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The Antioxidative Potential of Irradiated and Lyophilized Citrus Peel Extract in Beef and Pork

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Introduction

The oxidative process in meat leads to the degradation of lipids and proteins which, in turn, contribute to the deterioration in flavor, texture and color of displayed fresh retail meat(1). To retard the biochemical changes, synthetic antioxidants such as butylated hydroxytoluene (BHT) and butylated hydroxyanisole (BHA) have long been used but the use of these synthetic antioxidants is limited due to their low water solubility(2) and some toxic properties(3). Therefore, there is a growing interest in the identification of new natural antioxidants that could serve as alternatives to the synthetic compounds(4). The objective of the present study is to investigate the effect of the addition of lyophilized citrus peel extract to raw and cooked patties prepared from beef and pork on lipid oxidation and surface color. Furthermore, the effect of irradiation of the extract on the antioxidative property of these meat systems, if present, is also investigated.

Materials and Methods

Citrus (*Citrus unshiu*) peel harvested from the Jeju area, Korea in 2002 was obtained from a local wholesale store, Daejeon, Korea and frozen (-40℃) until used. The frozen citrus peel was finely ground and extracted with 70 % ethanol (sample to solvent ratio 1:10) at room temperature (20℃) for 72 hours with several agitations. The extracts were filtered using Whatman filter paper No. 4 (Whatman International Ltd., Springfield Mill, Kent, England), and the filtrate was divided into two screw-capped bottles (2 L capacity) (0 and 20 kGy) and subjected to irradiation treatment in a Co-60 irradiator (point source. AECL, IR79, MDS Nordion International Inc., Ontario, Canada) as described earlier (Jo et al., 2003). After that, the irradiated samples were centrifuged (4,000 rpm for 10 minutes at 4℃) in a refrigerated centrifuge (Union 5KR, Hanil Co., Ltd, Seoul, Korea). Ethanol in the irradiated or

non-irradiated citrus peel extract was removed using a vacuum evaporator (Rotary Vacuum Evaporator N-11 Eyela, Tokyo Rikakikai Co., Ltd, Tokyo, Japan). Samples were then lyophilized in a laboratory lyophilizer (SFDSF12, Samwon Co. Ltd., Busan, Korea).

Raw beef and pork loin were purchased from 3 different local stores and ground twice through a 9-mm plate. The meat from the different stores was pooled to achieve a homogeneous sample and the patties (approximately 50 g each) were prepared without (control) or with 0.1% lyophilized citrus peel extract (NICP) and 0.1% irradiated (20 kGy), lyophilized citrus peel extract (ICP). Half of the prepared raw patties were wrapped in oxygen permeable polyethylene and stored for 8 days at 20℃. The other half of the raw patties were vacuum packaged in the oxygen impermeable nylon bags and immersed in a waterbath (85℃) for 30 min achieving to an internal temperatures of approximately 72℃. After cooking the packaging of cooked patties was removed and they were wrapped in oxygen permeable polyethylene and stored for 8 days at 20℃.

Color measurement was performed at 0 and 4 days of storage. The prepared patty was placed on the plate of a Color Difference Meter (Spectrophotometer CM-3500d, Minolta Co., Ltd. Osaka, Japan) and measured. Four different areas of patty per treatment were evaluated and the mean values were used for replication. A medium size aperture was used and the measurement was duplicated. The Hunter color L^*-, and a^*- values were reported through a computerized system using the Spectra Magic software (version 2.11, Minolta Cyberchrom Inc. Osaka, Japan). Lipid oxidation was determined as a 2-thiobarbituric acid reactive substances (TBARS) value by using a spectrophotometer (UV 1600 PC, Shimadzu, Tokyo, Japan) as described by Ahn et al.[5]. The lipid oxidation development was reported as a mg malondialdehyde/kg meat sample. The experimental design used was a 3 treatments x 3 storage factorial for each meat system and the whole experiment was duplicated. One-way Analyses of the Variance was performed using SAS software and the Duncan's multiple range test was used to compare the differences among the mean values at the significance defined as $P<0.05$.

Results and Discussion

The TBARS value of the raw patties prepared from beef and pork loins increased during 8 days of storage at 20℃ in all the treatments; however, the TBARS values of the raw patties with added lyophilized citrus peel powder (0.1%) were significantly lower than those of the control (Figure 1). There was no difference between the addition of irradiated and non-irradiated lyophilized citrus peel extract powder.

Cooked meat is more susceptible to lipid oxidation than raw meat during refrigerated and frozen storage due to the fact that heating accelerates the oxidative reactions with the lipid in meat. Cooking not only inactivates catalase and denatures heme proteins but also it denaturesthe membrane and exposes the phospholipids to the outer environment[6]. In cooked patties, the overall TBARS values significantly

increased compared to the raw patties but during storage the patties treated with lyophilized citrus peel extract powder reduced the lipid oxidation. At day 8, the TBARS value in beef patties showed no difference. Jo et al.[7] reported that the lipid oxidation of cooked pork patty with green tea leaf extract powder (200 ppm) was significantly reduced and maintained almost the same values as the raw pork patties. The citrus peel extract from this study, however, did not show as powerful an antioxidative effect as the green tea leaf. But the added lyophilized citrus peel extract can reduce the lipid oxidation development of the four different meat patties.

