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Microbial and Sensory Characteristics of Camel Meat During Refrigerated Storage as Affected by Gamma Irradiation

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Abstract: The present study was undertaken to assess the microbiological profile of fresh camel meat and the possibility of improving microbial quality and extending the refrigerated storage life of meat by using low-dose gamma irradiation. Camel meat samples were subjected to 0 (control), 1.5 and 3 kGy doses and stored at 3±1°C. the microbial and sensory attributes were evaluated. Exposure to 1.5 kGy dose significantly reduced the initial counts of Aerobic Plate Counts (APCs), psychrophilic bacteria, Lactic Acid Bacteria (LAB), molds and yeasts, *Staphylococcus aureus*, *Listeria monocytogenes* and Enterococci. Moreover, *Pseudomonas*, coliforms and *Escherichia coli* were below the detection levels. Irradiation at 3 kGy significantly reduced the initial counts of APCs, LAB and Enterococci by 99.5, 93.5 and 93.9%, respectively. *Pseudomonas*, coliforms, *S. aureus*, *L. monocytogenes* and *E. coli* were not found at dose of 3 kGy during entire storage period, also psychrophilic bacteria and molds and yeasts were below the detection levels during 6 days of storage. This study shows that irradiation had no significant effects on the sensory attributes of camel meat. Refrigerated shelf-life of the meat irradiated at 1.5 and 3 kGy were 15 and 21 days, respectively, compared to 7 days for non-irradiated controls.

Key words: Irradiation, camel meat, microbiological quality, sensory preference

INTRODUCTION

The desert camel (*Camelus dromedaries*) is one of the most important domestic animals in arid and semi-arid regions in the world. The camel can survive, thrive and produce meat in harsh environmental conditions difficult for other domestic livestock. Therefore, the camel production for meat could be a profitable livestock activity in most arid and semi-arid regions of the world. Quality of meat from young camels, 3 years old or less, is comparable to beef (Kadim *et al*., 2006). The amount of mineral elements, protein and ash in camel meat are generally similar to beef. However, the meat of camel contains significantly less fat and higher moisture than beef (Dawood and Alkanhal, 1995; El-Faer *et al*., 1991; Elgasim and Alkanhal, 1992; Kadim *et al*., 2006). The meat is also relatively rich in polyunsaturated fatty acids in comparison to beef (Rawdah *et al*., 1994).

Under refrigerated conditions, fresh raw meat has a limited shelf-life due to susceptibility to spoilage with aerobic, psychrotrophic bacteria. Even at refrigeration temperatures, depending on the microbial quality of the meat, food-borne pathogens can also proliferate (Naik *et al*., 1994; Paul *et al*., 1997). Among the different treatments used in order to extend the shelf-life of meat, ionizing radiation is one of the best emerging preservation technologies to improve the microbiological safety of meat (Dogbevi *et al*., 1999; Giroux and Lacroix, 1998). The main purpose of irradiating meat is to control pathogenic microorganisms in raw meat during storage. In 1997, the US Food and Drug Administration approved irradiation of fresh and frozen red meats with up to 4.5 and 7.0 kGy, respectively (FDA, 1997).

The use of low-dose gamma irradiation accompanied by refrigerated storage to reduce the microbial population and thereby extend the storage life of beef (Lefebvre *et al*., 1994), buffalo (Naik *et al*., 1994), lamb (Paul *et al*., 1990), rabbit (Badr, 2004) and chicken (Gomes *et al*., 2003) has been reported. However, there is limited information on the microbiological quality of fresh camel meat and to our best knowledge, no data have been published on the preservation and extension of the shelf-life of camel meat by using ionizing radiation. Therefore, the objectives of this study were to investigate the microbiological quality of fresh camel meat and the possibility of using gamma irradiation to extend its shelf-life at refrigeration temperatures.

