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Effects of Gamma Irradiation and X-ray Irradiation on Quality, Sensory Characteristics of Beef Patties

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Abstract. The physicochemical properties (pH, color, and texture) and sensory properties of beef patties that irradiated by gamma ray and X-ray were evaluated and compared. Ground beef patties were cooked and vacuum-packaged before irradiation by gamma ray and X-ray at 0, 2.5, 5, 7.5, 10 kGy. The redness of beef patties decreased by irradiation regardless of irradiation method compared to control ($p < 0.05$). Since gamma irradiation affected the sensory quality more than X-ray irradiation, gamma irradiated samples got lower scores on the sensory evaluation (flavor and overall acceptability) compared to X-ray irradiated samples ($p < 0.05$). The result of this study suggests that X-ray is more effective irradiation method than gamma irradiation to improve the flavor and overall acceptability of beef patties.

Keywords: food irradiation, beef patty, x-ray, gamma-ray

1. Introduction

Since the 1950s, studies on irradiation of food started, and radiation technology using an gamma ray or electron beam, and X-ray has been known one of the most effective method to improve the food safety [1]. In 1997, FDA approved of utilization of radiation technology to the red meat and meat products, and it has facilitated elimination of pathogenic and spoilage microorganisms in various meat and meat products. Irradiation is non-thermal process so that it can maintain the quality of the products. Also, irradiation can treate the products in packaged state so that reduce the risk of cross-contamination [2]. Among the ionizing irradiation, gamma irradiation is commonly used for irradiation of food including meat. Although gamma irradiation has higher penetrating power than the other sources, there are still safety concerns since it deals with the nuclear substance. Mitchell [3] suggested that consumer prefers the machine irradiation sources to isotope irradiation sources. Besides, Wagner [4] reported that X-ray irradiators can save time and cost compared with gamma irradiators through continuous processing and low energy that readily manageable than gamma ray. Thus, studies on X-ray irradiation on the meat and meat products has been conducted by many researchers recently. The objective of this study was to compare the effect of gamma irradiation and X-ray irradiation on physicochemical properties (pH, color, and texture) and sensory properties of beef patties.

2. Materials and Methods

2.1. Manufacturing and Irradiation of Beef Patties

Frozen beef top round was purchased from a local butcher shop and ground using 8mm plate. Then ground beef was mixed with pork backfat, ice, nitrite pickling salt, sodium tripolyphosphate, sugar, isolated soy protein, pepper, garlic powder, onion powder, ginger powder, spices, and ascorbic acid. After mixing process, about 100g of the mixture was shaped into patties (diameter 10 cm, and thickness 1.5 cm) by using

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mould. Beef patties were heated in a oven that preheated at 150℃ for about 10 minutes until the core temperature get to 75℃. Cooked patties were cooled to room temperature for 6 hours, then vacuum packaged individually in polyethylene/nylon pouch. Vacuum-packaged beef patties were irradiated at 0(control), 2.5, 5, 7.5, 10 kGy by Gamma ray, X-ray at room temperature. Gamma ray irradiation was conducted using ^{60}Co irradiator (point source AECL, IR-79, MDS Nordion International Co. Ltd., Canada) in the Advanced Radiation Technology Institute, Korea Atomic Energy Research Institute (Jeoung-Eup, Korea). X-ray irradiation was performed with an LINAC Electron-Accelerator (10 MeV) at the EB-tech (EB-tech Co., Daejeon, Korea).

2.2. pH and Color Evaluation

The 5 g of samples with 20 mL distilled water was homogenized for 60 s using a homogenizer (Ultra-Turrax T25, Janke and Kunkel, Staufen, Germany). The pH of samples was determined with a pH meter (Model 340, Mettler-Toledo GmbH, Schwerzenbach, Switzer-land). The color of surface of irradiated beef patties was measured with colorimeter (Chroma meter, CR210, Minolta, Japan) to determine the CIE-L^* value (lightness), a^* value (redness), and b^* value (yellowness). The standard plate that has L^* value; +97.83, a^* value; -0.43, and b^* value; +1.98 was used.

2.3. Texture Profile Analysis (TPA)

The TPA was performed on each sample at room temperature using a spherical probe (5 diameter), attached to a texture analyzer (TA-XT2i, Stable Micro Systems Ltd., Surrey, England). The test conditions were as follows: pre-test speed 2.0 mm/s, post-test speed 5.0 mm/s, maximum load 2 kg, head speed 2.0 mm/s, distance 8.0 mm, and force 5 g. The data of hardness (kg), springiness, cohesiveness, gumminess (kg), and chewiness (kg) were determined as described by Bourne [5].

2.4. Sensory Evaluation

The beef patty samples were evaluated color of appearance, flavor, texture, juiciness, and overall acceptance (1 = extremely undesirable, 10 = extremely desirable). The irradiated samples were cut in cube (1×1×1 cm) and served in random order to the panelists that consisted of 12 members from the Konkuk university. The sensory evaluation was performed under fluorescence light and panelists were instructed to clean their palates between samples using water.

