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Effect of a pectin-based edible coating containing green tea powder on the quality of irradiated pork patty

H.J. Kang [a,b], C. Jo [b], J.H. Kwon [a], J.H. Kim [b], H.J. Chung [c], M.W. Byun [b,*]

[a] Department of Food Science and Technology, Graduate School, Kyungpook National University, Daegu 702-701, Republic of Korea
[b] Radiation Food Science and Biotechnology, Korea Atomic Energy Research Institute, P.O. Box 105, Yuseong, Daejeon 305-600, Republic of Korea
[c] Department of Pediatrics, College of Medicine, Konkuk University, Chungju 380-704, Republic of Korea

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Abstract

Physicochemical, microbiological and sensorial qualities of cooked pork patty coated with pectin-based material containing green tea leaf extract powder were studied. Cooked pork patties were separated into three groups; uncoated control (C), coated with pectin-based materials (CP), and coated with pectin-based materials containing 0.5% green tea powder (CGP). The prepared patties were irradiated at 0 and 3 kGy using cobalt-60 gamma rays. Lipid oxidation, free radical scavenging effects, moisture content, total plate count, and sensory properties were evaluated during storage for 14 days at 10 °C. Lipid oxidation decreased ($p \leqslant 0.05$) and radical scavenging ($p \leqslant 0.05$) increased in the pork patties in CGP or CP relative to those of the controls when vacuum packaged. Coated patties contained higher moisture contents than the controls in both air- and vacuum packagings. The numbers of total aerobic bacteria were significantly reduced by the coating treatments as well as by irradiation. No difference were detected in sensory characteristics due to gamma irradiation or coating treatments.

Keywords: Edible coating; Pectin; Green tea extract; Gamma irradiation; Pork patties

1. Introduction

In general, edible coatings made from polysaccharides, proteins, and lipids extend the shelf-life of foods by functioning as solute, gas, and vapor barriers (Gennadios, Hanna, & Kurth, 1997). Moreover, the coatings may serve as carriers for antimicrobial compounds in order to maintain high concentrations of preservatives on the surface of foods. Although use of edible coatings and films to preserve food quality is not a novel concept, research in this field at academic, government, and private industry laboratories has recently intensified (Gennadios et al., 1997). Factors contributing to this renewed index include consumer demand for high quality foods; food processors' needs for new storage techniques; environmental concerns over disposal of non-renewable food packaging materials; and opportunities for creating new market outlets for film-forming ingredients derived from under utilized agricultural commodities (Gennadios et al., 1997).

Film formation and properties of several polysaccharide, protein, and lipid substances have been reviewed (Gontard & Guilbert, 1994; Kester & Fennena, 1986). Commercial applications of edible films and coatings include fresh produce coatings of waxes, oils, resins, and sucrose fatty acid polyesters (Baldwin, 1994); sausage casings from collagen (Hood, 1987); confections coatings from chocolate (Alikonis, 1979; Biquet & Labuza, 1988); confectioner's glaze made from shellac (Alikonis, 1979); nutmeats coatings candy, and corn zein-based pharmaceutical coatings (Rose, 1987); and food ingredients in cellulose ether-based water soluble pouches (Anonymous, 1992). Nisperos-Carriedo (1994) reviewed the characteristics of several polysaccharide materials such as starch and starch derivatives, alginates, cellulose derivatives, carrageenan, various plant and

* Corresponding author. Tel.: +82 42 868 8060; fax: +82 42 868 8043.
E-mail address: mwbyun@kaeri.re.kr (M.W. Byun).

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microbial gums, chitosan and pectinates. In general, due to their hydrophilic nature, polysaccharide films generally exhibit limited water vapor barrier ability. However, moisture loss from foods was retarded by polysaccharides in high moisture gelatinous coatings, and these coatings functioned as sacrificing agents rather than moisture barriers (Kester & Fennena, 1986).

Pectin is one of the main components in citrus by-products. Pectin is primarily composed of linear homogalacturonan (α-1,4-galacturonic acids) chains interspersed with branched rhamnogalacturonan (α-1,4-galacturonic acid to α-1,2-rhamnose) chains (the neutral sugar branches are attached through rhamnose residues) (Savary & Nunez, 2003). There has rarely been the study of pectin utilization as a source of edible coatings for meat patties.

