

## Effect of Gamma Irradiation on the Quality and Safety of Egyptian Karish Cheese

Salwa A. Aly<sup>1</sup>; D.E.Farag<sup>2</sup> and E. Galal<sup>3</sup>

<sup>1</sup>Food Hygiene Department, Faculty Veterinary Medicine, Cairo University

<sup>2</sup>Food Irradiation Research Department, National Center for Radiation Research and Technology, Cairo, Egypt

<sup>3</sup>Dairy Technology, Faculty of Agriculture, El- Fayoum University

[salwaaly@hotmail.com](mailto:salwaaly@hotmail.com)

**Abstract:** The effect of gamma irradiation on the quality of Egyptian karish cheese was evaluated. Raw skimmed milk soft (karish) cheese were subjected to gamma irradiation at different safety doses beginning from 1 kilo gray (KGy) to a maximum of 5 KGy. The physico-chemical composition as well as microbiological quality of karish cheese samples was monitored before and after irradiation. Moisture, salt, soluble nitrogen and total nitrogen were decreased while pH was higher in cheese samples before irradiation in comparison with the irradiated groups. Irradiation reduced population of bacteria i.e. Total colony count, Total yeast and mold count, *Coliform* count, total *Enterobacteriaceae* count and total *Staphylococcus* count. The effect was more pronounced at the highest dose (5 KGy). It could be concluded that increasing the dose of irradiation up to 5 KGy had high reduction percentages for bacterial counts with no effects on either sensory or chemical characteristics. Our results suggest that karish cheese manufacturers could use gamma irradiation to improve the safety and quality of this product.

[Salwa A. Aly, D.E.Farag and E. Galal. **Effect of Gamma Irradiation on the Quality and Safety of Egyptian Karish Cheese.** *J Am Sci* 2012;8(10):761-766]. (ISSN: 1545-1003). <http://www.jofamericanscience.org>. 102

**Key words:** karish cheese, Gama irradiation, quality and safety cheese.

### 1. Introduction

Cheese is an important integral part of diet consumed in Egypt. It is consumed almost three times a day. There are many traditional local cheese type produced in local regions. Karish cheese is one of the most popular local type of fresh soft cheese in Egyptian cities. The increasing demand for it by Egyptian consumers is mainly attributed to its high protein content and low price. The traditional method for karish cheese production affords many opportunities for microbial contamination. It is generally made from raw skim buffaloes or cows milk which is often of poor bacteriological quality owing to the high microbial load present in raw milk and the unsatisfactory conditions under which it is produced (Brooks *et al.*, 2012). Also, this product is sold uncovered and without container where the risk of contamination is high. Therefore it can be considered as a good medium for the growth of different types of spoilage and pathogenic microorganisms (Yousef, 2004 and Dawood, *et al.*, 2006).

Food irradiation is a preservation process exposing food to high energy rays to improve product safety and shelf life. It could be used to replace chemical preservatives as well as thermal treatment. It is considered as cold pasteurization of food and currently permitted in 35 countries world wide for 40 different food products (Robert, 1998; Loaharanu, 2005 and Thayer, 2005). The use of gamma irradiation in dairy product is considered as one of the most important peaceful application of nuclear energy

(FDA, 1997 and WHO, 2005). There was no hazard caused by irradiation up to 10 kilo grey which could not cause cancer, genetic mutation or tumors (Mason, 1993; Ordonez *et al.*, 1999; Sofos, 2002; Mehran *et al.*, 2005 and Steel, 2006). Therefore, hospitals use irradiated food for patients with severely impaired immune system (Lee, 1994; FAO, 1998; Leuschner & Boughtflower, 2002; Bernnand, 2006 and koteles *et al.*, 2009).

In Egypt, the information about the involvement of karish cheese in human illness and economic losses are unknown. Therefore, this investigation was aimed to study the effect of gamma irradiation on organoleptic, physicochemical and microbiological quality of commercial karish cheese samples.