MATERIALS AND METHODS

Sample preparation: Camel meat (hind leg) from four different animals was purchased at a slaughter house

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(Ghanlogh, Tehran, Iran) after 4 h of slaughtering in June 2007. After the removal of external fat, ligament and connective tissue at the cutting room of the slaughter house, the total mass of obtained camel meat was minced using a meat grinder (National, MK-G20N, Japan) through a 4 mm discharge plate. The minced camel meat was divided into 100±5 g samples and aerobically packed in sterile polyethylene bags, rapidly heat-sealed and randomly divided into 3 groups. One group used as non-irradiated control while the other 2 groups were subjected to gamma irradiation at doses of 1.5 and 3.0 kGy. Samples transported for irradiation at 3±1°C inside an automatic portable digital refrigerator.

Irradiation and storage: Samples of the minced camel meat were gamma irradiated at the Atomic Energy Organization of Iran (AEOI, Tehran, Iran) in a package irradiator (Gamma cell 220, Nordion, Canada) with a Co-60 source at a dose rate of 0.438 Gy sec^{-1}. The samples received minimal doses of 1.5 and 3.0 kGy. Dosimetry was performed with cerric-cerrous dosimeters. Samples were covered with crushed ice to keep them at 33±2°C during irradiation process. After irradiation all samples were transported to our microbiology laboratory at Urmia University via air while stored in the automatic portable digital refrigerator at 3±1°C.

Microbiological analyses: Microbial analyses were carried out at the first day of each 3-day intervals. The first day of the first interval was registered as day zero. For this purpose, a 25 g minced camel meat was transferred to a sterile plastic bag under aseptic conditions and homogenized for 1.5 min with 225 mL of 0.1% (w/v) sterile peptone water (Merck, Germany) in a stomacher (Seward Medical, UK). From the resulting homogenate, 10-Fold appropriate serial dilutions were prepared. Colony forming units for Aerobic Plate Counts (APCs) and psychrophilic bacteria were determined on plate count agar (Merck) after 3 and 7 days incubation at 30 and 7°C, respectively (APHA, 1992). *Pseudomonas* spp. were determined on *Pseudomonas* agar (Merck) supplemented with *Pseudomonas* CFC selective supplement (Merck) after incubation at 25°C for 2-3 days and confirmed by the oxidase test. Lactic Acid Bacteria (LAB) counts were determined using the double-layer deMan Rogosa Sharpe (MRS) agar (Merck) incubated at 30°C for 72 h (Roberts and Greenwood, 2003). Total molds and yeasts were counted on potato dextrose agar (Merck) after incubation at 25°C for 3-5 days in the dark. Enumeration of *Staphylococcus aureus* was performed on Baird-Parker agar (Merck) after incubation at 35°C for 24-48 h (APHA, 1992) and confirmed by the tube coagulase test (Roberts and Greenwood, 2003). For detection of *Salmonella* spp., a 25 g of sample was homogenized with 225 mL lactose broth (Merck) and incubated at 35°C for pre-enrichment. selective enrichment was performed in tetrathionate broth (Merck) at 43°C for 24 h and selenite cystine broth (Merck) at 35°C for 24 h followed by plating on *Salmonella-Shigella* (SS) agar (Merck) and brilliant-green phenol-red lactose sucrose (BG) agar (Merck) incubated at 35°C for 24 h. Suspected colonies developed on each plate served to biochemical and serological analyses (APHA, 1992). Enumeration of Enterococci was performed on kanamycin aesculin azide agar (Merck) after incubation at 35°C for 16-24 h and confirmed by the Gram staining, catalase test and utilization of glucose (Harrigan, 1998).

The five-tube Most Probable Number (MPN) method was used for counting *Listeria monocytogenes*, using diluents 10^{-1}, 10^{-2}, 10^{-3} and 10^{-4}. Tubes contained *Listeria* Enrichment Broth (LEB, Merck) and incubated at 30°C for 48 h. After incubation, a loopful from LEB was streaked onto PALCAM *Listeria* selective agar (Merck) supplemented with PALCAM *Listeria* selective supplement (Merck) and Axford *Listeria* selective agar (Merck) supplemented with Axford *Listeria* selective supplement (Merck). At least five suspected colonies developed on each plate were confirmed by Gram staining, β-haemolysis and catalase tests, motility (hanging drop) and sugar fermentation testes for D-xylose, D-manitol and L-rhamnose. The same technique was used for enumerating coliforms using MacConkey broth (Merck). After incubation at 35°C for 48 h, presumptive positive results (acid and gas produced) were confirmed by subculture into brilliant green lactose bile broth (BGLB, Merck) incubated at 35°C for 24-48 h. To identify *Escherichia coli* each positive BGLB tube (gas produced) was streaked onto eosin-methylene-blue lactose sucrose agar (Merck) and presumptive *E. coli* colonies subjected to indol, methyl red, voges proskauer and simmon citrate tests (APHA, 1992; Harrigan, 1998).

