RISING CALLS FOR FOOD SAFETY

RADIATION TECHNOLOGY BECOMES A TIMELY ANSWER

BY PAISAN LOAHARANU

Food safety has become an issue of high priority to many governments. Well publicized cases have shown that an outbreak of a major foodborne disease can have health, political, and economic consequences. Coupled with the increasing interest and publicity by the media, public awareness and concerns about food safety have reached a new height. Issues related to mad cow disease, and genetically modified food have attracted further attention and concern.

Awareness of risks involving microbiological contamination of food has increased significantly in the past decade. There have been several major foodborne disease outbreaks caused by various pathogenic bacteria and parasites and widespread coverage by the media.

The outbreaks have focused closer attention on food processing technologies to ensure the safety and quality of food. This article reports on developments for the application of irradiation technology for food processing, which has been approved for use in more than 40 countries.

FOODBORNE DISEASES

According to the World Health Organization (WHO), over 4000 million episodes of diarrhoea occur worldwide annually, the great majority in the developing world. Statistics from industrialized countries show that up to 10% of the population in these countries may suffer annually from a foodborne illness.

In many industrialized countries, recent outbreaks of foodborne diseases show that raw foodstuffs, including poultry, meat and meat products, seafood, fruits and vegetables, are frequently contaminated with one or several bacterial pathogens such as *Salmonella, Campylobacter, Yersinia, Listeria, Shigella, Vibrio, E. coli O157:H7,* and parasites such as protozoa, nematodes and trematodes. These infections result in often severe, chronic or fatal consequences apart from reduced economic productivity. According to the US Center for Disease Control and Prevention, 5000 deaths, 325,000 hospitalizations and 76 million illnesses are caused by food poisoning every year in the USA.

Globalization of food trade and consolidation of major food producers could compound the problem of foodborne illnesses. Because of the speed in modern day transportation systems, food produced in one country can be consumed in other countries in matters of hours or days. Contamination of food produced centrally by a major food company can spread quickly to countries which import such food. In addition, the variety of foods available has increased considerably faster than the ability of imported governments to inspect them. For example, the US Food and Drug Administration (FDA) estimated that the number of imported food items increased from 2.7 million in 1997 to 4.1 million in 2000. But because of limited resources, less than 1% of all imported foods can be inspected by the US-FDA.

FOOD SAFETY & QUALITY

The scientific consensus that irradiation can be effectively used to inactivate various food-borne pathogenic bacteria and parasites dates back to the 1970s. In the mid-1980s, it was backed with a report by a task force of the International Consultative Group on Food Irradiation (ICGFI) which conducted a detailed risk

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assessment. The Group was established under the aegis of the IAEA, Food and Agriculture Organization (FAO), and WHO in 1984. The task force concluded in 1986 that "at present and in the foreseeable future, no technology exists to produce raw foods of animal origin, particularly poultry and pork in which the absence of certain pathogenic microorganisms and parasites such as *Salmonella, Campylobacter, Trichinella, Toxoplasma,* can be guaranteed. These foods, therefore, pose significant threat to public health. Thus, where such foods are important to the epidemiology of food-borne diseases, irradiation decontamination/ disinfection must be seriously considered".

The recommendation was effectively followed up by the US Department of Agriculture, Food Safety and Inspection Service (FSIS). It petitioned the US-FDA to approve the use of irradiation to control pathogenic bacteria in poultry meat and meat products in 1988. After a detailed evaluation of irradiation of poultry meat, the US-FDA approved irradiation for this purpose with a maximum dose of 3 kGy in 1992. A quality control programme on irradiation of poultry meat was approved by the FSIS in 1994.

Although small-scale commercial applications of irradiation to ensure hygienic quality of solid food -- especially spices, shrimp and frog legs -- were carried out in some European countries in the early 1990s, the approval of irradiation for chicken set off a series of milestones on the technology's use to ensure microbiological safety of food globally.

By coincidence, the first commercial food irradiator using cobalt-60 as the radiation source became operational in Mulberry, near Tampa, Florida in early 1992. The opposition to its establishment and operation by a number of consumer groups on ideological grounds and the associated wide media coverage provided much needed information about the advantages and disadvantages of food irradiation to the public.

Fortunately, it was the news organizations that put the safety and technology issues into proper perspective. A popular US investigative television series called "20/20" aired a programme called "The Power of Fear" in December 1991 just prior to the licensing of the irradiator in Mulberry. The programme called into question the veracity of the claims of opponents.

Even so, no food company then decided to use irradiation to ensure microbiological safety of poultry meat, mainly because there was no incentive for doing so despite convincing scientific data. Even today, non-irradiated poultry meat, often contaminated by pathogenic bacteria such as *Salmonella* and *Campylobacter jejuni*, continues to be marketed without any treatment.

The Power of *E. coli.* Scientific articles starting in 1980s began to document that a number of emerging pathogenic bacteria, among them *E. coli 0157:H7* and *Listeria monocytogenes*, could cause major foodborne diseases especially among young children, the elderly and those who are immuno-compromised. The prediction of these scientists turned out to be true -- in early 1993, hundreds of people including a number of children under five-years-old who consumed undercooked hamburgers in a restaurant chain on the USA's west coast came down with serious illness; four children died because of *E. coli 0157:H7* infection. Studies demonstrated that ground meat used for the hamburgers was contaminated by this deadly bacterium which was not completely inactivated by the undercooking process used in the restaurant chain.