### 2. Materials and Methods

Fourty random samples of karish cheese were collected from dairy shops in Giza and Cairo Governorates in sterile plastic bags and transferred directly to an insulated ice box. The karish cheese samples (800 g) were divided into four parts (200g each). The first part unirradiated and used as a control. The second part (group I) was subjected to irradiation with one Kilo grey (KGy). The second part (group II) was irradiated with dose 3 KGy. The third part (group III) was irradiated with dose 5 KGy. The samples were subjected to gamma irradiation at 19°C ± 1°C with a dose rate of 0.105 KGy / min from A Cobalt 60 source at National Research for Radiation and Technology at Nasr City, Cairo, Egypt. The facility used was Gamma Chamber 400 (A Cobalt 60,

Facility of India). The mean deviation of the absorbed dose from the target dose was 0.048 KGy with a standard error of 0.005 KGy. All cheese samples were examined immediately before and after irradiation for:

#### Organoleptic examination

The karish cheese samples were organoleptically scored using score card for flavor (50 points), body and texture (35 points) and appearance & color (15 points). The scores were averaged by five panelists according to Nelson and Trout (1981).

#### Chemical analysis

All karish cheese samples were chemically examined for pH using pH meter (model SA 720). Moisture and salt content according to AOAC (1998), Total nitrogen (T.N.) % and water soluble nitrogen content (S.N.) using microkjeldhal method according to Kuchroo and Fox (1982) & IDF (1993).

#### Microbiological examination

The cheese samples were prepared for microbiological examination according to ICMSF (1996). All samples were examined for total colony count (TCC); total mold and yeast count; *Coliform* (MPN) count; total *Enterobacteriaceae* count and total *Staphylococcus* count/g, according to American public health Association (APHA, 1993).

#### Statistical analysis

The logarithmic transformation of bacterial count and their analysis were done with the aid Microsoft Excel 2000 and Statistica 5, Version 97 software. All results were calculated as means and were subjected to statistical analysis according to the procedures reported by Steel and Torrie (1982). The reduction % was calculated as follows: Logarithmic number in the irradiated cheese/ Logarithmic of the control cheese multiplied by 100.

### 3. Results and Discussion

Table 1: Organoleptic examination of karish cheese sample

Cheese Samples	Organoleptic scores			
	Flavor (50)	Body & Texture (35)	Appearance & Color (15)	Total scores (100)
Control	49±0.01	34±0.08	15±0.06	98
Group I	48±0.3	34±0.06	15±0.02	97
Group II	47±0.02	34±0.01	14±0.03	95
Group III	47±0.01	34±0.04	14±0.05	95

\*There was no significant difference between the control and irradiated groups ( $P > 0.05$ ).

Table 2: The mean Chemical composition of karish cheese samples

Cheese samples	Moisture%	Salt%	SN/TN%	pH	TN%
Control	65.2 ± 0.9	1.28 ± 0.03	9.05 ± 0.1	4.16 ± 0.8	2.58 ± 0.02
I	64.0 ± 0.5	1.25 ± 0.1	8.62 ± 0.4	4.30 ± 0.12	2.67 ± 0.05
II	62.8 ± 0.03	1.26 ± 0.5	8.25 ± 0.3	4.37 ± 0.05	2.66 ± 0.05
III	60.0 ± 0.08	1.27 ± 0.03	8.02 ± 0.7	4.50 ± 0.01	2.59 ± 0.01

\*TN= Total nitrogen%

\*\*S.N. / T.N. = soluble nitrogen/total nitrogen%

\*\*\*There was no significant difference between the control and irradiated groups ( $P > 0.05$ ).

Table 3: The mean total colony count (cfu/g) of karish cheese

Cheese samples	Mean log./SE	Reduction%
Control	6.27 ± 2.02 <sup>a</sup>	0
I	4.47 ± 1.9 <sup>a</sup>	28.70
II	3.70 ± 1.1 <sup>b</sup>	40.98
III	1.69 ± 0.1 <sup>b</sup>	73.04

Mean Log. = Mean Logarithmic cfu/gm    Superscript <sup>a</sup> and <sup>b</sup> considered significantly different at  $P < 0.05$

Table 4: Mean total mold and yeast count of karish cheese.

