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EFFECT OF GAMMA IRRADIATION ON THE MICROBIAL QUALITY OF SOME PRODUCTS OF ANIMAL AND PLANT ORIGIN

(With 5 Tables)

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تأثير المعالجة بالإشعاع على الحالة الميكروبيولوجية لبعض المنتجات ذات الأصل الحيوانى والنباتى

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أجريت هذه الدراسة على عدد ٨٠ عينة من منتجات اللحوم المحفوظة بالتجميد تم شرائها من أسواق الجيزة. إشتملت هذه العينات على عدد ٢٠ عينة من كل من الكفتة البقرى والنباتى وكذلك البيرجر البقرى والنباتى وذلك لفحصها وتقيمها من الناحية الميكروبيولوجية إضافة إلى دراسة تأثير استخدام أشعة جاما بجرعات ٢,٠، ٣,٠، ٣,٥ و ٤,٠ ك جراى على المحتوى الميكروبى لهذة المنتجات. أظهرت النتائج وجود أعداد مرتفعة من البكتيريا الهوائية (١٠^٦ إلى ١٠^٧ خلية/جرام) فى عدد كبير من العينات إضافة إلى تلوث بعض العينات بالميكروبات المرضية مثل المكور العنقودى الذهبى وميكروب الإيشيريشيا كولاى والميكروب المعوى والخمائر والفطريات. أدى تعرض العينات إلى أشعة جاما إلى إنخفاض ملحوظ فى الأعداد الكلية للميكروبات التى سبق عزلها بدرجة تتناسب مع مقدار الجرعة المستخدمة. أدى استخدام جرعة إشعاعية مقدارها ٢,٠ ك جراى إلى إنخفاض ملحوظ فى أعداد البكتيريا الهوائية كما أدى إلى القضاء تماما على المكور العنقودى الذهبى وميكروب الإيشيريشيا كولاى والميكروب المعوى بينما تم القضاء على الخمائر والفطريات بجرعة إشعاعية مقدارها ٣,٠ ك جراى. أوضحت نتائج هذه الدراسة أنه يمكن استخدام أشعة جاما بجرعة مقدارها ٤,٠ ك جراى لضمان السلامة الصحية لمنتجات اللحوم ذات الأصل الحيوانى والنباتى التى تم حفظها بالتجميد مع عدم حدوث إى تغيرات فى الخواص الطبيعية (اللون-القوام-الرائحة) لهذة المنتجات.

SUMMARY

Eighty packages, ready-to-eat meat, of frozen beef kofta, vegetarian kofta, beef burger and vegetarian burger (2o each) were purchased from retail markets at Giza Governorate. The microbial quality as well as the effect of gamma irradiation (dose level of 2.0, 3.0, 3.5 and 4.0 kGy) on the microbial population of these products were investigated. High aerobic counts of 10^{6}-$<10^{7}$/g were recorded in 5o% and 25%, 10% and 20% of beef and vegetarian kofta and burger, respectively. Moreover, some samples were contaminated with some pathogens such as Staphylococcus aureus, Escherichia coli, Enterobacteriáceae, Yeast and moulds. Gamma irradiation greatly reduced the microbial density of the studied meat product samples. The microbial reduction was increased as the dose level of irradiation increase, whereas irradiation of meat product samples at 2 kGy dose reduced aerobic counts and inactivated Staphylococcus aureus, Escherichia coli, Enterobacteriaceae. Moreover, irradiation at 3 kGy was sufficient in inhibiting Yeast and mould growth. The application of gamma irradiation (at a dose of 4 kGy) might to be great importance in increasing the safety and acceptability of frozen meat products of animal and plant origin with no adverse effect on their sensory quality.

Key words: *Irradiation, meat products, plant origin*

INTRODUCTION

Food borne zoonotic pathogens have emerged as an important public health problems in developed and developing countries (Schlundt, 2001). Bacterial food borne infections are the most common cause of human intestinal diseases (Thorns, 2000).