Irradiation is an effective procedure to improve meat safety and extend shelf-life (Dogbevi, Vachon, & Lacroix, 1999). New trends in food irradiation technology exist to develop combined treatments in order to reduce the irradiation doses required to kill pathogenic bacteria and/or reduce overall microbial load (Lacroix & Ouattara, 2000). However, irradiation of meat accelerates lipid oxidation and produces off-odors under aerobic conditions. A strong antioxidantive effect of added green tea powder in manufacturing cooked pork patty, even after irradiation, was observed by Jo, Son, Sohn, and Byun (2003).

The present study investigated the effect of pectin-based edible coatings containing freeze-dried green tea leaf extract powder on the physicochemical, microbiological and sensory qualities of irradiated pork patties.

2. Materials and methods

2.1. Preparation and lyophilization of green tea extract powder (GP)

Green tea was extracted with 70% ethanol (30% distilled water) (sample:solvent = 1:20) at room temperature (20 °C) for 72 h. The extract was subjected to irradiation at 20 kGy in a cobalt-60 irradiator (point source. AECL, IR-79, MDS Nordion International Inc., Ont., Canada) in order to enhance color without any adverse change in physiological activities (Jo et al., 2003). An et al. (2004) reported that the electron donating ability of irradiated polyphenols, even at 40 kGy, was not different compared to non-irradiated controls at all concentrations tested. Ethanol in the green tea leaf 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 (SEDSF12, Samwon Co. Ltd., Busan, Korea). The dried samples were collected and stored in screw capped glass bottles at ambient temperature.

2.2. Preparation of coating solution

The three gram pectin (from citrus fruits; Sigma–Aldrich Co., St. Louis, MO, USA) were dissolved in 99 ml distilled water. After the addition of 1 ml polyethylene glycol (PEG, M.W. 400; Sigma–Aldrich Co., St. Louis, MO, USA), the solution was homogenized with a homogenizer (Diax 900, Heidolgh, Schwabach, Germany) for 1 h and homogenized again for 30 min after the addition of 0.5 g of GP. The final solution was sonicated about 1 h in order to remove air bubble or dissolved air.

2.3. Patty preparation

Raw ground pork was purchased from three different local grocery stores, pooled to obtain homogeneous samples, and patties (approximately 20 g each) were prepared. The raw patties were cooked in an oven (85 °C) for 30 min achieving an internal temperature to approximately 72 °C, then cooled in a laminar flow hood for 2 h.

2.4. Coating and irradiation

Cooked pork patties were separated into three groups; uncoated (C), coated with pectin-based materials (CP), and coated with pectin-based materials containing 0.5% green tea powder (CGP). The prepared cooked pork patties were coated by dipping them into the prepared coating solutions for 5 s at room temperature, then drying for 30 s. This dipping procedure was repeated three times, then the patties were dried for 2 h in a laminar flow hood. The dried patties were divided into two groups, for vacuum and aerobic packaging. The packed samples were irradiated at 0 and 3 kGy absorbed doses, then stored for 0, 7, and 14 days at 10 °C before analysis. The optimum storage temperature of meat is 2–4 °C, however, the samples in this study were stored at 10 °C stimulate temperature abuse.

2.5. Lipid oxidation

Lipid oxidation was determined as a 2-thiobarbituric acid reactive substances (TBARS) value by using the method described by Ahn, Olson, Jo, Love, and Jin (1999) with some modifications. Pork patty (5 g) and 15 ml of deionized distilled water were homogenized with 50 μl butylated hydroxyanisol (7.2%) for 15 s. One milliliter of the meat homogenate was transferred to a disposable test tube and then 1 ml of thiobarbituric acid/trichloroacetic acid (20 mM TBA in 15% trichloroacetic acid) solution was added. The mixture was vortexed and incubated in a boiling water bath for 15 min, then cooled in cold water for 10 min, and centrifuged for 15 min at 2500*g* at 4 °C. Absorbance was measured at 532 nm and lipid oxidation was reported as mg malondialdehyde/kg meat.

2.6. Moisture content

Moisture content, recorded as dry weight (%), was measured using an infrared spectroscopy (IR) moisture analyzer (SM0 01, Scaltech Instruments, Goettingen, Germany).