Cheese samples	Mean Log./SE	Reduction%
Control	7.89 ± 1.1 <sup>a</sup>	0
I	5.91 ± 1.4 <sup>a</sup>	25.09
II	3.62 ± 1.7 <sup>b</sup>	66.79
III	1.00 ± 0.31 <sup>b</sup>	87.32

Superscript <sup>a</sup> and <sup>b</sup> considered significantly different at  $P < 0.05$

**Table 5:** Total *Enterobacteriaceae* count of karish cheese samples

Cheese samples	Mean Log/SE	Reduction%
Control	4.80 ± 1.5 <sup>a</sup>	0
I	3.59 ± 1.1 <sup>a</sup>	25.21
II	1.69 ± 0.99 <sup>b</sup>	64.79
III	<Less than log 1 <sup>b</sup>	100

Superscript <sup>a</sup> and <sup>b</sup> considered significantly different at  $P < 0.05$

**Table 6:** The mean total *Coliform* count (MPN/g) of karish cheese

Cheese samples	Mean Log/SE	Reduction%
Control	5.54 ± 1.1 <sup>a</sup>	0
I	3.83 ± 1.2 <sup>a</sup>	30.86
II	1.47 ± 0.55 <sup>b</sup>	73.46
III	< Less than log 1 <sup>b</sup>	100

\*NA = not available      Superscript <sup>a</sup> and <sup>b</sup> considered significantly different at  $P < 0.05$

**Table 7:** Total *Staphylococcus* count (cfu/g) of karish cheese

Group	Mean Log/SE	Reduction%
Control	3.60 ± 1.6 <sup>a</sup>	0
I	2.80 ± 0.99 <sup>a</sup>	22.22
II	1.00 ± 0.5 <sup>b</sup>	72.22
III	Less than log 1 <sup>b</sup>	100

Superscript <sup>a</sup> and <sup>b</sup> considered significantly different at  $P < 0.05$

### Sensory examination

Data illustrated in Table (1) showed the total score of control karish cheese in comparison with irradiated cheese groups. Testing of irradiated karish cheese samples revealed no significant difference ( $P > 0.05$ ) between control and irradiated cheese (groups I, II and III). Nearly similar findings were reported by (El -Batawy, 1999; Yousef *et al.*, 2001; and Hamam, 2005) who stated that irradiation is known as cold pasteurization and does not significantly increase in temperature or change in the physical condition of food. The flavour of control cheese had the highest total score compared to irradiated cheese groups respectively. This may be due to the natural flora initially present in raw milk which participate in flavour production (Urbach, 1993; Henkel, 1998 and Cambell-Platt, 1999).

### Chemical analysis

Nutrition is an important issue to consumers. The effect of irradiation on the most important parameters in karish cheese was recorded in Table 2. The control cheese samples had a mean moisture content of  $65.2 \pm 0.9$  while the irradiated cheese samples had  $64.0 \pm 0.5$ ;  $62.8 \pm 0.03$  and  $60.0 \pm 0.08$  respectively. There was no significant difference between the control and irradiated groups ( $P > 0.05$ ). The moisture content of irradiated cheese samples was lower than control samples. This may be attributed to the effect of irradiation on the capacity of cheese protein on holding water (Kanka *et al.*,

1989; Schaffer *et al.*, 1995 and El-Batawy, 1999). Nearly similar findings were reported by Abd El-Salam *et al.* (1992) and Ghosh *et al.* (1999). There was no significant difference ( $P > 0.05$ ) between pH in control and irradiated cheese samples. Nearly similar findings were obtained by Abd El-Salam *et al.* (1992); Marth and Steele (2001); Lalaguna, (2003) and Omer & Elshirbiny (2005). Irradiated cheese samples showed the lowest total nitrogen % (T.N.%) while the highest value of S.N./T.N. % was recorded with the control cheese. This may be due to the destructive effect of irradiation on the natural flora and milk enzymes which in turn affect protein (Ghosh *et al.*, 1999; and Omer & Elshirbiny 2005). There was no significant difference between salt content in control and irradiated cheese samples.

