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Microbial Quality and TBA Values of Chicken Patties as Affected by Irradiation and Storage Temperature

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방사선 조사에 의한 닭고기 가공제품인 Patty의 미생물 및 TBA가 변화

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Abstract

prefried chicken patties were irradiated with doses of 0, 2, and 4 kGy, and stored at 3±1 °C and −10±1 °C, separately for the evaluation of microbiological quality and TBA values. Gamma irradiation increased ($P<0.05$) the shelf life of chicken patties stored at 3±1 °C. The time required to reach a log number of 6.5/g was 22 days for the control, while 43 and 44 days for 2 and 4 kGy-irradiated samples, respectively. No microorganism was isolated from patties irradiated at 4 kGy. Irradiation decreased the incidence of gram-positive cocci-type organisms in patties; while yeasts and gram-negative rod-type organisms dominated the microbial population isolated from 2 and 4 kGy-irradiated samples, respectively. TBA values were increased ($P<0.05$) as the irradiation dose increased and the storage time progressed.

Key words: chicken patties, microbiological quality, TBA, gamma irradiation

Introduction

In recent years considerable attention has focused on the development of further processed poultry products as a means of providing alternative food sources of high nutritional quality. Therefore, further processed poultry products will provide major markets for increasing poultry meat consumption in the future [1]. The market for further processed chicken products has more than doubled its size in the last five years[1].

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[3]. Igene *et al.*[3] showed a high correlation of WOF with TBA values and indicated that TBA values can be an indicator for WOF formation in cooked chicken.

The growth of microoganisms during refrigeration is the most critical factor limiting the shelf life. Several methods have been used to extend the self of refrigerated poultry products, such as the use of irradiation, packaging, storage condition, antimicrobial additives, etc. Food can be preserved by irradiation which inhibit microorganisms by radappertization or radurization. Radiation can also be used as a compoent in combination with other methods of preservation such as chemical additives, etc. Baker [4] predicted that irradiated further processed poultry products will become more popular in the next 25 years.

It was reported that chicken breast meat stored at 0 °C after gamma irradiation at 3.7 kGy maintained satisfactory quality for about 3 weeks[5]. Kahan and Howker[6] reported that irradiation doses of 2-4 kGy effectively destroyed all *Salmonella*. Cho *et al.*[7] indicated 5-10 kGy could extend the shelf life of chicken carcasses by 2-4 weeks at 3-4 °C. However,

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irradiation also induced an alternation of spoilage microflora, and post-irradiated microflora in meat is quite different in composition from preirradiated microflora[8].

Frozen storage extends the shelf life of poultry products by preventing the microbial growth. Cooked meat can have appreciable shelf life during frozen storage if precautions are taken to protect it from oxidation[9]. Berry and Morgan[10] reported that the minimum temperature for psychrotrophic growth was approximately -10 °C. The purpose of this study was to investigate the effects of gamma irradiation and storage temperature on the microbiological quality and TBA values of prefried chicken patties.

Materials and Methods

Gamma 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 °C. 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 gamma-irradiated using Co-60 at Process Technology in West Memphis, AR, USA. Three doses (0, 2 and 4 kGy) at ambient temperature without packaging were chosen and each dosage had four replications. After irradiation, the patties were divided and stored at 3 ± 1 °C and -10 ± 1 °C, separately, for further studies.

Total plate counts and total fungal counts

Total psychrotrophic plate counts were measured at 7-day intervals for a period of 49 days for samples stored at 3 ± 1 °C and monthly for 7 months for the patties stored at -10 ± 1 °C. The patties were ground aseptically through a homestyle grinder and thirty grams of the sample were blended with 270 m*l* of sterilized 0.1% Bacto peptone (Difco, Lab.) solution in a sterile Waring Blendor at high speed for 1 min. Serial dilutions of the sample were plated with Plate Count Agar (PCA) (Difco, Lab.) and acidified Potato Dextrose Agar (PDA) (Difco Lab.), separately.