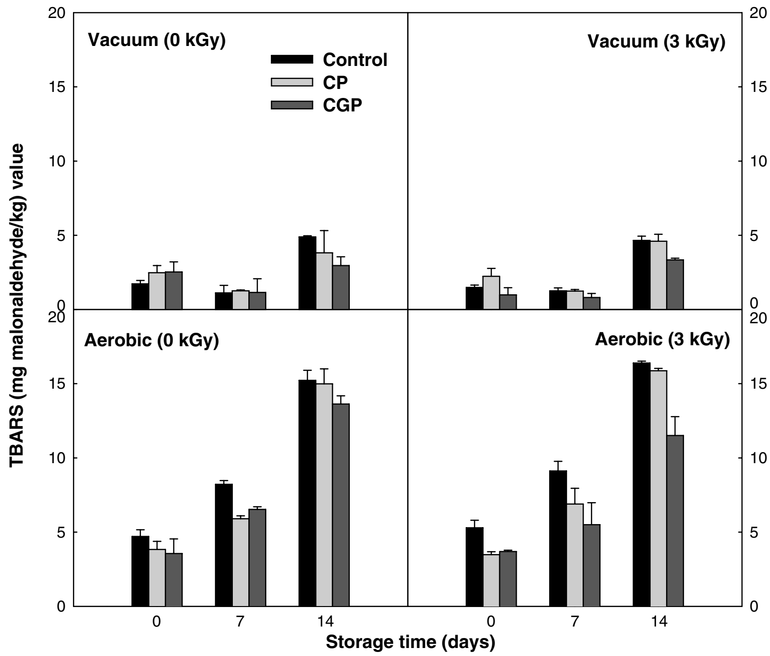

Fig. 1. 2-Thiobarbituric acid reactive substance value (TBARS; mg malondialdehyde/kg sample) of gamma-irradiated pork patty coated with pectin-based material during storage at 10 °C (control: uncoated; CP: coated by pectin-based material; CGP: coated by pectin-based material with the 0.5% green tea powder).

2.7. Microbiological analysis

A total amount of 10 g of the patties was collected, placed in a sterile plastic bag (Sterilin, Stone, Staffordshire, UK), and blended with 90 ml of 0.1% sterilized peptone water (Oxoid, Basingstoke, UK) using a Lab blender (FM 680T, Hanil, Co. Ltd., Seoul, Korea). The homogenized samples were serially diluted with 0.1% peptone water. Medium for the enumeration of the total aerobic bacteria was total plate count agar (Difco Laboratories, Detroit, MI, USA). Plates were incubated at 37 °C for 48 h. Experiments were independently conducted twice.

2.8. Sensory evaluation

An experienced 10 member team at the Radiation Food Science and Biotechnology of Korea Atomic Energy Research Institute evaluated the samples for the attributes of appearance, odor, and taste using a nine point descriptive hedonic scale (Larmond, 1977), where 9 = like extremely and 1 = dislike extremely. Three sittings ($n = 30$) were conducted at each storage time with the samples warmed in a microwave oven for 10 sec.

2.9. Statistical analysis

One way analysis of variance using SAS (SAS Institute, Cary, NC, USA) software (SAS Institute, Inc., 1989) and the Duncan's multiple range tests were used to compare the differences among mean values. Mean values with pooled standard errors of the mean (SEM) were reported, with the significance defined at $p \leqslant 0.05$.

3. Results and discussion

3.1. Lipid oxidation

Lipid oxidation, as determined by TBARS measurements, is shown in Fig. 1. The TBARS values of patties in aerobic packaging was higher than those in vacuum packaging throughout the storage period (0, 7, and 14 days). The patties coated with material containing green tea leaf extract (CGP) showed lower TBARS value than the other treatments. Irradiation did not affect TBARS values of the sample (Fig. 1). Zhu, Mendonca, and Ahn (2004) reported that when the loin chops were vacuum packaged, minimal irradiation and temperature fluctuation effects on TBARS were expected. Luchsinger et al. (1997) reported that TBARS of aerobically packaged ground beef patties increased as irradiation dose increased while those of vacuum packaged sample decreased.

Addition of green tea leaf extract powder to the coating materials for pork patties reduced lipid oxidation. Jeon, Kamil, and Shahidi (2002) found lower contents of TBARS in chitosan-coated herring and cod samples than in uncoated samples throughout the storage time. These authors found that these effects when using chitosan were due to the presence of large numbers of ionic functional groups, which created strong polymer interactions that restrict chain motion in high-viscosity chitosans, resulting in good oxygen barrier properties. Also, added green tea extract powder significantly reduced lipid oxidation of in pork patties (Jo et al., 2003).

The present results showed that the minimum lipid oxidation can be achieved in the samples containing green tea powder combined with an edible pectin-based coating film (Fig. 1).