### Microbial profile

The effect of irradiation on total colony count was presented in Table (3). The total colony count estimates the total microbial load without specifying the type of germ. It reflects the hygienic level of the untreated (control) cheese samples. The reduction percent in the total colony count of group I, II and III were 28.70, 40.98 and 73.04 % in the irradiated cheese samples, respectively. The presented data indicate that low level of irradiation up to 1 kgy substantially diminished the number of total colony count. For the dose of 3 and 5 kgy, the microbial destruction was significantly higher ( $P < 0.05$ ) than the control samples. Nearly similar findings were

reported by El-Batawy (1999) and Yousef *et al.* (2001). The count in all irradiated groups decreased with increase the dose of irradiation. This was probably due to the effect of energy produced from irradiation which breaks the bonds in the DNA molecules, leading to inability of microorganisms to replicate and reproduce resulting in bacterial death (Gillard *et al.*, 2007). Some bacteria can repair the damage of DNA strands and resist the effect of irradiation. The effectiveness of the process depends on the organism's sensitivity to irradiation, the rate at which it can repair damaged DNA, and especially on the amount of DNA in the target organism. Also it depends on pH, temperature, water activity content ( $A_w$ ), and the nature of the radiation used in the process (Molins and Ricardo, 2001). The obtained results declared that irradiation did not sterilize kareish cheese samples but it may prolong shelf life time by reducing growth of spoilage bacteria. The control karish cheese samples had high total colony counts in relation to the Egyptian standards which should not exceed  $10^2$ cfu/g with their freedom from all pathogenic microorganisms (EOSQC, 2005). Thus control karish cheese is more likely to serve as a vector for food borne illness.

The total mold and yeast counts were significantly ( $P<0.05$ ) higher in control cheese group in comparison with II and III irradiated groups (Table 4). The reduction percent in the total mold and yeast count were 25.09, 66.79 and 87.32% in the examined irradiated group I, II and III, respectively. There was significant difference ( $P<0.05$ ) in control cheese samples in comparison with irradiated group II and III. Nearly similar findings were reported by Hamed *et al.* (1992) and Rehman *et al.* (2000). Irradiation at doses up to 5 Kg did not eliminate the mold and yeast population but reduce their growth by inhibiting their sprouting and maturation (Radomeski *et al.*, 1994 and Lucht *et al.*, 1998). Yeast and mould in cheese are considered as spoilage organisms resulting in flavor and textural deterioration including softening, discoloration and slime formation (Besancon *et al.*, 1992). Not only molds and yeast deteriorate cheese but they also have pathogenic, allergic and toxic action. A large number of molds including mycotoxigenic fungi which produce mycotoxins are wide spread to contaminate karish cheese rendering it unpalatable and unsafe for consumption (Law, 1999). As the Egyptian standard for mold should not exceed 10cfu/g while for yeast count should not exceed 400 cfu/g, control kareish cheese is more likely to serve as a vector for food borne illness (EOSQC, 2005).

The reduction percentage of *Enterobacteriaceae* count were 25.21, 64.79 and 100% in the examined irradiated groups I, II and III, respectively (Table 5). Increasing the dose of irradiation induced greater

reduction in count of indicator organisms (*Enterobacteriaceae*). At dose 5 kGy there was complete reduction in *Enterobacteriaceae* count. Nearly similar findings were reported by Kroll (1995); Beresford *et al.* (1998) and Moatsou *et al.* (2001). *Enterobacteriaceae* are germs indicative of faecal pollution. In Europe they are an index widely used in cheese to appraise their hygienic quality. The result obtained would suggest that 5 kGy dose of irradiation leads to optimum sanitation, not forgetting that the destruction of *Enterobacteriaceae* would ensure the absence of other pathogenic gram negative bacteria. We, therefore think that a dose of 5 kGy is optimum.

Although *Coliforms* are subgroup of *Enterobacteriaceae* but we have studied their destruction as independent group. From the data summarized in Table (6) it could be seen that the reduction percent of *Coliform* counts were 30.86, 73.46 and 100% for groups I, II and III, respectively. The *Coliforms* count was markedly decreased with irradiation and completely disappeared in irradiated cheese group III. There was a significant difference ( $P<0.05$ ) in control cheese samples in comparison with irradiated group II and III, respectively. At 5 kGy there was complete destruction of *Coliforms* in the irradiated III cheese samples. Nearly similar findings were reported by El-Sissi and Neamat Allah (1996) and Leuschner & Boughflower (2002).