Meat is an excellent source of particularly all the essential nutrients necessary to establish the microbial growth. Microorganisms play an important role in the quality of meat before, during and after processing by initiating many undesirable biological changes in the meat. Microbial contamination of meat and meat products caused from external sources during bleeding, skinning, deboning, handling and processing as well as from spices and other ingredients commonly used in the processed meat (Schwab *et al.,* 1982; Gracey, 1986; Rodriguez *et al.*, 1991; Little *et al.,* 2003).

High meat prices and technological advance in manufacturing vegetable proteins, such as Soya protein, have resulted in development of meat substitutions. It seems likely that lower cost vegetable proteins will be used as meat extender in combination products containing meat and vegetable proteins (Gassmann and Kroll, 1984).

Treatment of food by ionizing radiation is a technological approach which enhance the hygienic quality of food and contributes to reduce pathogen levels on raw meat and poultry (Thayer *et al.*, 1995), processed meat (Sommers *et al.*, 2004), cheese (Bougle and Stahl, 1994; Ennhar *et al.*, 1994; Cecchi *et al.*, 1996) and processed fruit and vegetable products (Niemira, 2003; Prakash and Foley, 2004). Moreover, the World Health Organization (WHO) recommended food irradiation as a safe and a non thermal effective process to eliminate food borne pathogens and food losses (Käferstein, 1992). An average (10kGy) irradiation dose of food presents neither toxicological hazard nor nutritional or microbiological problems (WHO, 1994; Diehl, 1995).

The present study was, therefore, aimed to evaluate the microbiological aspects of some frozen meat products (Kofta and burger) of animal and plant origin as well as to determine the effect of different dose levels of gamma irradiation on the microbiological and sensory patterns of the aforementioned meat products.

MATERIALS and METHODS

Collection of samples:

Eighty packages, of frozen beef kofta, vegetarian kofta, beef burger and vegetarian burger (2o each) were purchased from retail markets at Giza Governorate. The collected samples were immediately transferred in an ice box to the laboratory for sensory evaluation and microbiological examination. Thence after, the samples were exposed to different doses (2.0, 3.0, 3.5 and 4 kGy) of gamma irradiation and re-examined for sensory and microbiological changes.

I- Sensory evaluation:

The samples were examined for colour, odour and texture by single number of judger's using 9- points hedonic scales as described by FAO/IAEA (1970).

II- Microbiological examination:

Preparation of samples:

Ten grams of each sample were homogenized with 90 ml of 1% sterile buffered peptone water for 1 minute using stomacher (Lab-blender 400Seward. Serial No. 30469 type BA 7021, London), to provide dilution 10^{-1}, then ten fold decimal serial dilutions up to 10^{-7} were prepared (APHA, 1992).

Enumeration and isolation techniques:

1- Aerobic bacterial count was carried out on a standard plate count agar at 35°C for 48 hours according to Jay (2002).
2- Enterobacteriaceae count was determined using the Violet red bile glucose agar medium incubated at 37°C for 24 hours according to APHA (1992).

3- Yeast and mould counts were performed on Sabaroud's dextrose agar medium supplemented with chloramephnicol 0.05mg/ml and incubated at 25°C for 5 days as described by Koneman *et al.* (1994).

4- *Staphylococcus aureus* count was carried out on Baird Parker agar medium at 37°C for 24-48 hours according to FAO (1992).

5- *Escherichia coli* was isolated using Eosin Methylene Blue agar incubated at 37°C for 24 hours (Macfadin, 1980; FAO, 1992).

III- Irradiation process:

The irradiation process was carried out using the Russian Medical Sterilizing CM-20 Gamma cell located at the National Center for Radiation Research and Technology (NCRRT), Nasr City, Cairo, Egypt. The source was giving a dose rate of 6 kGy/hour at the time of the experiment. Dose levels of 2.0. 3.0, 3.5 and 4.0 kilo Gray (kGy) were used to study the effect of gamma irradiation on the microbial density of the studied frozen meat product samples. Each kGy of gamma irradiation took about 10 minutes of exposure to the source. All irradiated samples were re-examined for sensory and bacteriological changes.

RESULTS

Table 1: Aaerobic bacterial counts in the studied frozen meat products.