3.2. Moisture content

Moisture content of the vacuum packaged control sample was not changed during the whole storage period while that of the aerobically packaged sample decreased (Fig. 2). Moisture content of CP was higher than those of CGP or control. Biswas, Keshri, and Bisht (2004) reported that uncoated patties showed reduced moisture content after 7 and 15 days of chilled and frozen storage, respectively. However, coated patties maintained initial moisture contents under each storage period. Wu et al. (2000) reported no significant differences in moisture loss between gluten, soy protein and chitosan wrapped patties and unpackaged patties after 3 days of refrigeration. Similarly, Dong, Cheng, Tan, Zheng, and Jiang (2004) reported chitosan coating of peeled litchi fruit retarded weight loss. This study was accordance with these studies and showed that application of pectin coating retarded water loss from irradiated pork patties.

3.3. Microbiological analysis

There were significant differences in microbial quality between the non-irradiated and irradiated samples (Fig. 3). Total plate count (TPC) of the control was above 4 log CFU/g at 0 day, and then 8 log CFU/g at 14 day. However, TPC of the sample irradiated with 3 kGy were 3 log CFU/g and 1 log CFU/g in aerobic and vacuum packaging, respectively, after storage of 14 days. Irradiation under vacuum packaging was more effective in reduction of the TPC than aerobic packaging (Fig. 3). Irradiation is widely accepted as an effective method for reducing microbial population including pathogenic and spoilage bacteria in meats, thereby improving food safety and extending shelf-life. Roberts and Weese (1998) reported a 1 and 3 decimal reduction in aerobic plate counts of gamma-irradiated ground beef at 1 and 3 kGy, respectively.

The result of the study showed that total plate count of control was the highest and followed by CP and CGP (Fig. 3). The antimicrobial activity of water or ethanol extract of green tea, oolong tea, and black tea was reported by Oh, Lee, and Park (1999) and An et al. (2004). Tea catechine, a predominant group of polyphenols present in green tea leaf, had antimicrobial activity of water or ethanol extracts (Jo et al., 2003). Vachon, D'Apprano, Lacroix, and Letendre (2003) reported that both gamma irradiation and edible coating using caseinate significantly delayed mold growth on fresh strawberries (*Fragaria* spp.) and also, irradiation treatment (32 kGy) of the coating was effective in delaying mold growth, and the addition of salt or a pectin–agar mixture further enhanced ($p \leqslant 0.05$) the coating's efficiency. Lopez-Caballero, Gomez-Guillen, Perez-Mateos, and Montero (2005) reported that chitosan coating inhibited microbial growth to the extent of around 2 log between control and coated batches for total plate count (TPC), *Pseudomonas* and enterobacteria during 8–11 days of storage.

The results indicated that in the maintenance of quality, including reduction of total plate count, addition of the green tea leaf extract powder into edible coatings and vacuum packaging with irradiation was more effective than aerobic packaging or non-irradiation treatments.

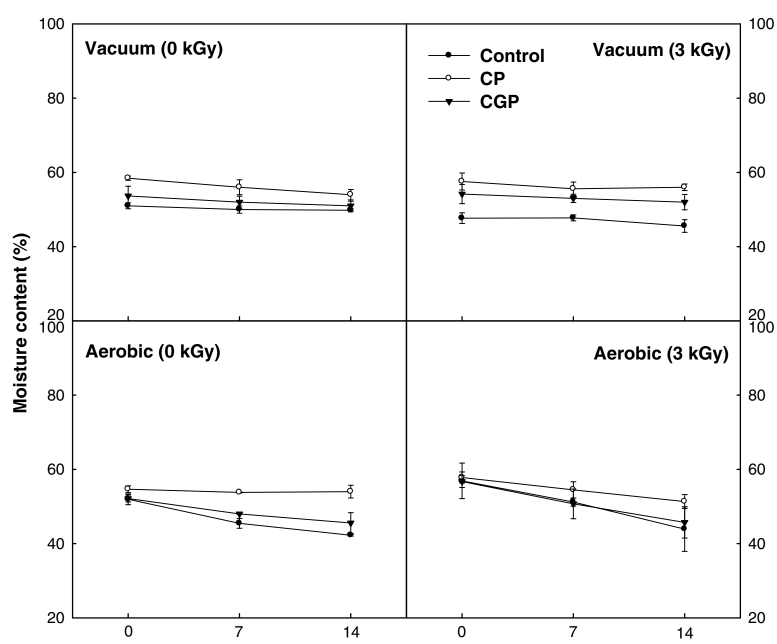

Fig. 2. Moisture content of gamma-irradiated pork patty coated with pectin-based material during storage at 10 °C (control: uncoated; CP: coated by pectin-based material; CGP: coated by pectin-based material with the 0.5% green tea powder).