As shown in Table (7), gradual decrease in *Staphylococcus* count in all irradiated karish cheese samples. Irradiated cheese group III contained no colony count. The result indicate that a dose of 5 kGy could eliminate 100% of the *Staphylococcus* count present in karish cheese samples. Irradiation at 5 kGy was demonstrated to be suitable for inactivating food borne microorganisms in cheese. Nearly similar findings were reported by Kanka *et al.* (1989); Hamed *et al.* (1992); Monk *et al.* (1995) and Ordonez *et al.* (1999). The growth of *Staphylococcus* in control karish cheese may produce enterotoxins which causes food borne illness. So control cheese may harbour public health hazard for consumers than irradiated cheese samples (Rashed *et al.*, 1992; Zottola & Smith, 1993; Bastian *et al.*, 1993; Lee, 1994; Kroll 1995 and Lamb *et al.*, 2002).

In conclusion, irradiated karish cheese has high quality and safety, free from pathogenic microorganisms with better flavor. The only disadvantage is the increase in cost. The advantages of irradiated cheese are strongly outweighing the disadvantages. Therefore, in karish cheese factories where hundreds of thousands of liters of raw milk may be processed in a single day, it is imperative to irradiate karish cheese at dose of 5Kgy to have high quality, safety and premium grade for the consumer.