Meat products	No. of samples	Count cfu/g					
		$<10^6$		10^6		10^7	
		No.	%	No.	%	No.	%
Beef kofta	20	6	30	10	50	4	20
Vegetarian kofta	20	12	60	5	25	3	15
Beef burger	20	17	85	2	10	1	5
Vegetarian burger	20	16	80	4	20	-	-
Total	80	51	64	21	26	8	10

Table 2: Yeast and mould counts in the studied frozen meat products.

Meat products	No. of samples	Yeast				Mould			
		No. +ve	% +ve	cfu/g		No. +ve	% +ve	cfu/g	
				$<10^2$	$\geq10^2$			$<10^2$	$\geq10^2$
Beef kofta	20	14	70	9	5	15	75	6	9
Vegetarian kofta	20	10	50	4	6	12	60	7	5
Beef burger	20	13	65	8	5	14	70	6	8
Vegetarian burger	20	8	40	3	5	10	50	5	5
Total	80	45	56	24	21	51	64	24	25

Table 3: Enterobacteriaceae counts in the studied frozen meat products.

Meat products	No. of samples	Count (cfu/g)			
		No. +ve	%	$<10^2$	$\geq 10^2$
Beef kofta	20	10	50	4	6
Vegetarian kofta	20	7	35	2	5
Beef burger	20	12	60	5	7
Vegetarian burger	20	9	45	3	6
Total	80	38	48	14	24

Table 4: Effect of Gamma irradiation on the initial microbial contamination of the studied frozen meat products.

Microorganisms	Dose (KGy)	Beef kofta		Vegetarian kofta		Beef burger		Vegetarian burger	
		Count	Log	Count	Log	Count	Log	Count	Log
APC	0.0	7.5×10^6	6.8	8.9×10^6	6.9	4.9×10^5	5.7	1.8×10^5	5.2
Enterobacteriaceae		3.5×10^2	2.5	3.9×10^2	2.6	2.1×10^2	2.3	5.0×10^2	2.7
Yeast and mould		5.6×10^2	2.7	7.4×10^2	2.9	3.8×10^2	2.6	2.6×10^2	2.4
S. aureus		4.0×10^2	2.0	2.0×10^2	2.0	1.0×10^2	2.0	3.0×10^2	2.0
E. coli		5.0×10	1.0	3.0×10	1.0	3.0×10	1.0	1.0×10	1.0
APC	2.0	3.0×10^5	5.5	4.1×10^5	5.6	2.5×10^4	4.4	3.0×10^4	4.5
Enterobacteriaceae		$<10^2$	<2	$<10^2$	<2	$<10^2$	<2	$<10^2$	<2
Yeast and mould		2.1×10^2	2.3	1.2×10^2	2.0	2.0×10^2	2.3	1.4×10^2	2.1
S. aureus		$<10^2$	<2	$<10^2$	<2	$<10^2$	<2	$<10^2$	<2
E. coli		<10	<1	<10	<1	<10	<1	<10	<1
APC	3.0	1.4×10^3	3.1	2.0×10^3	3.3	3.0×10^3	3.5	1.1×10^2	2.0
Enterobacteriaceae		$<10^2$	<2	$<10^2$	<2	$<10^2$	<2	$<10^2$	<2
Yeast and mould		$<10^2$	<2	$<10^2$	<2	$<10^2$	<2	$<10^2$	<2
S. aureus		$<10^2$	<2	$<10^2$	<2	$<10^2$	<2	$<10^2$	<2
E. coli		<10	<1	<10	<1	<10	<1	<10	<1
APC	3.5	2.4×10^2	2.3	3.1×10^2	2.5	1.8×10^2	2.3	1.1×10^2	2.0
Enterobacteriaceae		$<10^2$	<2	$<10^2$	<2	$<10^2$	<2	$<10^2$	<2
Yeast and mould		$<10^2$	<2	$<10^2$	<2	$<10^2$	<2	$<10^2$	<2
S. aureus		$<10^2$	<2	$<10^2$	<2	$<10^2$	<2	$<10^2$	<2
E. coli		<10	<1	<10	<1	<10	<1	<10	<1
APC	4.0	$<10^2$	<2	$<10^2$	<2	$<10^2$	<2	$<10^2$	<2
Enterobacteriaceae		$<10^2$	<2	$<10^2$	<2	$<10^2$	<2	$<10^2$	<2
Yeast and mould		$<10^2$	<2	$<10^2$	<2	$<10^2$	<2	$<10^2$	<2
S. aureus		$<10^2$	<2	$<10^2$	<2	$<10^2$	<2	$<10^2$	<2
E. coli		<10	<1	<10	<1	<10	<1	<10	<1

