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Color and Sensory Characteristics of Chicken Patties as Affected by Irradiation and Storage Temperature

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방사선 조사된 닭고기 Patty의 저장시 색깔 및 관능 성질 변화

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Abstract

Prefried chicken patties were irradiated at dose levels of 0, 2, and 4 kGy using Co^{60} source and stored at 3± 1℃ and −10± 1℃, separately for the evaluation of color and sensory characteristics. Irradiation dose of 4 kGy slightly darkened the internal color of chicken patties. Except for the internal portion of the frozen samples, an increase ($p<0.05$) in Hunter "L" values was observed for both the surface and interior of patties during storage. Upon refrigerated storage, Hunter "a" values, both on the surface and internally, decreased as the storage period progressed. Only storage period affected ($p<0.05$) the Hunter "b" values of patty surfaces and interiors. No difference ($p<0.05$) in odor, taste, color, and texture of the patties was observed for irradiation dose and storage period as evaluated by triangle tests except between 2 kGy and 4 kGy irradiated samples before forzen storage.

Key words: chicken patty, gamma irradiation, color, sensory evaluation

Introduction

As the poultry industry responds to changes in consumer demand patterns, the forms in which broilers are marketed have changed. In 1987, the following mix appeared: cut-up parts, 57%; and further-processed products, 20%. The 1990 forecast puts these numbers at 50% and 28%, respectively[1]. The rapid growth of broiler consumption has been enhanced by innovative product development.

Warmed-over flavor (WOF) has been characterized as the rapid rancidity development of precooked meat during refrigerated or frozen storage and phospholipids are the primary contributors[2]. Since WOF is a sensory phenomenon, sensory analysis can be conducted to elucidate the mechanisms involved in WOF development and evaluate the efficiency of additives and treatments in inhibiting WOF.

Several methods have been used to extend the shelf life of refrigerated poultry products, such as the use of irradiation, packaging, storage conditions, antimicrobial additives, etc. The effects of radiation and cooking on the organoleptic qualities of poultry meat have been studied. Coleby[3] reported that it was possible to detect organoleptic changes after irradiation with doses as low as 0.5 kGy, but after cooking it was difficult to detect such changes. For light cooking, a dose of 2.5 kGy was required before organoleptic changes in minced chicken meat could be detected. Hanson *et al.*[4] reported that taste panels could easily detect the odor and flavor changes in chicken meat caused by 1 kGy if irradiated at ambient temperature. Almost no irradiation flavor occurred when chicken was irradiated below −28.9℃. Hanson and Pouliver[5] also conducted a consumer survey for acceptance evaluation of cured ham treated by a combination of heat and irradiation and reported a slight difference in flavor between irradiated and non-irradiated samples. Chuang *et al.*[6] reported that TBA (2-thiobarbituric acid) values were increased as the irradiation dose increased and the storage time progressed. The purpose of this study was to investigate the effects of low dose irradiation and storage temperature on the color and sensory characteristics of prefried chicken patties.

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Materials and Methods

Irradiation and storage

Frozen prefried chicken patties were prepared in a commercial poultry product plant. The patties, averaging 9.5 mm in thickness and 85.9 g in weight, were fried to an internal temperature 71.7℃. The composition of the raw patty was 39.9% breast meat with skin including tenderloin, 26.6% water and/or ice, 19.9% skin, 12.3% soy protein and 1% seasoning. The fried patties were divided randomly into six batches and irradiated using Co^{60} gamma irradiator at Process Technology in West Memphis, AR, USA. Three doses (0, 2, and 4 kGy) at ambient temperature without packaging were chosen and each dose had four replications. After irradiation, the patties were divided and stored for a period of 7 weeks and 7 months at 3± 1℃ and −10± 1℃, respectively, for further studies.

Color measurement

The colors of the patties were measured using a Hunter-Lab Model D-25 Color and Color-Difference Meter (Hunter Associates Laboratory, Fairfax, VA, USA). The Hunter "L", "a", and "b" values of the chicken patties were gauged. Standard plate #6274, with a "L" value of 92.4, an "a" value of −0.7 and a "b" value of −0.9, was used as a reference.

The external color measurement of the patties was made by covering the aperture with the sample and flattened by applying pressure to insure proper surface illumination. For internal color determination, the patties were sliced in half horizontally. The sliced surfaces were exposed to the color meter.

Sensory evaluation

Frozen chicken patties were tempered to an internal temperature of 10± 1℃. Then heated in a microwave oven (Model JE1445, Louisville, KY, USA) at maximum power for 3 min to reach an internal temperature of 73.8℃. After reheating, the samples were cubed and presented to a taste panel consisting of ten experienced panelists.

