Radiation Physics and Chemistry 105 (2014) 78–82

Contents lists available at ScienceDirect

Radiation Physics and Chemistry

journal homepage: www.elsevier.com/locate/radphyschem

Food irradiation is safe: Half a century of studies

Peter B. Roberts*

Radiation Advisory Services, Lower Hutt, 31 Wyndrum Avenue, New Zealand

HIGHLIGHTS

- Food irradiation is safe and can benefit food safety, security and trade.
- Commercial use remains limited.
- The food trade tends to believe consumers will not buy irradiated food.
- There is good evidence that consumers buy irradiated food when it is offered.
- Demonstrating this evidence to industry is vital for commercial success.

ARTICLE INFO

Article history:
Received 12 January 2014
Accepted 11 May 2014
Available online 17 May 2014

Keywords:
Food
Irradiation
Food processing
Food safety and security
Consumers
Acceptability

ABSTRACT

The potential benefits of food irradiation are yet to be realized due to slow progress in the commercialization of the technology. Processing food with ionizing radiation has encountered several barriers, one of which is the belief that consumers will not purchase irradiated food and a consequent caution among food retailers and producers. There is sufficient evidence that consumers will purchase irradiated foods when offered at retail in contrast to the data from many surveys of general public opinion. Communicating this evidence to food retailers and producers is essential if a major barrier to a greater use of the technology is to be overcome.

1. Introduction

Although the concept of irradiating food to bring about beneficial outcomes has been considered for a century, it was not until the 1960s that commercially feasible sources of radiation became available. Initial interest was in using relatively high doses of irradiation as a replacement for canning for military rations, for space foods and for hospital diets in immune-compromised patients. However, it soon became apparent that lower doses could be used more generally to improve food safety, increase food security (reduction of food losses and wastage) and offer another option as a phytosanitary treatment of food moving across international or national borders (Diehl, 1995; Fan and Sommers, 2013; Farkas et al., 2014; Hallman, 2011).

The beneficial effects of food irradiation resulted from the ability of radiation to bring about the effects shown in Table 1, which also provides some indicative applications. Irradiation is one of the many physical processes applied to food, but it has a number of practical advantages that include –

- Versatile (safety, security and trade (biosecurity) applications).
- Highly effective and efficient (it has broad-spectrum effectiveness against all non-sporing bacteria and against insects and many other pests).
- A cold process (advantageous for many foods).
- Penetrating (foods are treated in their final packaging, target organisms are not protected by package shape or position in the package, product distribution is relatively unimportant, and treating pallet loads is possible).
- Solid, raw foods can be treated.
- Treatment does not involve chemicals or chemical residues.
- The process is relatively easy to control (usually dependent only upon conveyor speed and the power/activity of the radiation source)
- Food can be immediately distributed into the food supply chain after treatment.

Despite these potential applications and advantages, irradiation has not become a major commercial food process. This paper

* Tel.: +64 4 5699 455.
E-mail address: radservices@xtra.co.nz.

http://dx.doi.org/10.1016/j.radphyschem.2014.05.016
0969-806X/

Table 1
Effects and applications of food irradiation.

Dose range (kGy)	Effects	Example applications
0.1–1	Inhibit sprouting Delay ripening Pest disinfestation Parasite inactivation	Potato, onion, garlic Bananas Fresh produce, dried foods Pork (trichinella)
1–10	Reduce spoilage organisms (extend shelf-life Reduce non-sporulating pathogens	Strawberries, mushrooms, dried fish Meats, shellfish, spices
Above 10	Reduce pathogens to point of sterility	Spices; hospital diets, emergency rations.

discusses some of the issues that have, over the last 50 years, influenced food industry and public attitudes.

2. Safety

Since the 1960s, there have been many thousands of studies related to the safety of irradiated food. Most provide only a small link in the chain of evidence; some provide a major body of evidence, such as a study using 135 t of chicken meat (Thayer and Christopher 1987). Experts in toxicology, microbiology and nutrition reviewed the data at intervals and concluded that food irradiation presented no or minimal risk. International acceptance of the safety of irradiated foods stems from the work of international and national expert committees (see a review by Ehlerman, 2014).