The PCA plates were incubated at 20 ± 1 °C for 72 hrs for total psychrotrophic plate counts. The PDA plates were incubated at 25 ± 1 °C for 5 days for the total yeast and mold counts. The average number of colonies from the duplicate plates were reported as the number of colony forming units (CFU) per gram of sample.

Isolation and Gram stain of isolates

Total psychrotrophic count plates with approximately 30 CFU were selected from the control and irradiated chicken patties at 0 day and 49 days of refrigerated storage at 3 ± 1 °C. All isolated colonies were purified by a streak-plate technique and transferred to PCA slants. The cultures were then Gram stained as recommended by the Society of American Bacteriologists[11] and observed microscopically.

2-Thiobarbituric acid (TBA) value

The TBA values of the sample were obtained by a distillation method[12]. Briefly, ten grams of finely minced samples were added to a Kjeldahl flask containing 97.5 m*l* distilled water and 2.5 m*l* 4N HCl. The flasks were connected to a Kjeldahl distillation apparatus and 50 m*l* of the distillate was collected. Five m*l* of each distillate was transferred to a test tube containing TBA reagent, stoppered, mixed and placed in a boiling water bath for 30 min. After cooling, the absorbance was measured against a reagent blank at a wave length of 538 nm. The TBA values were obtained by multiplying the absorbance with a constant of 7.8.

Statistical analysis

The results were analyzed using a factorial arrangement and analysis of variance for a completely random design[13] with four replications per treatment. Duncan's New Multiple Range Test[14] was used to separate the means, determine significant differences, and the occurrence of all possible interactions between the means.

Results and Discussion

Total microbial counts of chicken patties upon storage

Irradiation of chicken patties at 2 kGy decreased total log psychrotrophic counts per gram from 2.3 to 0.75. No colony forming units were detected in the patties irradiated at 4 kGy (Table 1). Licciardello *et al.*[15] reported a dose of 4.75 kGy was needed to yield a 10^7 reduction in microbial counts of poultry meat. Firstenberg-Eden *et al.*[16] also reported that 3kGy irradiation at 5°C reduced the natural flora on chicken skin from 10^4–10^5 to 10-500 cells/7 cm^2. Applicatin of a dose of 2.5 kGy on poultry meat has been studied by Mulder[17]. Who indicated that the growth of microflora would be retarded but did not guarantee a *Salmonella* free product.

Storage time and irradiation dose affected ($p<0.05$) the total psychrotrophic counts of chicken patties upon refrigerated (3±1°C) storage. The interactions of storage time and irradiation dosage on total psychrotrophic counts are highly significant ($p<0.01$).

Regardless of irradiation dose, the log psychrotrophic counts of chicken patties increased with storage time (Table 1). At 3±1°C, the time required to reach a mean log TPC number of 6.5 was 22 days for the non-irradiated control; while 43 and 44 days were recorded for the 2 and 4 kGy-irradiated samples, respectively. The total psychrotrophic counts of 4 kGy-irradiated patties were low throughout the entire observation period. The extension of refrigerated shelf life of raw chicken meat by irradiation has been reported by Coleby[18] and Basker *et al.*[5]. However, little or no information is available for the further processed poultry products.

Irradiation dose and storage time affected ($p<0.05$) total psychrotrophic counts of patties upon frozen storage at −10±1°C. No interaction between dosage and storage time was observed.

Table 1. Total psychrotrophic counts of chicken patties stored at 3±1°C as affected by irradiation dose and storage time[a)]

Storage time (weeks)	Mean log CFU/g[b)]		
	0 kGy	2 kGy	4 kGy
0	2.30bc	0.75a	0.00a
1	2.30bc	0.50a	0.25a
2	3.71cde	1.00ab	0.58a
3	6.32gh	1.23ab	0.50a
4	7.37hi	3.24cd	1.15ab
5	8.30ij	4.70ef	4.33def
6	9.31j	6.36gh	6.30gh
7	9.28j	9.35j	7.18hi

a) Means within a column followed by unlike letters differ significantly (P<0.05).

b) Each value reprsents the mean of 4 observations.