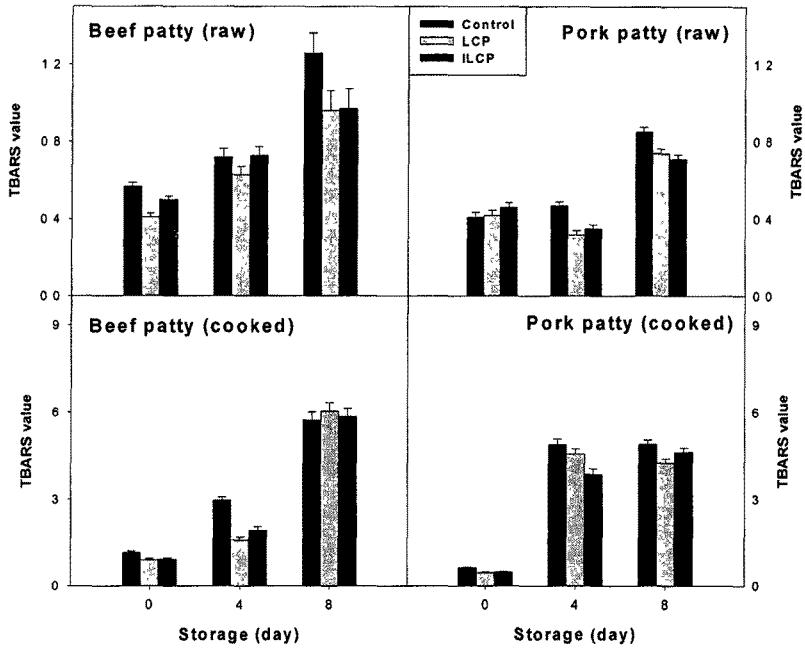

Fig. 1. TBARS value (mg malondialdehyde/kg meat) of raw and cooked meat patties added with lyophilized citrus peel extract (0.1%).

There was no significant changes of Hunter color L*-value in the raw meat patties (Table 1). However, an addition of lyophilized citrus peel extract reduced the Hunter color L*-value at day 0 in pork patty. The L*-value of cooked beef patty at day 4 and pork patty at day 0 with an addition of NICP or 20 kGy-irradiated citrus peel extract (ICP) was also significantly lower than control. Hunter color a*-value of raw beef and pork patties decreased at day 4 but both the NICP and ICP treatment had higher values in the beef patty than that of the control (Table 1). There was no difference in the a*-value of pork patty by an addition of NICP or ICP. In both the cooked patties with the addition of NICP or ICP had significantly higher a*-values than those of the control (Table 1). Kang et al.[8] supports the findings that irradiation did not change the phenolic content of the citrus peel extract. From the results, irradiation of the citrus peel extract (solution state) may not decrease its own antioxidative activity.

Table 1. Changes of Hunter color L*- and a*-value of beef and pork patties with added lyophilized citrus peel extract (0.1%)

Hunter color value	Meat	Treatment[1]	Raw			Cooked		
			Day 0	Day 4	SEM[2]	Day 0	Day 4	SEM[2]
L*-value	Beef	Control	49.0	49.1	0.78	53.4	54.9^{x}	0.85
		NICP	50.8	50.1	0.81	52.6	52.7^{z}	0.43
		ICP	50.6	50.2	0.58	52.3	53.4^{y}	0.32
		SEM[3]	0.78	0.68		0.775	0.27	
	Pork	Control	54.8^{x}	55.4	0.62	67.7^{bx}	69.9^{a}	0.40
		NICP	54.6^{x}	55.9	0.74	64.0^{by}	68.9^{a}	0.95
		ICP	52.0^{y}	55.0	1.05	63.2^{by}	68.4^{a}	0.59
		SEM[3]	0.62	0.99		0.82	0.52	
a*-value	Beef	Control	15.1^{a}	6.9^{by}	0.38	5.2^{y}	5.3^{y}	0.20
		NICP	14.0^{a}	7.8b[x]	0.43	6.2^{ax}	5.3^{by}	0.18
		ICP	14.1^{a}	8.3b[x]	0.35	5.6b[xy]	5.8^{ax}	0.24
		SEM[3]	0.50	0.22		0.28	0.12	
	Pork	Control	5.5^{a}	0.35^{b}	0.26	2.7b[xy]	2.4^{axy}	0.15
		NICP	5.4^{a}	0.60^{b}	0.33	3.2^{ax}	2.0^{bx}	0.22
		ICP	5.4^{a}	0.89^{b}	0.30	2.37^{y}	2.1^{y}	0.12
		SEM[3]	0.29	0.31		0.18	0.15	

[a,b] Different letters within the same row differ ($P<0.05$).

[x-z] Different letters within the same column with same color value differ ($P<0.05$).

[1] Control, meat patty itself; NICP, meat pattty with 0.1% of lyophilized citrus peel extract; ICP, meat patty with 0.1% of 20

[k] Gy-irradiated lyophilized citrus peel extract.

[2] Pooled standard errors of the mean (n = 6), [3](n = 9).

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