**Corresponding authors****Salwa A. Aly**

Food Hygiene Department, Faculty Veterinary

Medicine, Cairo University

[salwaaly@hotmail.com](mailto:salwaaly@hotmail.com)**References**

1. Abd El-Salam, M.; Askar, A.; Hamzawi, L. and Alam El Dien, H. (1992): Compositional quality of karish cheese as affected by irradiation. *Egyptian Journal of Dairy Science*, 20 (1) 41-51.
2. AOAC, Association of Official Analytical Chemists (1998): Official methods of analysis, 23<sup>th</sup> Ed. Association of Official Analytical Chemists INC, Wilson Boulevard, Arlington, USA.
3. APHA, "American Public Health Association" (1993): Standard methods for the examination of dairy products. 16<sup>th</sup> Ed. Marshall, R.T., APHA, Washington, DC, p.600-800.
4. Bastian, E.; Hansen, K. and Brown, R. (1993): Inhibition of microorganisms by irradiation. *Journal of Dairy Science* 76 (3) 354-361.
5. Beresford, T.; Fitzsimons, N; Cogan, T. and Condon, S. (1998): Non starter lactic acid bacteria: Growth in cheese, contribution to flavor development, In: Proceedings of the International Dairy Symposium. 19 October Rhodia Stockport, UK, p. 98-134.
6. Bernnand, C.P. (2006): Food irradiation. Frequently asked questions. University of Reading UK The Food Safety Advisory Centre London.
7. Besancon, X.; Smet, C.; Chablier, C.; Revemale, M.; Reverbel, P.; Ratpomahelma, R. and Galazy, P. (1992): Study of Yeast flora in cheese. *International Journal of Food Microbiology* 17 (1) 9-13.
8. Brooks JC; Martinez B; Stratton J; Bianchini A.; Krokstrom R. and Hutkins R. (2012). Survey of raw milk cheeses for microbiological quality and prevalence of foodborne pathogens. *Food Microbiol.* 31 (2) 154-158.
9. Campell-Platt (1999): Food irradiation. University of Reading, UK, The food safety Advisory Centre, London.
10. Dawood, M.; Abdou, R. and Salem, G. (2006): Effect of irradiation of skim milk on the quality of karish cheese. *Egyptian Journal of Dairy Science* 32 (4) 500-509.
11. El-Batawy, M.A. (1999): Shelf life of karish cheese as affected by gamma irradiation. *Egyptian Journal of Food Science* 18 (1) 1-5.
12. EOSQC, (2005): Egyptian Organization for Standardization and Quality. Egyptian standards. Soft cheese, Part: 4 Karish cheese, E.S.: 1008-4/2005.
13. El-Sissi, M. and Neamat Allah, A. (1996) Effect of salting levels on ripening acceleration of soft cheese. *Egyptian Journal of Dairy Science* 24 (2) 265-275.
14. FAO Food Agriculture Organization (1998): Study Group on High Dose Irradiation. "Food safety." *Wkly Epidemiological Record* 16 73(3) 9-11.
15. FDA, Food and Drug Administration (1997): Irradiation in the production, processing and handling of food. 62 Federal Register 232 (64107-64121).
16. Ghosh, B.; Steel, A. and Kessler, H. (1999): Effect of heat treatment and irradiation of milk on cheese. *Egyptian Journal of Dairy Science* 27 (2) 331-343.
17. Gillard, N.; Coffinonot, S.; Bure, C.; Davidlova, M.; Maurizot, J.; Cadone, M.; Spothium, M. and Maunizot, M. (2007): Radiation induced oxidative oxidation to the DNA binding domain repressor of lactose. *Chemistry Journal* 31 (1) 3-8.
18. Hamam, M.G. (2005): The effect of irradiation of the quality of Ras cheese. *Journal of Food Science and Technology* 11 (2) 401-409.
19. Hamed, A.; Nafisa, A. and Farag, S. (1992): Effect of irradiation and storage conditions on the microbiological chemical and organoleptic properties of cheese. *Journal of Dairy Science* 77 (1) 99-106.
20. Henkel, T.J. (1998): Food irradiation. *Journal of Food and Drug Association* 62 (4) 41-45.
21. ICMSF "International Committee on Microbiological Specification for foods" (1996): Microorganisms in Foods: Their significance and method of enumeration. 2<sup>th</sup> Ed. University of Toronto Press, Toronto, Canada, p. 564-790.
22. IDF, International Dairy Federation (1993): Cheese Total nitrogen content. IDF Standard No. 20.
23. Kanka, B.; Joginder, S. and goyal, G. (1989): Effect of pasteurization on some physico-chemical properties of goat milk. *Egyptian Journal of Dairy Science* 17 (1) 53-61.
24. Konteles, S.; Sinanoglou VJ; Batrinou A, and Sflomos K. (2009). Effects of gamma-irradiation on *Listeria monocytogenes* population, colour, texture and sensory properties of Feta cheese during cold storage. *Fod Microbiol.* 26 (2) 157-165.
25. Kroll, S. (1995): Thermal stability. In: *Enzymes of Psychrotrophs in raw milk* (McKeller, S. Ed.) Academic Press Canada, p. 121-148.
26. Kuchroo, C.N. and Fox, P.F. (1982): Soluble nitrogen in cheddar cheese: composition and extraction procedures. *Milchwissenschaft*, 37 (3) 31-45.
27. Lalaguna, F. (2003): Physico chemical response of soft cheese to low dose irradiation. *Journal of Food Science* 58 (1) 186-192.
28. Lamb, J.L.; Geogley, J.M.; Thompson, M.J. and Solis, D.R. (2002): Effect of gamma irradiation on *Staphylococcus aureus* and product packaging in ready to eat cheese sandwiches. *Journal of Food Protection* 65 (11) 1800-1805.
29. Law, B.A. (1999): Microbiological surveillance and control in cheese manufacture. In: *Technology of*