Table 2. Total psychrotrophic counts of chicken patties stored at −10±1°C as affected by storage time[a)]

Storage time (months)	Mean log CFU/g[b)]
0	0.68a
1	0.86ab
3	1.00ab
5	1.22b
7	1.24b

a) Means within a column followed by unlike letters differ significantly (P<0.05).

b) Each value represents the mean of 12 observations.

Table 3. Total psychrotrophic counts of chicken patties stored at −10±1°C as affected by irradiation dose[a)]

Irradiation dose (kGy)	Mean log CFU/g[b)]
0	1.59b
2	0.74a
4	0.67a

a) Means within a column followed by unlike letters differ significantly (P<0.05).

b) Each value represents the mean of 20 observations.

Although the mean log number of CFU were low, there was a slight increase in total psychrotrophic counts for patty samples stored at −10±1°C (Table 2). Again, irradiated samples had lower psychrotrophic counts during frozen storage (Table 3). Urbain[19] indicated that radiation-damaged cells usually underwent self-repairment during storage.

This repairing effect might be responsible for the increased TPC during frozen storage.

Regardless of the irradiation dose, no CFU was detected for patty samples on the acidified potato dextrose agar plates. After 7 weeks of refrigerated storage at 3±1°, the mean potato dextrose agar counts increased from non-detectable to 7 and 25 CFU/g for the irradiated and non-irradiated samples, respectively (Table 4). No difference ($p>0.05$) was noticed between 2 and 4 kGy-irradiated patties in total fungal counts during refrigerated storage. Results demonstrated that no mold and yeast problems would be encountered during refrigerated storage. Similar results were observed for patties stored at −10±1°C (Table 4).

Isolation and Gram stain of isolates

The dominant microorganisms in the non-irradiated chicken patties before refrigerated or frozen storage consisted of 80% gram positive cocci and 10% yeasts. irradiation at 2 kGy reduced the incidence of yeasts and gram negative rod-type organisms. Increasing the irradiation dose upto 4 kGy resulted in patties with non-detectable plate counts (Table 5). The high incidence of gram-positive cocci on fresh and processed poultry meat has been reported earlier[20-22]. Certain ecological shifts in the microbial population may be caused by irradiation and storage. After 49 days refrigerated storage, the predominant microflora in the non-irradiated and 4 kGy irradiated patties were gram-negative rod-type organisms, while yeasts dominated in the 2 kGy irradiated samples (Table 5). This high incidence of yeast populations in the 2 kGy irradiated patties after 49 days of refrigerated storage warrants further investigation.

TBA values of chicken patties

Table 4. Mean total fungal counts of chicken patties stored at 3±1°C and −10±1°C as affected by irradiation dose[a) (Mean CFU/g)[b)

	Irradiation dose (kGy)	Storage time (weeks)							
		0	1	2	3	4	5	6	7
3±1°C	0	0.0a	1.8ab	1.8ab	8.5cd	11.5d	20.0e	20.3e	25.0f
	2	0.0a	0.0a	0.5a	2.0ab	2.0ab	2.3ab	6.8c	7.3c
	4	0.0a	0.0a	0.3a	1.3ab	1.3ab	2.5ab	5.3bc	6.5c

	Irradiation dose (kGy)	Storage time (months)				
		0	1	3	5	7
−10±1°C	0	0.0a	1.8abc	1.5abc	3.3c	2.5bc
	2	0.0a	0.0a	0.5ab	2.0abc	2.8bc
	4	0.0a	0.0a	0.5ab	0.8ab	2.3abc

a) Means within a column followed by unlike letters differ significantly ($P<0.05$).
b) Each value represents the mean of 4 observations.

