Irradiation

TECHNOLOGY SUMMARY	
Status	Partially emerged technology
Location	Normally packaging/retail, though whole carcases can be treated
Intervention type	Surface treatment for E-beam, but Gamma irradiation can penetrate deeper
Treatment time	A few seconds
Regulations	Approved in the US and in some EU countries, but not yet approved for meat in Australia
Effectiveness	Up to 4 log reduction
Likely cost	Up-front capital cost of equipment AU$1,000,000 +
Value for money	Poor in Australia unless central service facility available
Plant or process changes	The unit may be retro-fitted after the packing machine, but extra space may need to be provided E-beam cabinet would require space for installation at the end of the slaughter line
Environmental impact	The equipment requires power
OH&S	Irradiation units must be properly screened
Advantages	E-beam radiation capable of treating whole carcases after chilling Easy to treat packaged primals In-package treatment can reduce potential post-processing contamination Good for smaller cuts such as patties and individual steaks etc
Disadvantages or limitations	Consumer perceptions may be hard to overcome Packs must be labelled, i.e., 'Treated with radiation'

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Irradiation

In this process, products are exposed to ionizing radiation- radiant energy that includes gamma rays, electron beams, and X-rays. Gamma irradiation uses high-energy gamma rays with high penetration power and thus can treat bulk foods on shipping pallets. Electron beam (E-beam) irradiation uses a stream of high-energy electrons, known as beta rays, which can only penetrate about 50 mm, while X-irradiation has intermediate penetration. Irradiation damages the bacterial cells' genetic material, disrupting their normal functions, and can result in significant extensions in shelf life of the product treated. The biggest obstacle to irradiation as an intervention is consumer acceptance. There is a perception that irradiation is dangerous to health, which in large doses, it is, but the doses required to treat foods are tiny and considered safe.

Irradiation is approved by more than 50 countries and endorsed by such international and governmental organisations as the World Health Organization, the United Nations Food and Agriculture Organization, the European Community Scientific Committee for Food, the United States Food and Drug Administration, a United Kingdom House of Lords committee and by scientists at FSANZ. It offers a significant opportunity to reduce pathogens and extend the shelf life of meat, but consumer acceptance is still a hurdle. Ionizing radiation has been approved in the US for use in treating refrigerated or frozen uncooked meat, meat by-products, and certain other meat products to reduce levels of food-borne pathogens and to extend their shelf life (USDA/FSIS, 1999). In Australia, Food Standard 1.5.3 of the Food Code governs irradiated food and to date, only herbs and spices and some tropical fruits have been approved to be irradiated (FSANZ, 2013), as is the case in the EU. Labeling requirements vary from country to country. Some, like Australia, New Zealand and the EU, require the labelling of any food that contains an irradiated ingredient, however small the percentage of that product, whereas in the United States, labelling applies only where the whole food item is treated. In Australia, irradiated products must bear a particular logo and must either have the word "Irradiated" in the product name, or the pack must be labelled "Treated with radiation" or "Treated with irradiation".

Low-dose, low-penetration E-Beam irradiation has now evolved to the point where large non-uniform surface areas can be effectively treated, which allows whole carcasses to be treated after chilling. Only the surface (about 15 mm penetration) receives a significant radiation dose (Koohmaraie *et al.*, 2005). If present on the carcass surface, the organisms responsible for food-borne illnesses can be readily destroyed when exposed to irradiation. Doses of 1.0 to 10.0 kGy have been shown to be effective in reducing pathogen levels on meat carcasses. It has been demonstrated that E-beam irradiation at 1 kGy reduced stationary phase *E. coli* O157:H7 on the surface of chilled beef carcasses by at least 4.0 log with acceptable effects on organoleptic properties (Arthur *et al.*, 2005). However, the study of Kundu *et al.* (2014) has reported that treatment of beef surfaces with the same does (1 kGy) of E-beam irradiation could only achieve no more than 4-log reduction of *E. coli* O157:H7 (≤ 4.0 log cfu/g), *E. coli* non-O157 (≤ 3.9 log cfu/g). In addition, previous studies have evaluated the efficacy of E-beam irradiation in eliminating other pathogens. Irradiation at 0.4-0.6 kGy caused a 1-log reduction of *L. moncytogenes* (Radomyski *et al.*, 1994), while a 1-kGy dose reduced *Salmonella* spp. by ≤ 1.9 log cfu/g (Kundu *et al.*, 2014). Considering the fact that the numbers of pathogens present on fresh meats are usually below 2 log cfu/cm^2, an irradiation dose of 1.5 kGy would in theory remove this level of contamination (Murano, 1995).

Irradiation also increases the shelf life of meats, by reducing the initial load of spoilage organisms present. Most studies agree that irradiation at least 2 kGy does not affect the organoleptic properties of ground beef patties (Arthur *et al.*, 2005; Lopez-Gonzalez *et al.,* 2000; Wheeler *et al.,*1999). It has been reported in a trial on beef patties that the irradiated patties appeared to be more moist (juicier) and tender than the non-irradiated patties (Murano *et al.*, 1998). However, Ismail *et al*. (2009) found that irradiation at 2.5 kGy increased lipid oxidation of ground beef but the addition of antioxidants such as ascorbic acid and α-tocopherol was effective in reducing lipid oxidation during storage. The packaging method used for the meat has been shown to affect the efficacy of the irradiation treatment. Irradiation is far more effective on packs containing air than on vacuum packs or MAP packs (Thayer & Boyd, 1999).

Like other physical processes such as cooking and freezing, irradiation can cause some alteration of the chemical and sensory profiles of a food but, in general, most nutrients are unaffected by irradiation with the exception of some vitamins for which minor decreases may occur. It is unlikely that any vitamin deficiency would result from the consumption of irradiated food (IFT, 2010). The two most important concerns related to the microbiological safety of irradiated foods are: (1) the potential to create highly virulent mutant pathogens; and (2) the potential that reducing the harmless background microflora could eliminate competitive microbial forces and allow uncontrolled pathogen growth (IFT, 2010). A key advantage of food irradiation is that it reduces the microbial loads at the point at which the product has been packaged, which increases the likelihood that the products the consumer receives will be safe.

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