Table 5: Sensory evaluation of unirradiated and irradiated frozen meat products.

Meat products	Colour					Texture					Odour				
	Dose/KGy					Dose/KGy					Dose/KGy				
	0.0	2.0	3.0	3.5	4.0	0.0	2.0	3.0	3.5	4.0	0.0	2.0	3.0	3.5	4.0
Beef kofta	1.2	1.4	1.3	1.5	1.7	1.0	1.7	1.2	1.3	1.5	1.1	1.4	1.6	1.5	1.7
Vegetarian kofta	1.1	1.3	1.5	1.2	1.6	1.0	1.9	1.4	1.3	1.6	1.2	1.5	1.7	1.4	1.3
Beef burger	1.1	1.3	1.6	1.8	2.0	1.1	1.4	1.5	1.5	1.6	1.2	1.3	1.3	1.6	1.7
Vegetarian burger	1.2	1.3	1.7	1.6	1.9	1.0	1.2	1.4	1.5	1.7	1.1	1.3	1.4	1.4	1.6

0.0 = Control sample (unirradiated samples)
KGy =Kilo Gray
Score system: 1: Extremely liked 7.5: Rejected 9: Extremely disliked

DISCUSSION

Microbiological quality of meat products:

Microbiological examination of retail packages of meat product (frozen beef and vegetarian kofta and burger) samples was carried out and their microbial aspects were evaluated.

Table (1) presents a wide variation in the total bacterial counts in the different products and within the same product. Total aerobic bacterial count ranged from $<10^6$ to 10^7 cfu/g in the studied meat product samples. High cfu/g of 10^6 to> 10^7 were recorded in 50% and 25% of beef and vegetarian kofta, respectively. The respective values were 10% and 20% for beef and vegetarian burger. Meanwhile, a total aerobic bacterial count of 10^7 cfu/g was recorded in 20, 15 and 5% of beef kofta, vegetarian kofta, and beef burger samples, respectively. Variations in the total aerobic bacterial counts could be attributed to unhygienic handling, processing, transport and/or storage procedures (Sharma *et al.*, 1996). Moreover, spices and other ingredients commonly used in the processed meat may be implicated in the microbial contamination of meat product samples (Rodriguez *et al.*, 1991; Little *et al.*, 2003). In this respect, Palumbo *et al.* (1979) reported a higher number of bacteria reaching 1.0×10^8 cfu/g in the spices commonly used in meat products. In addition, uncontrolled thawing and storage temperature can result in a significant increase in bacterial population of meat product samples (Kosic *et al.*, 1991; Kukay *et al.*, 1996).

Yeasts were found ($<10^2$ to $\geq 10^2$ cfu/g) in 70% and 50% of beef and vegetarian kofta and 65% and 40% of beef and vegetarian burger, respectively (Table 2). The corresponding figures for moulds were 75% and 60% for the former and 70% and 50% for the later products, respectively. Contamination of meat products with yeast and moulds could be attributed to bad hygienic conditions during processing, handling, transport and storage (Malin, 1983).

The present results revealed that the higher percentages (60% and 50%) of contaminated meat products with Enterobacteriaceae were detected in beef burger and kofta followed by (45% and 35%) vegetarian burger and kofta (Table 3). Enterobacteriaceae counts of all positive meat product samples were less than 10^3 cfu/g. The presence of Enterobacteriaceae in meat products may indicate microbial proliferation, which could allow multiplication of pathogenic and toxigenic microorganisms constituting public health hazard (ICMSF, 1978).