Sensory evaluation: Sensory attributes of fresh camel meat was evaluated both as raw meat and cooked meat. Raw camel meat samples were evaluated during storage every day, to determine the shelf-life of the samples. The sensory attributes evaluated were appearance (color), odor and overall acceptability using a scale of 0 to 9, where 9 represented excellent and < 5 represented poor. Rating of 5 indicated as the lower limit of acceptability. The samples were defined as unacceptable at the poor appearance (slime formation and/or mold growth) and/or the off-odors were detected. Regarding the cooked camel meat, for the safety reasons only, the sensory attributes were evaluated at the day zero. The pan fried burgers

prepared from non-irradiated and irradiated camel meat had approximately 1.0 cm diameter and 0.6 cm thickness. Finally, the taste, texture and juiciness, odor and overall acceptability of burgers were evaluated by the same ratings as described for raw samples. Juiciness was defined according to the method described by Rocha-Garaz and Zayas (1996). The panel consisted of 5 staff members who were familiar with meat characteristics. An orientation session was conducted before participating in the formal panel.

Statistical analysis: All analyses were performed using four samples (bags) per treatment. Before statistical analysis, microbiological data were transformed to $\log_{10}$ cfu g^{-1}. All data were analyzed using the one-way ANOVA of the SPSS software for windows, version 12.0. The differences among means at $p<0.05$ were compared by using Duncan multiple analysis method (SPSS, 2003).

RESULTS AND DISCUSSION

Microbial flora: The mean log values of APCs, psychrophilic bacteria, *Pseudomonas* spp., LAB, coliforms and molds and yeasts from non-irradiated (control) and irradiated (1.5 and 3.0 kGy) of fresh camel meat during storage at 3±1°C are shown in Table 1. The immediate effect of gamma irradiation (1.5 and 3.0 kGy) of camel meat was significantly decreased ($p<0.05$) in the counts of microbial flora with the concomitant benefit of prolonging refrigerated shelf-life of the samples. During storage, these microorganisms significantly increased ($p<0.05$) in both non-irradiated and irradiated samples, while the rate of increase was higher in non-irradiated samples.

After 6 days, APCs for non-irradiated camel meat reached about 7 log cfu g^{-1}, while Samples irradiated at 1.5 and 3.0 kGy reached about 7 log cfu g^{-1} after 15 days and 5.5 log cfu g^{-1} after 21 days, respectively. This is in agreement with Thayer *et al.* (1995), who reported that aerobic mesophilic bacteria in mechanically deboned chicken meat irradiated at 1.5 kGy reached 7 log cfu g^{-1} after more than 2 weeks under refrigerated condition, whereas samples irradiated at 3.0 kGy never reached this population.

Of the psychrotrophic bacteria, *Pseudomonas* spp. are gram negative bacteria dominated at refrigeration temperatures and considered as one of the main spoilage microorganisms in meat and poultry (Jay, 2000). In non-irradiated camel meat, *Pseudomonas* spp. reached 8.08 log cfu g^{-1} after 6 days and were more numerous than the other microorganisms in the microbial flora because these organisms grow faster and have greater affinity for oxygen than the others (Jay, 2000). Irradiated (1.5 and 3.0 kGy) camel meat samples were completely free of *Pseudomonas*. The sensitivity of these organisms to irradiation process was previously reported (Naik *et al.*, 1994) and it could be very useful for the preservation of meat and meat products in view of the main role of these organisms in spoilage of refrigerated fresh meat and poultry. Urbain (1983) reported that *Pseudomonas fluorescens* has D value of 0.13 kGy at 5°C in beef.

