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Effect of gamma irradiation on microbiological quality of fermented sausages

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Summary

Turkish fermented sausages are one of the commonly consumed meat products in Turkey. In this study the effects of low dose gamma irradiation (1, 2 and 3 kGy) on the microbiological quality properties of Turkish fermented sausages have been investigated. The numbers of total aerobic mesophilic bacteria, coliform, Staphylococcus aureus, mould, yeast, lactic acid bacteria, and sulphite reducing Clostridia were analyzed. In sausage samples it was determined the number of microorganisms decreased or were eliminated according to the increased doses of gamma irradiation. The dose of 1 kGy was sufficient to eliminate the yeasts and sulphite reducing Clostridia. Coliforms and moulds were reduced to under detectable values after the application of 2 kGy irradiation doses, Staphylococcus aureus and lactic acid bacteria by the application 3 kGy. It was concluded that the 2 kGy dose was sufficient to control bacterial population to maintain Turkish fermented sausages within designated standards for this product.

Keywords: fermented sausage, gamma irradiation, microbiological quality

The nutritional value of meat products including dry sausages is mainly due to the energy supplied by these products, and also to their high biological value proteins, vitamins and minerals (15). Turkish fermented sausages are one of the common consumed meat products in Turkey. They are called sucuk, and are produced mostly by natural microflora or the addition of a starter culture. It is similar to semi-dried fermented meat products in Europe and the USA (7, 17). It is produced from beef and water buffalo meat, beef fat, sheep tail fat, salt, sugar, nitrite, nitrate, various spices with or without starter cultures (9, 12).

Meat and meat products are being called among the important cause of food-borne illnesses. Limiting the contamination and subsequent inactivation of occurring pathogenic bacteria will be decisive to the safety of meat and their products (4).

Gamma irradiation is well known to the best method for destroying pathogenic and spoilage microorganisms without compromising the nutritional properties and sensory quality of food (1). The use of ionizing radiation ensures the microbiological safety of processed meats (22). Irradiation provides a means to reduce use of chemical additives (8). Ahn et al. (1) reported that residual nitrite in sausage was significantly reduced by irradiation.

However, there is a paucity of literature on the effect of gamma irradiation on the keeping quality of Turkish fermented sausage. The aim of this study was to investigate the effect of gamma irradiation on microbiological quality properties and to define the effective irradiation dose for Turkish fermented sausages.

Material and methods

Collection of the sausage samples. In this study; the fermented sausage samples (n: 48) were collected from different sales points in Istanbul region. All samples were transported immediately in cooling boxes at 4°C for irradiation. The samples were separated into 4 groups. First group was labelled and observed as control group without any preservation process. Groups no: 2, no: 3 and no: 4 were separated for irradiation process with the dose rates of 1, 2 and 3 kGy, respectively.

Irradiation of the samples. Irradiation was performed in Gamma-Pak Sterilisation Company irradiation facility, Cerkezkoy, Turkey. The irradiation instrument was a Nordion-Canada model JS 9600 boxed irradiation device and had a source loading capacity up to 3.000.000 Ci. The instrument was a category 4, liquid source storage and box carrier type gamma irradiator and was registered in International Atomic Energy Agency (IAEA) with model no. JS 9600 and serial no: IR-185.

Sausage samples have been irradiated in original packages and the dose rate was 1 kGy/h. The treatment was performed at 4°C for sample temperature at the beginning and 15°C for internal temperature of the facility. All irradiated

samples have been brought to laboratory under cold transport condition (4°C) and analyzed immediately.

Dosimeter system. Secondary Standard Ceric-Cerious chemical dosimeters and plastic specified Harwell red acrylic (perspecs) (PMMA) dosimeters, which relatively scales doses; has been used as reference dosimeters in order to measure the radiation doses, which were absorbed by irradiated sausages. In validation and control process, calibre able Harwell red acrylic dosimeters have been used as daily dosimeters against secondary standard Ceric--Cerious dosimeters.

Microbiological analyses. 10 g of sausage samples were aseptically homogenized in peptone water (Oxoid, Hampshire, UK) at 1/9 (w/v). Serial decimal dilutions were made using the same media and then plated in duplicate for bacterial counts. Total aerobic mesophilic bacteria (TAMB), coliforms, *S. aureus*, mould and yeast, lactic acid bacteria (LAB) and sulphite reducing Clostridia (SRC) were analyzed (2). Medias used in the microbiological analysis and incubation conditions are shown in tab. 1.

Statistical evaluation. Data were analyzed statistically. SPSS packet program was used in formation of statistics and variance analysis method (ANOVA) was utilized. Duncan multiple analysis method was used to determine the differences between groups. Evaluating the significant differences between the values at the level of $p < 0.05$ (20).

Results and discussion

Results of the microbiological analysis of un-irradiated (control) and irradiated Turkish fermented sausages are presented in tab. 2. The fermented sausage samples were initially contaminated with a high population of microorganism and the TAMB counted were about 7.72 log cfu/g. The 1, 2, and 3 kGy of irradiation doses decreased about 0.82, 1.91 and 2.76 log cycles of TAMB, respectively. Coliform, *S. aureus*, mould, yeast, lactic acid bacteria and sulphite reducing Clostridia were decreased or eliminated. The dose of 1 kGy was sufficient to eliminate the yeasts and sulphite reducing Clostridia. Coliforms and moulds were reduced under detectable value after application of 2 kGy irradiation doses; *Staphylococcus aureus* and lactic acid bacteria by the application 3 kGy. According to the overall test result, there were statistically significant differences among the groups ($p < 0.05$).