The modified triangle test as described by Larmond[7] was used to identify differences among samples. Of the three samples presented, two were the same and one was an odd sample. The samples were identified by a three digit number derived from a random number table. The quality of the chicken patties were evaluated for odor, taste, color, and texture.

Table 1. Mean Hunter "L" values of chicken patties as affected by irradiation dose and storage temperature[a]

Irradiation	3± 1℃[b]		−10± 1℃[c]	
dose(kGy)	Surface	Internal	Surface	Internal
0	59.03a	70.15b	55.10a	66.89a
2	59.10a	70.38b	57.10b	67.57a
4	59.12a	68.56a	58.67b	66.70a

[a]Means within a column followed by unlike letters differ significantly ($p<0.05$)
[b]Each value represents a mean of 32 observations
[c]Each value represents a mean of 20 observations.

Statistical analysis

This study was designed and the results were analyzed using a factorial arrangement and analysis of variance for a completely random design[8] with four replications per treatment. Duncan's New Multiple Range Test[9] was used to separate the means, determine significant differences, and the occurrence of all possible interactions between the means.

Results and Discussion

Color of chicken patties as affected by storage period and irradiation dose

The effect of irradiation dose on Hunter "L" values of chicken patties stored at 3± 1℃ and −10± 1℃ is summarized on Table 1. It was found that 4 kGy irradiation slightly darkened (lower Hunter "L" values) the internal color of chicken patties during 7 week storage at 3± 1℃ when compared to the 2 kGy and non-irradiated samples. Urbain[10] indicated that both fresh and cured meats can undergo color changes during radappertization or radurization. It produced a reduced denatured myoglobin pigment that is easily oxidized by oxygen and darken the color.

Regardless of storage temperature, no interaction between irradiation dose and storage period on both surface and internal Hunter "L" values was found for the patties. Except for the internal portion of the frozen samples, an increase ($p<0.05$) in Hunter "L" values was observed for both the surface and interior of patties held at 3± 1℃ and −10± 1℃ (Table 2). Both the surfaces and internal portion of the chicken patties became lighter as the refrigerated period progressed.

Irradiation decreased ($p<0.05$) the redness (Hunter "a" values) of patty surfaces (Table 3); however, no effect on the internal Hunter "a" values was observed

Table 2. Mean Hunter "L" values of chicken patties stored at 3± 1°C and −10± 1°C as affected by storage period[a]

Temperature (℃)	Storage period (weeks)	Mean Hunter "L" values[b]	
		Surface	Internal
3± 1	0	55.27a	68.27a
	1	56.66ab	68.69ab
	2	58.10bc	69.79bcd
	3	60.68d	69.89bcd
	4	59.75cd	70.53cd
	5	59.51cd	70.06bcd
	6	59.63cd	71.19d
	7	63.08e	70.41cd
−10± 1	0	55.27A	68.25A
	4	55.87AB	66.70A
	12	54.30A	65.94A
	20	58.29B	67.14A
	28	61.06C	66.65A

[a]Means within a column followed by unlike letters differ significantly ($p<0.05$)
[b]Each value represents a mean of 12 observations

Table 3. Surface Hunter "a" values of chicken patties stored at 3± 1°C as affected by irradiation dosage and storage period[a]

Storage period (weeks)	Mean Hunter "a" values[b]		
	0 kGy	2 kGy	4 kGy
0	9.30j	5.50a-i	4.03abc
1	5.40a-i	7.66f-j	3.69ab
2	6.13a-j	6.35c-j	6.13a-j
3	8.67ij	5.98a-i	5.52a-i
4	6.84d-j	7.87g-j	4.59a-g
5	4.69a-h	4.54a-f	5.42a-i
6	6.23b-j	7.91hij	7.20e-j
7	4.27a-d	4.27a-e	3.41a

[a]Means within a column or row followed by unlike letters differ significantly ($p<0.05$)
[b]Each value represents a mean of 4 observations

Table 4. Internal Hunter "a" values of chicken patties stored at −10± 1°C as affected by irradiation dosage and storage period[a]

Storage period (months)	Mean Hunter "a" values[b]		
	0 kGy	2 kGy	4 kGy
0	1.85abc	1.77abc	2.72bc
1	3.18c-f	2.67b-e	3.50def
3	4.21f	4.01ef	5.58f
5	3.61def	1.62a	1.22ab
7	1.91abc	2.11bcd	2.69b-e

[a]Means within a column or row followed by unlike letters differ significantly ($p<0.05$)
[b]Each value represents a mean of 4 observations

Table 5. Mean Hunter "a" values of chicken patties stored at 3± 1°C as affected by storage period[a]