Among the microbial flora in minced camel meat, the greatest resistance to irradiation was observed with LAB. Irradiation doses of 1.5 and 3.0 kGy produced immediate LAB reduction of 0.84 and 1.19 log units, respectively. Lacroix *et al.* (2004) reported *Brochothrix thermosphacta* and LAB were more resistant to irradiation than *Pseudomonas* and Enterobacteriaceae.

Table 1: Log of microbial flora count in non-irradiated and irradiated camel meat during refrigerated storage (3±1°C)

		Storage time (day)							
Microbial flora	Radiation dose (kGy)	0	3	6	9	12	15	18	21
APCs	0.0	${}_{z}5.08^{a}$	${}_{z}5.96^{b}$	${}_{z}6.90^{c}$	Spoiled	Spoiled	Spoiled	Spoiled	Spoiled
	1.5	${}_{y}3.73^{a}$	${}_{y}4.01^{a}$	${}_{y}4.96^{b}$	${}_{y}5.68^{c}$	${}_{y}6.29^{d}$	${}_{y}6.90^{e}$	Spoiled	Spoiled
	3.0	${}_{x}2.77^{a}$	${}_{x}2.89^{a}$	${}_{x}3.25^{ab}$	${}_{x}3.77^{bc}$	${}_{x}4.03^{cd}$	${}_{x}4.51^{d}$	5.29^{e}	5.50^{e}
Psychrophil	0.0	${}_{z}4.81^{a}$	${}_{z}5.11^{b}$	${}_{z}6.01^{c}$	Spoiled	Spoiled	Spoiled	Spoiled	Spoiled
	1.5	${}_{y}3.25^{a}$	${}_{y}3.31^{a}$	${}_{y}3.99^{b}$	${}_{y}4.32^{c}$	${}_{y}4.78^{d}$	${}_{y}5.34^{e}$	Spoiled	Spoiled
	3.0	${}_{x}<2^{a}$	${}_{x}<2^{a}$	${}_{x}2.71^{b}$	${}_{x}3.09^{bc}$	${}_{x}3.39^{c}$	${}_{x}4.03^{d}$	${}_{x}4.31^{d}$	${}_{x}5.10^{e}$
Pseudomonas	0.0	${}_{y}3.33^{a}$	${}_{y}5.86^{b}$	${}_{y}8.08^{c}$	Spoiled	Spoiled	Spoiled	Spoiled	Spoiled
	1.5	${}_{x}<2$	${}_{x}<2$	${}_{x}<2$	${}_{x}<2$	${}_{x}<2$	${}_{x}<2$	Spoiled	Spoiled
	3.0	${}_{x}<2$	${}_{x}<2$	${}_{x}<2$	${}_{x}<2$	${}_{x}<2$	${}_{x}<2$	${}_{x}<2$	${}_{x}<2$
LAB	0.0	${}_{z}3.60^{a}$	${}_{y}4.81^{b}$	${}_{y}6.16^{c}$	Spoiled	Spoiled	Spoiled	Spoiled	Spoiled
	1.5	${}_{y}2.76^{a}$	${}_{x}2.97^{ab}$	${}_{x}3.25^{b}$	${}_{y}4.03^{c}$	${}_{y}5.10^{d}$	${}_{y}6.00^{e}$	Spoiled	Spoiled
	3.0	${}_{x}2.41^{a}$	${}_{x}2.64^{ab}$	${}_{x}2.84^{b}$	${}_{x}3.81^{c}$	${}_{x}4.02^{c}$	${}_{x}4.92^{d}$	5.17^{d}	5.95^{e}
Coliforms	0.0	${}_{y}3.61^{a}$	${}_{y}4.23^{b}$	${}_{y}5.11^{c}$	Spoiled	Spoiled	Spoiled	Spoiled	Spoiled
	1.5	${}_{x}<1.3^{a}$	${}_{x}<1.3^{a}$	${}_{y}1.93^{b}$	${}_{y}2.11^{b}$	${}_{y}3.01^{c}$	${}_{y}4.04^{d}$	Spoiled	Spoiled
	3.0	${}_{x}<1.3$	${}_{x}<1.3$	${}_{x}<1.3$	${}_{x}<1.3$	${}_{x}<1.3$	${}_{x}<1.3$	<1.3	<1.3
Mold and yeast	0.0	${}_{z}4.11^{a}$	${}_{z}4.32^{a}$	${}_{z}5.38^{b}$	Spoiled	Spoiled	Spoiled	Spoiled	Spoiled
	1.5	${}_{y}2.09^{a}$	${}_{y}2.24^{a}$	${}_{y}2.83^{b}$	${}_{y}3.10^{b}$	${}_{y}3.74^{c}$	${}_{y}4.51^{d}$	Spoiled	Spoiled
	3.0	${}_{x}<2^{a}$	${}_{x}<2^{a}$	${}_{x}2.11^{b}$	${}_{x}2.23^{b}$	${}_{x}2.41^{b}$	${}_{x}3.50^{c}$	4.32^{d}	5.64^{e}

