level during the 7-d storage period. At 1-, 4-, and 7-d storage point, vitamin E supplemented group had 7.52%, 10.19%, and 10.12% lower carbonyl values than the control group at the respective storage day, which were much weaker than the inhibitory effect of vitamin E on lipid oxidation (78%, 85%, and 87% at each storage point). Since lipid and protein oxidation are probably coupled with each other in meat and meat products, dietary addition of vitamin E may protect meat products from both lipid and protein modifications. Based on current study, it is suggested that dietary treatment of vitamin E is an excellent method to protect proteins from chemical and functional damages during processing and storage of meat products. The carbonyls contents of vacuum-packaged chicken rolls were 4.53 and 4.92 nmol/mg protein after 4 and 7 d storage, respectively (Table 2), which were 10.4% and 23.39% lower than those packaged in oxygen-permeable bags because oxygen catalyzes protein oxidation. It appeared that limiting oxygen contact to meat through vacuum-packaging was an effective method to minimize protein modifications.

Table 1. Effects of diets and packaging on lipid oxidation during refrigerated storage of chicken rolls[1].

Storage time	Treatment	TBARS (mg MDA/kg meat)				
(d)	Diet	Control	Oxidized	Antioxidants	SEM	*P*
1		1.36[a]	1.48[a]	0.30[b]	0.04	<0.05
4		2.60[a]	2.56[a]	0.40[b]	0.19	<0.001
7		3.56[a]	3.84[a]	0.48[b]	0.16	<0.001
	Package	O2-permeable	Vacuum			
1		1.16[a]	0.96[b]		0.02	<0.001
4		2.48[a]	1.20[b]		0.16	<0.001
7		3.92[a]	1.32[b]		0.13	<0.001

[1]On the same row, means with different letters differ significantly.

Table 2. Effects of diets and packaging on protein oxidation during refrigerated storage of chicken breast rolls[1].

Storage time	Treatment	Carbonyl content (nmol/mg protein)				
(d)	Diet	Control	Oxidized	Antioxidants	SEM	*P*
1		4.12[a]	4.50[a]	3.71[b]	0.14	<0.05
4		4.81[a]	5.26[a]	4.32[b]	0.22	<0.05
7		5.63[a],[b]	6.31[a]	5.06[b]	0.26	<0.05
	Packaging	O2-permeable	Vacuum			
1		4.22	4.00		0.11	NS2
4		5.06[a]	4.53[b]		0.10	<0.001
7		6.42[a]	4.92[b]		0.02	<0.001

[1]On the same row, means with different letters differ significantly.
2NS = not significant.