A key report was the 1981 publication of a Joint Expert Committee on Food Irradiation (JECFI, 1981) established by the WHO/IAEA/FAO. Its main conclusions were that irradiation of food up to an overall average dose of 10 kGy presents no toxicological hazard and introduces no special nutritional or microbiological problems. Since 1981, several other international agencies have reviewed safety issues again, including the World Health Organization and the European Food Safety Authority (WHO, 1994, JSGHDI, 1999, EFSA, 2011). Broad reviews of the safety of food irradiation have also been conducted by national food safety agencies. Many reviews undertaken by the US Food and Drug Administration in response to petitions to irradiate various foods (eg., FDA, 2008) are notable. Food Safety Australia New Zealand has carried out several reviews as it operates a policy of approving food irradiation on a specified food and use basis (e.g., FSANZ, 2012). Health Canada (HC, 2008) and numerous other agencies have reviewed irradiated food safety over the years. Some specialist professional organizations such as the International Committee on Food Microbiology and Hygiene (ICFMH, 1982), the American Medical Association and public health organizations (Steel, 2001) and the American Dietetic Association (Wood and Bruhn, 2000) have also endorsed food irradiation as a safe process.

A Joint Study Group (JSGHDI, 1999) found that from the viewpoint of safety any food may be irradiated at any dose and this was reflected in a revision of the Codex General Standard for Irradiated Foods (CAC, 2003)

Despite these international reviews, some critics of food irradiation still question its safety (PC, 2003). Some seek 50 year tests in humans; most quote old data, often selectively, that superficially appear to raise doubts about safety but which have been considered and addressed by international panels. A fruitful topic for critics has been the identification of specific products of irradiation (radiolytic products) that were not known at the time of the early international reviews. Identification of extremely low concentrations of products has become possible with new analytical methods capable of identifying products at the ppb level.

The most celebrated of these 'new' radiolytic products were 2-alkylcyclobutanones (reviewed in Sommers et al., 2013), in part because they could be unique to radiation as opposed to any other food process, although there are reports that cyclobutanones can be found naturally in some nuts and nut products. Some preliminary and simple in vitro studies indicated that further safety studies were required, and critics used the findings to re-open the safety question even though the authors of the studies cautioned against such over-interpretation of their data (e.g., Delincee and Pool-Zobel, 1998).

More detailed and in vivo studies were eventually conducted and reviewed (Sommers et al., 2013), and cyclobutanones are not considered a toxicological hazard by food safety authorities (for example FDA, 2008; EFSA 2011). It is also pertinent that, in all the food irradiation safety studies, 2-alkylcyclobutanones would have been present in those fat-containing foods in which they may be produced even though their presence was not suspected at the time.

3. Global use of food irradiation

As a result of the JECFI conclusions of 1981, Codex Alimentarius issued a General Standard for the Irradiation of Food, which was subsequently revised in 2003 (CAC, 1983, 2003). The Codex provisions (any food and any dose for a legitimate technical purpose) are rarely implemented totally, but over 50 countries have approved the use of irradiation for at least one food or food class with a maximum dose dependent upon the purpose of treatment. Approximately 30 countries have facilities that irradiate food, but in many countries the facilities treat only research or pilot scale quantities. Most irradiated food is consumed in the country of treatment. The only irradiated food that is traded internationally are fruits treated for quarantine purposes, a small trade that has developed only in recent years between several Asian countries and the USA and between Australia and New Zealand.

Trends in the amount of food irradiated globally are difficult to evaluate for several reasons. The large volumes of grain treated in a single facility in the Ukraine from the 1980s that was subsequently decommissioned distort the totals, and commercial sensitivity probably leads to significant underestimation of the true amounts relative to amounts revealed in surveys. The best data come from studies in 2005 and 2010 reported by Kume et al. (2009) and Kume and Todoriki (2013). It is clear that food irradiation is decreasing in Europe, increasing substantially in parts of Asia and increasing slowly in the USA, Australasia and other regions. The 2010 survey data indicated a global total for irradiated food of approximately 400,000 t. However, the rapid increase in use in China, particularly, and some other Asian countries since 2010, and the likelihood of underestimation, suggest that the true total is nearly 1 million tonnes per annum today. This is still a minute fraction of the world-wide production and consumption of food.

4. Barriers to the greater use of irradiation

The remainder of this paper considers experience mainly in North America, Australasia and Asia in recent years and is substantially the view formed by the author. Europe is in a different situation as in the major regional bloc, the EU, political influences have shaped the discussion to a far greater extent than in other regions. Several barriers have been suggested, often