Effect of gamma irradiation on the microbial pattern of meat products:

The effect of the different dose levels (2.0, 3.0, 3.5 and 4 kGy) of gamma irradiation on the microbial counts of the studied meat product samples were determined (Table 4).

Unirradiated beef and vegetarian samples contained total aerobic bacteria of 7.5×10^6 and 8.9×10^6 cfu/g, Enterobacteriaceae of 3.5×10^2 and 3.9×10^2 cfu/g, *Staphylococcus aureus* of 4.0×10^2 and 2.0×10^2 cfu/g, *Escherichia coli* of 5.0×10 and 3.0×10 cfu/g, yeast and mould counts of 5.6×10^2 and 7.4×10^2 cfu/g, respectively. On other hand, unirradiated beef and vegetarian burger samples contained relatively lower aerobic, Enterobacteriaceae, *Staphylococcus aureus*, *Escherichia coli*, yeast and mould counts (Table 4). Gamma irradiation greatly reduced the microbial density of the studied meat product samples. The microbial reduction was increased as the dose level increased, whereas irradiation of meat product samples at 2.0 kGy dose reduced aerobic count by one log cycle reduction, about three, four and more than four log cycle reduction occurred at 3.0, 3.5 and 4.0 kGy, respectively. Similarly, Lefebvre *et al.* (1992) reported a three log reduction in aerobic bacterial count of ground beef irradiated at 2.5 kGy. Results listed in Table (4) revealed that a dose level of 2.0 kGy was sufficient to inactivate the common food borne pathogens including *Staphylococcus aureus* and *Escherichia coli* in different meat products (Frakas and Andrassy, 1993; Thayer, 1993; Lee *et al.*, 1995; Salwa *et al.*, 2001; Sommers and Boyed, 2006). Gamma irradiation at a dose level of 2.0 to 3.0 kGy was very effective in inhibiting yeast and moulds growth. The present results are in partial agreement with Mc-Carthy and Damoglou, (1993) who reported that irradiation (1.5-3.0 kGy) had a significant lethal effect on yeast count of fresh sausage. Moreover, Sallam *et al*. (2001) and Salwa *et al*. (2001) reported that irradiation (at a dose level of 2.0 kGy), almost inhibit the few cells of yeast and mould that were present in corned beef and frozen minced meat samples before irradiation. The effect of gamma irradiation (at a dose level of 2.0kGy) on Gram-negative bacteria belonging to Enterobacteriaceae group displayed a similar inhibitory pattern (Table 4). It is well emphathized that Enterobacteriaceae are very sensitive to gamma irradiation (Gibbs and Wilkunson, 1995; Thayer, 1993; Monk *et al*., 1995).

Sensory evaluation:

In agreement with the finding reported by (Thayer, 1993; Lagunas-Solar, 1995; Hammad *et al*., 1998; Niemira *et al*., 2002; Bari *et al*., 2005), no obvious difference in colour, texture and odour scores were observed between non-irradiated and irradiated meat product samples exposed to 2.0, 3.0, 3.5 and 4 kGy (Table, 5). Moreover, Clardy *et al*. (2002) and Lamb *et al*. (2002) found that irradiation (<4 kGy) of frozen sandwiches, that included a ready-to-eat meat and cheese products, produced an organoleptically acceptable product. In addition, Chen *et al*. (2004) found that irradiation of frankfurters (3.5 kGy) did not adversely affect their sensory quality.

Freezing of meat products for preservation will also preserve certain pathogenic organisms in a dormant state but when conditions are made favorable for their growth, they will create a hazard problem. Therefore, the performance of irradiation (at a dose level of 4.0 KGy) might be of great importance in increasing the safety and acceptability of frozen meat products of plant and animal origin with no adverse effect on their sensory quality.

It could be concluded that the application of gamma irradiation, at a dose of 4 kGy, is efficient as a mean of eliminating the contaminating and pathogenic bacteria, moulds and yeasts infecting ready to eat beef and vegetarian burger and kofta as well as improving the sensory quality of these products.

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