In many studies, microbiologic contamination levels of fermented sausage seem to vary (5, 19). These variable results may be explained by different causes such as sausage manufacturing procedures, different meat contaminations, type of meat and ingredient, conditions of sausage ripening, the country, and the season.

Molins et al. (14) have reported that meats and meat products, which were not irradiated and consumed raw or under-cooked, were being loomed health hazard. Gamma irradiation can be used for many applications related to food science. The use of combined treatment with irradiation had a synergistic effect reducing the microorganisms' load and the irradiation dose, required to eliminate pathogenic bacteria (13).

Tab. 1. Media and incubation conditions used in microbiologic analysis

Micro-organism	Microbiologic media	Incubation conditions		
		Heat °C	Time (hours)	Aerobic/ anaerobic
TAMB	PCA (Oxoid CM 463)	35	48 h	aerobic
Coliform	VRB (Oxoid CM 107)	35	24 h	anaerobic
S. aureus	BPA (Oxoid CM 275)	35	48 h	aerobic
Mould	PDA (Oxoid CM 139)	25	5 days	aerobic
Yeast	PDA (Oxoid CM 139)	25	5 days	aerobic
LAB	MRS (OxoidCM 361)	30	48-72 h	anaerobic
SRC	SPS (Merck 1.10235)	37	48 h	anaerobic

Explanations: TAMB – total aerobic mesophilic bacteria; LAB – lactic acid bacteria; SRC – sulphite reducing Clostridia

Tab. 2. Microbiological properties of irradiated and non--irradiated Turkish fermented sausages (log cfu/g ± SD) (n = 48)

Micro-organism	Irradiation dose (kGy)			
	0 (control)	1	2	3
TAMB	7.72 ± 0.32^a	6.90 ± 0.46^b	5.81 ± 0.38^c	4.96 ± 0.14^d
Coliforms	3.93 ± 0.25^a	2.86 ± 0.33^b	ND	ND
S. aureus	4.68 ± 0.29^a	3.46 ± 0.41^b	2.48 ± 0.35^c	ND
Mould	3.62 ± 0.24^a	2.95 ± 0.12^b	ND	ND
Yeast	2.30 ± 0.27^a	ND	ND	ND
LAB	7.41 ± 0.66^a	6.28 ± 0.44^b	2.60 ± 0.27^c	ND
SRC	2.26 ± 0.24^a	ND	ND	ND

Explanations: ND – not detected; a, b, c – means within the same row with the different superscript letter are significantly different ($p < 0.05$).

Naik et al. (16) have been detected a decrease of 2-3 log cfu/g for mesophilic bacteria count in fresh meats irradiated with 2.5 kGy dose against control samples, in which *Enterobacteriaceae* spp., *Pseudomonas* spp. and *Staphylococcus* spp. counts were 3.63, 2.32 and 3.42 log cfu/g, respectively. *Enterobacteriaceae* spp., *Pseudomonas* spp. and *Staphylococcus* spp. were not detected in irradiated samples. Kanatt et al. (11) have been reported that total mesophilic bacteria, *Enterobacteriaceae* spp., fecal coliform and *Staphylococcus* spp. counts were 6.87, 3.17, 3.25 and 4.54 log cfu/g, respectively in beef. Mesophilic bacteria count has been reduced to 3.57 log cfu/g and other group bacteria were absent in samples after irradiation with 2.5 kGy doses. El Zawahry et al. (6) have been reported that 4-6 kGy doses were enough to inhibit the natural fungal flora in different foodstuffs. The studies conducted on the irradiation of fermented sausages are insufficient; it is obvious that high irradiation doses decrease bacteria counts in various studies. However, reduction rates show differences depending on the doses. The possible causes of those differences are

irradiation dose, composition of the product and microbial population at the beginning.

The maximum allowed bacterial counts for total mesophilic bacteria, coliforms, *S. aureus*, mould and yeast counts in Turkish Standards for fermented sausages are 10^6 cfu/g, 10 MPN, 10^2 cfu/g, 10^2 cfu/g and 10^2 cfu/g, respectively and the absence of *Salmonella* and *E. coli* (23). Maximum bacteria count limits in Turkish Food Codex (TFC) are 5×10^3 cfu/g for *S. aureus*, 10^2 cfu/g for *Clostridium perfringes*, *E. coli*, mould, yeast and the absence of *Salmonella*, *E. coli* O157:H7, *Listeria monocytogenes* (25). Although bacteria count limits, which have been detected in control samples, were not suitable for Turkish Standards and Turkish Food Codex, it was seen that all irradiated samples treated with low irradiation dose as 2 kGy had met these standards and limits.

Maximum allowed irradiation dose levels in meat and meat products are 3 kGy for to extend shelf life and antiparasitic control and 7 kGy for the control of pathogens (24). High dose levels of irradiation (8 kGy to 32 kGy) affect sensory, texture, flavour and palatability of frankfurters made from pork and beef (10).

Conclusion

In this study, it was seen that microbiologic quality of fermented sausages has been supplied without using maximum irradiation doses indicated in Turkish Food Codex. It has also been reported by various researchers that there were no significant differences in sensory parameters between non-irradiated and irradiated samples with 1.5-3.0 kGy (3, 18, 21).

2 kGy doses would be use to preserve and control bacterial populations in Turkish fermented sausages. These results indicate that the gamma irradiation in 2 kGy dose may be successfully used in preservation of fermented sausages. Irradiation at appropriate levels was also more effective in combination with salt and nitrite added to fermented sausage for bacterial control. It was also concluded that irradiation process may be utilized for the preservation of fermented sausage with success and without any requirement for high doses when used in combination with modern packaging techniques.

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