2.5. Statistical Analysis

An analysis of variance was performed on all the variables measured using the general linear model (GLM) procedure of the SAS statistical package [6]. Duncan's multiple range tests ($p < 0.05$) was used to determine differences between treatment means.

3. Results and Discussion

3.1. pH and Color

The pH values of sample that irradiated by X-ray were slightly higher than that of non-irradiated control sample (Table 1). However, regardless of irradiation method or absorbed dose, irradiation did not influenced significantly on the pH of beef patty samples ($p > 0.05$).

After irradiation treatment, within the treatments have absorbed dose 7.5 kGy, the lightness of gamma ray irradiated patties was lower than X-ray irradiated patties ($p < 0.05$). As absorbed dose of gamma ray increasing, the lightness of gamma irradiated samples showed decreasing tendency though there was no significant difference compared to that of non-irradiated sample. This result is in accordance with the result of study conducted by Park *et al*. [1]. By the study reported Kim *et al*. [7], beef color changed into greenish brown by the gamma irradiation. In agreement, the redness of the beef patties decreased by irradiation ($p < 0.05$), except 7.5 kGy irradiated by gamma ray. In this study, gamma irradiation or X-ray irradiation did not influenced on the yellowness of all samples, therefore, significant differences between irradiated and non-irradiated samples did not observed ($p > 0.05$). Among the all treatments, irradiated by X-rat at 7.5 kGy has the lowest yellowness value.

Table 1. Effect of gamma-ray and X-ray irradiation on pH value and color of beef patties

	Ionizing sources	Irradiation dose (kGy)					SEM[1)]
		0	2.5	5	7.5	10	
pH	Gamma-ray	5.87	5.82	5.86	5.90	5.89	0.033
	X-ray	5.87	5.97	5.90	5.94	5.95	0.030
	SEM[1)]	0.077	0.041	0.034	0.037	0.037	
CIE L* (lightness)	Gamma-ray	50.24^{ab}	51.00^{a}	51.05^{a}	47.68^{Bb}	49.98^{ab}	0.371[2)]
	X-ray	50.24	51.57	49.63	51.72^{A}	49.88	0.342
	SEM[2)]	-	0.318	0.490	0.492	0.427	
CIE a* (redness)	Gamma-ray	16.80^{b}	15.35^{c}	15.60^{c}	18.52^{Aa}	16.76^{b}	0.159
	X-ray	16.80^{a}	15.83^{ab}	16.26^{a}	14.92^{Bb}	16.15^{a}	0.142
	SEM	-	0.176	0.201	0.267	0.187	
CIE b* (yellowness)	Gamma-ray	12.01^{ab}	12.03^{ab}	11.96^{b}	12.80^{Aa}	12.13^{ab}	0.095
	X-ray	12.01	12.27	12.32	11.53^{B}	12.07	0.100
	SEM	-	0.211	0.141	0.197	0.132	

[1)]SEM: standard error of the means. (n=4).
[2)]SEM: standard error of the means. (n=20).
[A-B] Mean values within a column follow by the different letter are significantly different ($p < 0.05$).
[a-c] Mean values within a row follow by the different letter are significantly different ($p < 0.05$).

3.2. Texture Profile Analysis

The hardness (kg) of X-ray irradiated samples was increased as absorbed dose increased (Table 2). However, the springiness of samples did not affected significantly by the irradiation treatment up to 10 kGy ($p > 0.05$). The cohesiveness of 5 kGy X-ray irradiated sample showed lower value than gamma irradiated samples ($p < 0.05$), although, in compare with non-irradiated sample, cohesiveness did not show significant changes by the irradiation. Also, the gumminess (kg) and chewiness (kg) of irradiated patties were not different compared to the control ($p > 0.05$). Therefore, the effect gamma irradiation and X-ray irradiation on the texture characteristics of beef patties did not observed in the result from this study.

Table 2. Effect of gamma-ray and X-ray irradiation on textural properties of beef patties

Parameters	Ionizing sources	Irradiation dose (kGy)					SEM[1)]
		0	2.5	5	7.5	10	
Hardness (kg)	Gamma-ray	1.124	1.063	1.226	1.272	1.075	0.049
	X-ray	1.124	1.082	1.195	1.260	1.332	0.045
	SEM	-	0.055	0.067	0.069	0.062	
Springiness (ratio)	Gamma-ray	0.814	0.812	0.859	0.819	0.824	0.008
	X-ray	0.814	0.824	0.854	0.813	0.809	0.008
	SEM	-	0.001	0.012	0.011	0.007	
Cohesiveness	Gamma-ray	0.452	0.451	0.452^{A}	0.435	0.459	0.004
	X-ray	0.452	0.448	0.430^{B}	0.453	0.433	0.003
	SEM	-	0.004	0.004	0.005	0.004	
Gumminess (kg)	Gamma-ray	0.509	0.484	0.553	0.548	0.493	0.020
	X-ray	0.509	0.481	0.515	0.561	0.567	0.020
	SEM	-	0.025	0.030	0.029	0.025	
Chewiness (kg)	Gamma-ray	0.409	0.393	0.471	0.455	0.402	0.016
	X-ray	0.409	0.402	0.433	0.450	0.460	0.017
	SEM	-	0.023	0.024	0.024	0.020	

[1)]SEM: standard error of the means. (n=12).
[A,B] Mean values within a column follow by the different letter are significantly different ($p < 0.05$).