APCs = Aerobic Plate Counts; LAB = Lactic Acid Bacteria; ${}^{a-e}$Means within a row, which are not followed by a common superscript letter(s) are significantly different ($p<0.05$); ${}_{x-z}$Means within a column, which are not preceded by a common subscript letter(s) are significantly different ($p<0.05$)

Table 2: Log of *Staphylococcus aureus*, *Listeria monocytogenes* and Enterococci count in non-irradiated and irradiated camel meat during refrigerated storage (3±1°C)

Bacterial pathogens	Radiation dose (kGy)	Storage time (day)							
		0	3	6	9	12	15	18	21
S. aureus	0.0	${}_{z}3.80^{a}$	${}_{z}4.01^{a}$	${}_{z}4.44^{b}$	Spoiled	Spoiled	Spoiled	Spoiled	Spoiled
	1.5	${}_{y}2.04^{a}$	${}_{y}2.15^{ab}$	${}_{y}2.39^{b}$	${}_{y}3.01^{c}$	${}_{y}3.48^{d}$	${}_{y}4.10^{e}$	ND	ND
	3.0	${}_{x}<2$	${}_{x}<2$	${}_{x}<2$	${}_{x}<2$	${}_{x}<2$	${}_{x}<2$	<2	<2
L. monocytogenes	0.0	${}_{z}3.91^{a}$	${}_{z}4.30^{b}$	${}_{z}4.81^{c}$	Spoiled	Spoiled	Spoiled	Spoiled	Spoiled
	1.5	${}_{y}1.75^{a}$	${}_{y}2.00^{ab}$	${}_{y}2.31^{bc}$	${}_{y}2.62^{c}$	${}_{y}3.14^{d}$	${}_{y}3.82^{e}$	Spoiled	Spoiled
	3.0	${}_{x}<1.3$	${}_{x}<1.3$	${}_{x}<1.3$	${}_{x}<1.3$	${}_{x}<1.3$	${}_{x}<1.3$	<1.3	<1.3
Enterococci	0.0	${}_{z}3.29^{a}$	${}_{z}3.74^{b}$	${}_{z}4.43^{c}$	Spoiled	Spoiled	Spoiled	Spoiled	Spoiled
	1.5	${}_{y}2.58^{a}$	${}_{y}2.75^{ab}$	${}_{y}2.89^{b}$	${}_{y}3.22^{c}$	${}_{y}3.40^{c}$	${}_{y}4.02^{d}$	Spoiled	Spoiled
	3.0	${}_{x}2.07^{a}$	${}_{x}2.18^{a}$	${}_{x}2.31^{a}$	${}_{x}2.73^{b}$	${}_{x}3.14^{c}$	${}_{x}3.52^{d}$	3.83^{d}	4.33^{e}

${}^{a-e}$Means within a row, which are not followed by a common superscript letter(s) are significantly different ($p<0.05$); ${}_{x-z}$Means within a column, which are not preceded by a common subscript letter(s) are significantly different ($p<0.05$)

The initial count of coliforms in non-irradiated camel meat was 3.61 log cfu g^{-1} and reached 5.10 log cfu g^{-1} after 6 days of storage. In all irradiated (1.5 and 3.0 kGy) samples coliforms were not detected throughout the storage period. Thayer and Boyd (2000) reported similar results. They found that no coliforms were detected in irradiated (1.5 and 2.5 kGy) ground turkey stored at 7°C under aerobic or modified atmosphere packaging conditions (CO_2:30%, O_2:20%, N_2:50% or CO_2:53%, O_2:22%, N_2:25%).