Storage period (weeks)	Mean Hunter "a" values[b]	
	Surface	Internal
0	6.28bc	2.25c
1	5.58abc	1.59bc
2	6.20bc	0.68a
3	6.72c	0.81a
4	6.43bc	0.80a
5	4.88ab	0.36a
6	7.11c	0.59a
7	3.98a	0.99ab

[a]Means within a column followed by unlike letters differ significantly ($p<0.05$)
[b]Each value represents a mean of 12 observations

Table 6. Mean Hunter "b" values of chicken patties stored at 3± 1°C and −10± 1°C as affected by storage period[a]

Temperature (℃)	Storage period (weeks)	Mean Hunter "b" values[b]	
		Surface	Internal
3± 1	0	16.56a	12.87a
	1	17.88b	13.61ab
	2	18.58b	14.38bc
	3	18.41b	14.42bc
	4	17.70b	14.44bc
	5	17.42ab	14.62bc
	6	18.06b	15.23c
	7	18.40b	15.24c
−10± 1	0	18.40A	12.87A
	4	18.10A	12.95A
	12	18.28A	13.04A
	20	18.00A	13.78B
	28	20.32B	14.65C

[a]Means within a column followed by unlike letters differ significantly ($p<0.05$)
[b]Each value represents a mean of 12 observations

(Table 4). Upon refrigerated storage, the Hunter "a" values, both on the surface and internally, decreased as the storage period progressed (Table 3 and 5). This decrease in redness was much more severe for the surfaces of non-irradiated patties (Table 3). Irradiation dosage and storage time affected ($p<0.05$) the internal Hunter "a" values of frozen patties but not the surface.

Analysis of variance data indicated only storage time affected ($p<0.05$) the Hunter "b" values of patty surfaces and interiors in both refrigerated and frozen samples. No storage time and dosage interaction effect ($p>0.05$) was found. In general, a slight increase in Hunter "b" values was recorded as the storage time progressed, especially for internal patty color (Table 6).

Table 7. Summary of triangle test of fresh chicken patties

	0 dnd 2 kGy			2 and 4 kGy		
	Correct	Total	Difference	Correct	Total	Difference
Odor	3	10	No[a]	8	10	**
Taste	5	10	No	7	10	*
Color	5	10	No	6	10	No
Texture	4	10	No	6	10	No

[a]No difference between two samples
*Significant at the 0.05 level of probability
**Significant at the 0.01 level of probability

Table 8. Summary of triangle test of irradiated chicken patties stored at −10°C for one month

	0 dnd 2 kGy			2 and 4 kGy		
	Correct	Total	Difference	Correct	Total	Difference
Odor	6	10	No[a]	2	10	No
Taste	4	10	No	2	10	No
Color	3	10	No	1	10	No
Texture	4	10	No	1	10	No

[a]No difference between two samples

Sensory evaluation

No difference ($p>0.05$) in odor, taste, color, and texture characteristics between the non-irradiated and 2 kGy irradiated fresh patties before storage was observed by triangle tests. However, differences ($p<0.05$) in odor and taste were found between the fresh samples treated with 2 and 4 kGy (Table 7). This difference in odor and taste disappeared after the patties were frozen for one month at −10± 1℃ (Table 8) Niemand *et al.*[11] reported that irradiated beef cuts scored equally or slightly better than the controls in most parameters except odor and taste. Gruenewald[12] reported no differences ($p>0.05$) in flavor, smell, color, consistency and overall quality between irradiated with 2.5~8.0 kGy and non-irradiated deep-frozen broilers stored at −30℃ for 2 years.

요 약

방사선이 조사(0, 2, 4 kGy)된 튀긴 닭고기 patty를 각각 3± 1℃와 −10± 1℃로 저장한 뒤 색깔 변화 및 관능검사를 하였다. 선량 4 kGy로 조사된 patty 내부의 색깔은 어두워졌으며, 저장동안 동결된 시료의 내부를 제외한 모든 시료의 외부와 내부의 Hunter "L"값의 증가 ($p<0.05$)가 관찰되었다. 냉장 저장 중 시료 외부와 내부의 Hunter "a"값은 저장기간이 지날수록 감소했다($p<0.05$). 방사선 조사나 선량과 상관없이 저장 시간만이 patty의 외부와 내부의 Hunter "b"값에 영향을 미쳤다 ($p<0.05$). 삼점시험법에 의한 patty의 관능검사 결과 냄새와 맛에서 2 kGy와 4 kGy로 조사된 시료사이의 차이를 제외하고는 냄새, 맛, 색깔 및 조직감에서의 차이점이 뚜렷하지 않았다($p<0.05$).

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