Table 5. Incidence of microflora on chicken patties as affected by irradiation dose[a)

Microbial group	Fresh			Spoiled[b)		
	0 kGy	2 kGy	4 kGy	0 kBy	2 kGy	4 kGy
			(% Incidence)			
Gram + cocci	80.0	75.0	ND	10.0	ND	3.3
Gram + rod	6.6	25.0	ND	ND	ND	3.3
Gram − rod	3.3	ND	ND	90.0	3.3	93.3
Yeast	10.0	ND	ND	ND	96.6	ND
Total	(30)	(12)	(0)	(30)	(30)	(30)

a) ND = non-detectable
b) After 49 days of storage at 3±1°C

Table 6. TBA values of chicken patties as affected by irradiation dose and storage temperature[a)]

Irradiation dose (kGy)	Mean TBA values(mg MA[b)]/kg)	
	3±1 °C[c)]	-10±1 °C[d)]
0	0.18a	0.27a
2	0.30b	0.41b
4	0.47c	0.65c

a)Means within a column followed by unlike letters differ significantly (P<0.05).
b)MA is molonaldehyde.
c)Each value represents the mean of 32 observations.
d)Each value represents the mean of 20 observations.

Table 7. TBA values of chicken patties stored at 3±1 °C as affected by storage time[a)]

Storage time (weeks)	Mean TBA values (mg MA[b)]/kg)[c)]
0	0.30ab
1	0.25b
2	0.29ab
3	0.31b
4	0.30ab
5	0.31b
6	0.39c
7	0.39c

a)Means within a column followed by unlike letters differ significantly (P<0.05).
b)MA is malonaldehyde.
c)Each value represents the mean of 12 observations.

Table 8. TBA values of chicken patties stored at -10±1 °C as affected by storage time[a)]

Storage time (months)	Mean TBA values (mg MA[b)]/kg)[c)]
0	0.30a
1	0.41b
3	0.41b
5	0.47b
7	0.64c

a)Means within a column followed by unlike letters differ significantly (P<0.05).
b)MA is malonaldehyde.
c)Each value represents the mean of 12 observations.

Storage time and irradiation dose significantly ($P<0.01$) affected the TBA values of chicken patties upon refrigerated and frozen storage. No interaction ($P>0.05$) of storage time and irradiation dose was found. The TBA values of patties increased ($P<0.05$) as the irradiation dose increased (Table 6). This increase in TBA values might due to autooxidation of fat induced by the gamma irradiation. Results agree with those of Ehioba *et al.*[(23)] who reported that the TBA values of non-irradiated ground pork were slightly ($P<0.05$) lower than the irradiated samples at 2 and 4 kGy.

Regardless of the storage temperature, the TBA values of chicken patties increased ($P<0.05$) as the storage time progressed (Table 7, 8). Overall, the TBA values were low and ranged from 0.25 to 0.64 during the observation period. Chang *et al.*[(24)] reported that off-odor and rancid flavor can be detected from frozen precooked and prefried chicken pieces when the TBA number is 0.5-1.0. However, Basker *et al.*[(5)] have found that oxidative rancidity can be seldom detected in chicken meat with a TBA value below 1.0.

요 약

감마선 조사(0, 2, 4 kGy)에 따른 튀긴 닭고기 patty의 미생물 및 TBA 가의 변화를 조사하기 위하여 닭고기 patty를 각각 3±1℃와 -10±1℃에서 저장하였다. 방사선 조사에 의하여 3±1℃에 저장된 닭고기 patty의 품질 수명은 증가하였다(p<0.05). 대조구 1g당 미생물 총균 log 수가 6.5에 다다르는데 걸리는 시간은 22일인 반면 방사선 조사구는 40일이 걸렸으며 4 kGy로 조사된 patty에서는 초기에 미생물이 발견되지 않았다. 조사선량 증가에 따라 gram-positive cocci의 미생물은 감소한 반면 2 kGy와 4 kGy로 조사된 시료에서는 각각 yeasts와 gram-negative rod 미생물이 현저했다. TBA 가는 조사량과 저장기간이 증가함에 따라 증가하였다.

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