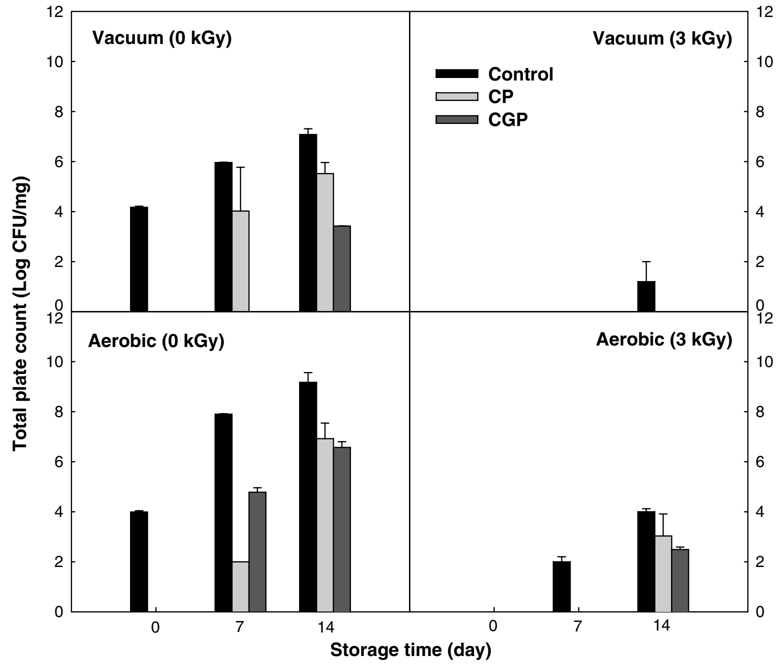

Fig. 3. Total plate count of gamma-irradiated pork patty coated with pectin-based material during storage at 10 °C (control: uncoated; CP: coated with pectin-based material; CGP: coated with pectin-based material containing 0.5% green tea powder).

Table 1
Sensory scores of gamma-irradiated pork patties coated with pectin-based materials during storage at 10 °C

	Sensory parameters								
	Appearance			Odor			Taste		
	0 kGy	3 kGy	SEM[a]	0 kGy	3 kGy	SEM[a]	0 kGy	3 kGy	SEM[a]
V-Control	6.25	6.38	0.546	5.25b	6.25	0.590	5.25	5.38	0.664
V-CP	6.50	6.75	0.765	6.00ab	5.88	0.525	5.63	5.00	0.681
V-CGP	6.38	7.00	0.755	7.25a	7.38	0.703	4.88	5.00	0.713
SEM[a]	0.713	0.679		0.603	0.618		0.674	0.698	
A-Control	6.00	5.75	0.665	4.88	5.38	0.524	4.50	5.63	0.834
A-CP	7.00	6.88	0.700	5.25	5.25	0.453	5.88	5.63	0.589
A-CGP	6.50	6.88	0.850	6.38	6.50	0.640	4.63	6.13	0.430
SEM[a]	0.645	0.828		0.579	0.508		0.719	0.549	

Abbreviation: V-Control, vacuum packaged pork patty; V-CP, vacuum packaged pork patty coated with pectin-based materials; V-CGP, vacuum packaged pork patty coated pectin-based material containing 0.5% green tea powder; A-Control, aerobic packaged pork patty; A-CP, aerobic packaged pork patty coated with pectin-based material; A-CGP, aerobic packaged pork patty coated with pectin-based material containing 0.5% green tea powder.
Different letters (a–c) within the same row differ ($p \leqslant 0.05$).
[a] Pooled standard errors of the mean ($n = 6$).

3.4. Sensory properties

Table 1 shows the sensory scores of pork patty coated with different pectin-based edible film. There were no significant differences in sensory properties between the packaging methods and none of the sensorial parameter was significantly affected by gamma irradiation ($p > 0.05$). The only difference was in the odor of the vacuum packaged sample, which was higher in CGP than in the control. Biswas et al. (2004) reported similar findings. Enrobed patties had higher ($p \leqslant 0.05$) acceptability scores than controls, since they had higher scores for appearance and color, flavor, juiciness and texture. Also, Jo et al. (2003) reported that the panelists preferred the odor of raw patties with the addition of irradiated, freeze-dried green tea extract powder to that of the controls.

In conclusion, lyophilized green tea leaf extract powder added to pectin-based coatings had positive effects on irradiated pork patty quality.

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