3.3. Sensory properties

Table 3. Effect of gamma-ray and X-ray irradiation on sensory properties of beef patties

Parameters	Ionizing sources	Irradiation dose (kGy)					SEM[1)]
		0	2.5	5	7.5	10	
Color	Gamma-ray	8.22	7.83	7.78	7.83	7.78	0.074
	X-ray	8.22	8.11	8.00	7.83	7.83	0.078
	SEM	-	0.089	0.086	0.088	0.093	
Flavor	Gamma-ray	7.89	6.94	6.89	6.67	6.50^{B}	0.116
	X-ray	7.89^{a}	7.67^{b}	7.61^{b}	7.44^{b}	7.33^{Ab}	0.116
	SEM	-	0.156	0.150	0.148	0.145	
Texture	Gamma-ray	7.33	7.00	7.00	7.06	6.83	0.108
	X-ray	7.33	7.39	7.11	7.28	7.11	0.107
	SEM	-	0.141	0.145	0.137	0.132	
Juiciness	Gamma-ray	7.33	7.11	6.94	6.94	6.83	0.096
	X-ray	7.33	7.11	7.17	7.06	7.06	0.095
	SEM	-	0.134	0.123	0.121	0.121	
Overall acceptance	Gamma-ray	8.06	7.06^{B}	6.89^{B}	6.72^{B}	6.33^{B}	0.097
	X-ray	8.06^{a}	8.06^{Aa}	7.78^{Ab}	7.67^{Ab}	7.67^{Ab}	0.103
	SEM	-	0.144	0.131	0.127	0.145	

[1)]SEM: standard error of the means. (n=6).
[a-b] Mean values within a row follow by the different letter are significantly different ($p < 0.05$).
[A-B] Mean values within a column follow by the different letter are significantly different ($p < 0.05$).

Although instrumental redness values of samples affected by irradiation, sensory characteristic (color) of the beef patties did not show significant differences in the scores ($p > 0.05$) compared to control (Table 3). As absorbed dose increasing, flavor of the beef patties decreased in both irradiation methods. However, it seems that X-ray irradiation induced less decrease of flavor than gamma irradiation in beef patties. The texture and juiciness of irradiated beef patties did not show any distinctive changes by neither irradiation method nor absorbed dose ($p > 0.05$). Gamma irradiation decreased overall acceptability scores of beef patties largely compared to X-ray irradiation ($p < 0.05$). Overall acceptability of samples decreased according to an increase of absorbed dose in both irradiation methods.

In conclusion, both gamma irradiation and X-ray irradiation induced changes of the color and sensory characteristics of beef patties. However, X-ray irradiation can be more effective than gamma irradiation for reducing decreases of flavor and overall acceptability of beef patties up to 10 kGy.

4. Acknowledgements

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5. References

[1] J. G. Park, Y. Yoon, J. N. Park, I. J. Han, B. S. Song, J. H. Kim, W. G. Kim, J. J. Hwang, S. B. Han, J. W. Lee. Effects of gamma irradiation and electron beam irradiation on quality, sensory, and bacterial populations in beef sausage patties. *Meat Science.* 2010, 85: 368-372.

[2] H. M. Badr, K. A. Mahmoud. Antioxidant activity of carrot juice in gamma irradiated beef sausage during refrigerated and frozen storage. *Food Chemistry*. 2011, 127: 1119-1130.

[3] G. E. Mitchell. Irradiation preservation of meats. Food Australia. 1994, 46: 512-516.

[4] J. K. Wagner, J. A. Dillon, E. K. Blythe, J. R. Ford. Dose characterization of the rad source^{TM} 2400 X-ray irradiator. *Applied radiation and isotopes.* 2009, 67:334-339

[5] M. C. Bourne. Texture profile analysis. *Food Technology*. 1978, 32(7): 62-66.

[6] SAS/STAT Software for PC. SAS. 2010. Release 9.2, SAS Institute Inc., Cary, NC, USA.

[7] Y. H. Kim, K. C. Nam, D. U. Ahn. Color, oxidation-reduction potential, and gas production of irradiated meat from different animal species. *Journal of Food Science*. 2002, 67: 1692-1695.