- cheese making (Law, B.A. ed.) 1<sup>st</sup> Ed. Academic Press, p.251-280.
30. Lee, P.R. (1994): Irradiation to prevent food borne illness. *Journal of Animal Research and Practice* 272 (4) 28-91.
  31. Leuschner R. and Boughtflower M. (2002): Laboratory scale preparation of soft cheese artificially contaminated with low levels of *Escherichia coli* O157, *Listeria monocytogenes*, and *Salmonella enterica* Serovars Typhimurium, Enteritidis, and Dublin. *Journal of Food Protection* 65 (3) 508-514.
  32. Loaharanu, P. (2005): Irradiation as a cold pasteurization process of food. *Journal of Veterinary and Parasitology* 64 (2) 171-182.
  33. Lucht L.; Blank, G. and Borsa, J. (1998): Recovery of foodborne microorganisms from potentially lethal radiation damage. *Journal of Food Protection* 61(5) 586-590.
  34. Marth, E. and Steele, J. (2001): Starter cultures and their use. In: *Applied Dairy Microbiology*. 3<sup>rd</sup> Ed. USA, p.131-173.
  35. Mason, J.O. (1993): Food irradiation. *Public Health report volume 108, NO. 3*, p. 402-410.
  36. Mehran, N.T.; Tawfeak, Y. and Hewedy, M. (2005): Incidence of pathogens in kareash cheese. *Egyptian Journal of Dairy Science* 26 (1) 295-300.
  37. Moatsou, G.; Kandarakis, J.; Moushopolou, K.; Anifantakis, E. and Alichanidis, E. (2001): Effect of technological parameters on the quality of irradiated soft cheese. *International Dairy Journal* 54 (2) 69-77.
  38. Molins, G. and Ricardo, A. (2001): Inactivation of microorganisms by irradiation. In: *Food irradiation: Principles and Applications*. 1<sup>st</sup> Ed, Willey, J. ed. Academic Press London, p.119-250.
  39. Monk, J.D.; Beuchat, L.R. and Doyle, M.P. (1995): Irradiation and their effect on food-borne microorganisms. *Journal of Food Protection* 58(2)197-208.
  40. Nelson, J.A. and Trout, G.M. (1981): Judging of dairy products, 4<sup>th</sup> Ed. INC Westport, Academic Press, p. 345-567.
  41. Omer, M. and Elshirbiny, S. (2005): Composition and microstructure of cheese as affected by irradiation. *Egyptian Journal of Dairy Science* 13 (1) 33-39.
  42. Ordonez, A.; Lbanez, F.; Torre, P. and Barcina, Y. (1999): Effect of milk irradiation on the free amino acids in Idiazabal cheese. *International Dairy Journal* 9 (2) 135-141.
  43. Radomeski, T.; Murano, E. and Olson, D. (1994): Elimination of significant pathogens in food by low dose irradiation. *Journal Food Protection* 57 (1) 53-86.
  44. Rashed, M.; Mehanna, A.; Nofal, A. and Zommara, A. (1992): Studies on improving the keeping quality of raw milk soft cheese during storage. Effect of irradiation. *Egyptian Journal Dairy Science* 19 (2) 99-104.
  45. Rehman, S.; Bank, J.; Mcsweeney, P. and Fox, P. (2000): Effect of ripening temperature on the growth and significance of lactic acid bacteria in irradiated cheese. *International Dairy Journal* 10 (1) 45-53.
  46. Robert, T. (1998): Cold Pasteurization of food by irradiation. *Nutrition Food Science* 11 (1) 40-44.
  47. Schaffer, S.; Tatini, S. and Baer, R. (1995): Microbiological safety of soft cheese containing naturally modified fat. *Journal of Food Protection* 58 (2) 132-138.
  48. Sofos, J.N. (2002): Microbial control in foods, needs and concern. In: *Control of food borne microorganisms* (Juneja, V. and Sofos, J.N. eds.) 1<sup>st</sup> Ed. New York, Academic Press, London, p.1-13.
  49. Steel, J.H. (2006): Food Irradiation: A public Health opportunity. *World Veterinary Association (WVA) Bulletin Vol 19 Number 1 January 2006*.
  50. Steel, R. and Torrie, J. (1982): *Introduction to statistics*, International 2<sup>nd</sup> Ed. p. 200-258 (Eds. H McGraw & E Kogak) USA,.
  51. Thayer, D.W. (2005): Food irradiation: benefits and concerns. *Journal of Food Quality* 13 (1)147-169.
  52. Urbach, G. (1993): Relations between cheese flavor and chemical composition. *International Dairy Journal*. 3 (4) 485-507.
  53. WHO, World Health Organization (2005): Safety and nutritional adequacy of irradiated food. Geneva, Switzerland.
  54. Yousef, A. (2004): Effect of technological factors on the manufacture of karish cheese. *Egyptian Journal of dairy science* 31 (1) 161-165.
  55. Yousef, H.; Sobieh, M. and Nagedan, K. (2001): Microbial status of soft cheese at Al Gassiem area Saudi Arabia. 8<sup>th</sup> Sci. Con. Fac. Vet Med. Assiut University, p. 91-97.
  56. Zottola T. and Smith, P. (1993): Irradiation of cheese: Physical, chemical and biological aspects. In: *Cheese chemistry, physics and microbiology*. 2<sup>nd</sup> Ed. (Fox, P.F. ed.) Chapman and Hall, London UK, p. 257-389.

9/9/2012