



USE OF IRRADIATION TO CONTROL LISTERIA IN MEAT

Irradiation can damage and destroy most foodborne bacteria including *Listeria monocytogenes* (Lm). (See reference 6 for a recent review.) Irradiation dosage, expressed in kiloGrays (kGy), is a function of the energy of the radiation source and the time of exposure. Effectiveness of a given radiation dose varies depending on the density, antioxidant levels, moisture, and other components or characteristics of the foods. External factors, such as temperature, the presence or absence of oxygen, and subsequent storage conditions also influence the effectiveness of radiation. A split dose application of irradiation increased the radiosensitivity of Lm to irradiation under some conditions(1).

Different isolates of Lm exhibit some variation in resistance to irradiation. Under similar experimental conditions, the range in D_{10} values in: (a) culture media was 0.28-0.34 kGy (11); (b) mechanically deboned chicken meat was 0.41-0.53 kGy (11); (c) minced raw chicken was 0.48-0.54 kGy (15); (d) ground beef was 0.5-1.0 kGy (3); (e) ground pork was 0.42-0.64 kGy (19). *Listeria innocua*, a nonpathogenic species, is similar to Lm in its sensitivity to irradiation and so may be used for the safe evaluation of irradiation processes for different meats (13).

In nearly all experiments, *Salmonella* and *Listeria* proved to be more resistant to irradiation than *E. coli*, *Arcobacter*, *Campylobacter*, *Yersinia*, and *Staphylococcus* (5,6,7,8,14, 22). *Listeria* and *Salmonella* appear to have a similar susceptibility to irradiation; in some experiments, Lm has a larger D_{10} value while in other cases, *Salmonella* appears to be more resistant (4,6,7,8,9,22).

Irradiation of Lm in laboratory media offers some useful preliminary information but Lm is significantly more resistant to irradiation in meats than in culture media (2,3,10,11,12,13,15). However, neither the fat content of the meat (14) nor the source (beef, chicken, lamb, pork, turkey breast, turkey leg) of raw meat (12,22) had a significant effect on D values for irradiation.

Factors which do affect the effectiveness of a radiation dose in meat include cooking, concentration of bacteria in the meat, and temperature during irradiation. Lm added to raw turkey nuggets was more susceptible to irradiation than that added to cooked turkey nuggets (23). At lower temperatures, the radiation resistance of Lm increased (2,12,20). With larger concentrations of Lm in solution or on meat, larger doses of radiation are required to destroy the cells (2,16). Therefore, if food is highly contaminated, the usual radiation dose may not kill all the Lm and, as several researchers reminded us, Lm can grow in the cold and surviving and damaged cells may begin to multiply if the irradiated meat is stored under refrigeration (10,24).

Heat treatments as in sous vide processing (9,17,18) and modified atmosphere packaging (7,21,24) have been found to enhance the safety of irradiated foods. In addition, salt, nitrites, and

other compounds added to preserved meats may increase the effectiveness of a radiation dose: Lm is more radiation-resistant in uncured pork than in ham (4). These additives may act by amplifying the kill by irradiation or by preventing the repair and growth of damaged, surviving cells. However, there has been very little published research on the effects of irradiation on cured and processed meats.

Some recommended doses of irradiation include: (a) 3 kGy for elimination of 10^3 cells Lm/g in air-packed frozen chicken (12); (b) 2.5 kGy to kill $10^{4.1}$ Lm/g in ground beef (14); (c) 2 kGy to destroy 10^4 Lm in mechanically deboned chicken meat at 2-4°C (11).

Food processors should be aware that various food additives and changes in processing parameters may affect the effectiveness of a radiation dose and that any surviving *Listeria* may grow to dangerous levels during storage at refrigeration temperatures if some other hurdle(s) to growth are not present. In addition, only a few types of plastic wraps and packaging are approved for use in irradiating packaged foods.

Irradiation has been approved by the FDA (25,26) for the purpose of microbial disinfection of:

fresh or frozen uncooked poultry	to a limit of	<3.0kGy
pork carcasses and meat (for Trichinella)	"	<1.0kGy
packaged meat for NASA flights	"	<44kGy
fresh or frozen red meat	"	4.5kGy (fresh) 7 kGy (frozen)

Irradiation of red meat (not including processed ready-to-eat meats) was approved by the FDA in December, 1997 and the recommended procedures for irradiating meat have been published by the USDA in the Federal Register. (26) Since the periods for comments on these procedures has been extended, the final rules have not been published as yet (July 1, 1999).

A number of individual European countries have regulations in place permitting (or in some cases prohibiting) irradiation of foods under specified conditions. The European Community is at this time working to establish a common set of guidelines.

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