At day zero, a considerable number of molds and yeasts (4.10 log cfu g^{-1}) were detected in non-irradiated camel meat samples. Irradiation dose of 1.5 kGy reduced the initial counts of molds and yeasts by 2 log units, while at 3.0 kGy molds and yeasts were below the detection levels during 6 days of storage. As a matter of fact, because of the large genomic structure, molds and yeasts have low resistance to irradiation process (Olson, 1998; Yildirim *et al*., 2005).

Bacteria of public health significance: The mean log values of *Staphylococcus aureus*, *Listeria monocytogenes* and Enterococci found in non-irradiated and irradiated (1.5 and 3.0 kGy) fresh camel meat during refrigerated storage (3±1°C) are shown in Table 2. Gamma irradiation (1.5 and 3.0 kGy) significantly decreased ($p<0.05$) the counts of these pathogenic bacteria in samples.

Initial counts of *S. aureus* and *L. monocytogenes* in the non-irradiated camel meat were 3.80 and 3.91 log cfu g^{-1} which significantly increased to 4.44 and 4.81 log cfu g^{-1} during 6 days, respectively. Irradiation dose of 1.5 kGy reduced the initial counts of *S. aureus* and *L. monocytogenes* by 1.76 and 2.16 log units, respectively, while at dose of 3.0 kGy these pathogenic bacteria were not found throughout the storage period. Among the foodborne pathogens found in camel meat Enterococci were more resistant to irradiation. Irradiation of samples at 1.5 and 3.0 kGy resulted to immediate Enterococci reductions of 0.70 and 1.21 log units, respectively. Radiation sensitivity of non-sporeforming pathogenic bacteria in meat and meat products is well documented (Farkas, 1998; Tarkowski *et al*., 1984; Yildirim *et al*., 2005; Zhu *et al*., 2005), while the resistance of Enterococci (*Enterococcus faecalis* and *Enterococcus faecium*) to irradiation process was previously reported by Huhtanen (1990).

Escherichia coli was detected in all samples of non-irradiated camel meat during 6 days of storage. In all irradiated (1.5 and 3.0 kGy) samples *E. coli* was not detected. The minimum low irradiation dose of 1.5 kGy is sufficient to destroy 6 logs of *E. coli* O157:H7 at 5°C (Olson, 1998; Satin, 2002). Thayer and Boyd (1993) reported that *E. coli* has D value of 0.27 at 5°C and 0.42 at -5°C in chicken meat, also Gezgin and Gunes (2007) reported a D value of 0.29 kGy at 4°C for *E. coli* O157:H7 in Cig Kofte (raw meat ball).

Only at day zero, *Salmonella* was found in 2 samples of non-irradiated and one sample of irradiated (1.5 kGy) camel meat. It was *Salmonella dublin*. However, in samples irradiated at 3.0 kGy no *Salmonella* was observed. It has been reported the optimum dose of gamma irradiation to improve microbial safety of meat and eliminate *Salmonella* spp. was observed at 3.0 kGy (Badr, 2004; Sedeh *et al*., 2007).

Sensory evaluation: Figure 1 shows the result of the sensory evaluation of non-irradiated and irradiated raw camel meat during storage at 3±1°C. Gamma irradiation of camel meat at doses of 1.5 and 3.0 kGy had no significant effect ($p>0.05$) on the initial sensory attributes of the meat samples. Moreover, both irradiated and non-irradiated samples received similar preference scores as judged by appearance (color), odor and overall acceptability during refrigeration until their rejections. On day 8 of storage non-irradiated samples were slimy and emanated off-odors. Therefore, scored as poor samples and rejected. Slime appearance, mold growth and off-odors were

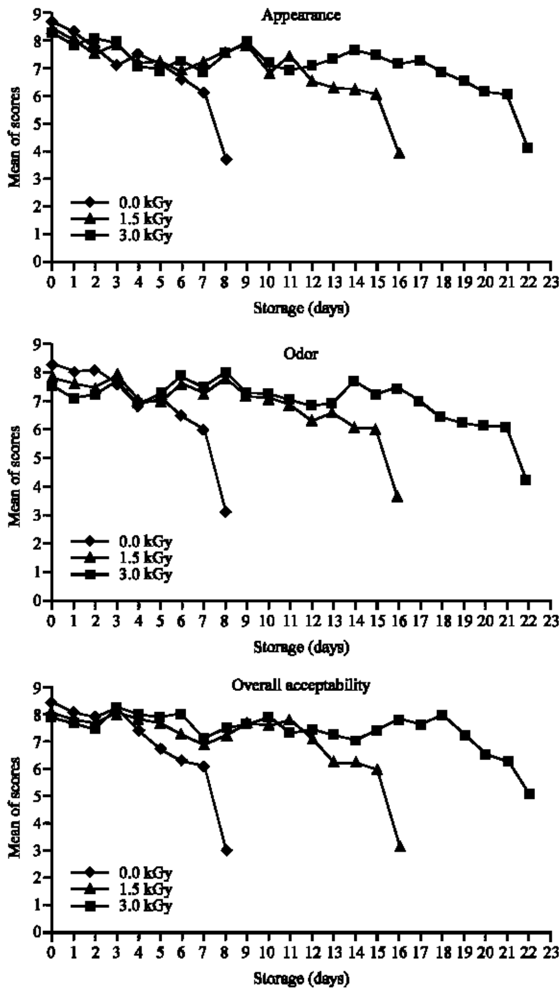

Fig. 1: Sensory attributes of non-irradiated and irradiated raw camel meat during refrigerated storage (3±1°C)

Table 3: Sensory attributes of fried burgers prepared from fresh non-irradiated and irradiated camel meat at the day zero

	Scores(mean)/Irradiation dose (kGy)		
Sensory attributes	0.0	1.5	3.0
Taste	7.6[a]	7.4[a]	6.8[a]
Odor	8.2[a]	8.0[a]	7.8[a]
Texture and juiciness	7.2[a]	7.2[a]	7.4[a]
Overall acceptability	7.4[a]	7.2[a]	7.2[a]

[a]Means within a row for each property is not significantly different (p>0.05)

detected on day 16 of refrigerated storage for samples irradiated at 1.5 kGy. Spots of mold growth and off-odors were appeared on day 22 of refrigerated storage for samples irradiated at 3.0 kGy. Thus, based on sensory evaluations, irradiation doses of 1.5 and 3.0 kGy could extend the refrigerated storage life of camel meat to 15 and 21 days, respectively, compared to 7 days for non-irradiated samples. Sedeh *et al.* (2007) showed that irradiation at 3.0 kGy increased the refrigerated (4-7°C) life of bovine meat samples to 14 days, compared to 3 days for non-irradiated controls.

In the case of cooked camel meat, fried burgers prepared from non-irradiated and irradiated samples received similar high scores for taste, texture and juiciness, odor and overall acceptability (Table 3). Present study showed that irradiation had no significant effects (p> 0.05) on the sensory quality of the cooked meat.

CONCLUSION

Gamma irradiation treatment of camel meat significantly decreased the counts of microorganisms and extend the refrigerated storage life of meat. Both radiation doses (1.5 and 3.0 kGy) were effective in suppressing microbial flora and bacterial pathogens without any significant effect on the sensory attributes of the meat. However, dose of 3.0 kGy was more effective through its effectiveness in eliminating *Pseudomonas* spp., coliforms, *S. aureus*, *L. monocytogenes* and *E. coli*, with extending refrigerated storage life of camel meat by 21 days.

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