The media carried nationwide coverage on this unfortunate incident and the public became aware of the risk from this emerging pathogenic bacterium in their common food for the first time. Several court cases were filed against the chain restaurant and the settlement out of court was estimated to cost several millions of dollars.

Since then numerous incidences of illnesses and deaths caused by *E. coli 0157:H7* have been reported by the media. Major outbreaks included one in Japan in the summer of 1996 through a widespread school lunch programme involving fresh radish sprouts, consumed as salad, which caused illness in thousands of people and the deaths of 11 school children. Another case in Scotland in December 1996 involved the consumption of contaminated meat from a local butcher,

which resulted in 16 deaths among the elderly.

The outbreaks caused by *E. coli 0157:H7* prompted a large radiation processing company, Isomedix, Inc., New Jersey, USA, to submit a petition to the US-FDA in 1995 to approve irradiation of meat and meat products. It took the FDA two years to evaluate this petition prior to granting it in 1997. The USDA/FSIS approved another regulation on quality control programmes for irradiated meat and meat products in December 1999.

The Power of Recalls. The outbreaks of *E. coli 0157:H7* which caused deaths to children in 1993 resulted in a major regulatory action in the USA. The FSIS declared in 1994 that ground meat with this pathogenic bacterium is deemed to be "adulterated" whether it is raw, frozen or cooked. Although there were many incidences involving pathogenic bacteria in outbreaks of foodborne disease including deaths, this was the first time that a regulatory agency had declared a pathogenic bacterium to be an "adulterant".

For similar reasons, the US-FDA announced in 1996 that any ready-to-eat foods including ham, sausages, salami, cheeses, etc. shall not be contaminated by *Listeria monocytogenes* which can cause severe symptoms in pregnant women and immuno-compromised population. Thus, this bacterium was classified as another "adulterant" in such foods.

The largest food recall in history was in August 1997 when ground meat produced by a major meat processor in Iowa, USA, was found to be contaminated by *E. coli 0157:H7*. The company prompted a recall of its product which was already distributed to several states in the USA in amounts of more than 10,000 metric tonnes. As a result, the company was declared bankrupt and went out of business.

Another major recall resulted from contamination of *Listeria monocytogenes* in sausages produced by a major meat processing company in Illinois in December 1998/January 1999. Sausages produced by this large food company were distributed nationwide and caused hundreds of illnesses and deaths of several consumers, all of whom were immuno-compromised. The company decided to recall all of its sausages which amounted to 13,000 metric tonnes from its distribution chain. At the end, 21 consumers died from eating such contaminated sausages. A class action law suit was filed against the company and the case is still pending in court.

The Power of the Media. Starting in 1993 when news reports about the outbreaks of *E. coli 0157:H7* were carried by US media nationwide, there were already demands by scientists, professional food associations and some media representatives to use irradiation for ensuring the hygienic quality of ground meat. However, their demands did not attract much attention, since irradiation still had not been approved by the US-FDA for meat and meat products in mid-1990.

After the large recall of ground meat in 1997, the media began to issue strong statements demanding the use of irradiation. Headlines which demanded the use of irradiation to ensure hygienic quality of food were published by major newspapers in the USA, including *The New York Times, The Washington Post, USA Today, Wall Street Journal, and Chicago Tribune*.

These steps spread accurate information about the safety and benefits of food irradiation and created a much better understanding of the role which irradiation could play to ensure hygienic quality of food. Positive regulatory actions followed and consumers appeared to be more willing to purchase irradiated food whenever they had a choice.

The Power of Consumers. Any technology, no matter how safe and effective, is useless if consumers do not accept it. Originally, there was a widely held belief among the food industry and some governments that consumers would be reluctant to purchase irradiated food due to their misconception about the safety and benefits of irradiation technology and its association with "nuclear".

Although there is still widespread misunderstanding about irradiated food, records of market testing and retail sales in several countries have shown that consumer acceptance of irradiated food was underestimated.

A series of market tests of irradiated food, all with clear labelling to indicate the treatment, were conducted in several countries to gauge consumer response to the food at retail level. In 1986, market

FOOD PROCESSED BY IRRADIATION WORLDWIDE
(ESTIMATES AS OF 1999; TOTAL: 243,000 METRIC TONNES)

Argentina: Spices, dried vegetables, garlic, egg products, dehydrated bovine serum. 740 tonnes.

Bangladesh: Dried fish, frozen foods, pulses. 229 tonnes.

Belgium: Feed for laboratory animals, spices, frozen frog legs, shrimps, aromatic herbs and teas. 15,000 tonnes.

Brazil: Spices.

Canada: Spices. 3000 tonnes.

Chile: Spices and condiments, dried vegetables, frozen foods (sea products). 635 tonnes.

China: Spices, vegetable seasoning (garlic, 32,000 tonnes), sweet potato wine, potatoes, onion, dehydrated vegetables, chilled meat, health food, rice, grain, wheat powder, spices. 72,000 tonnes.

Croatia: Poppy seed, ground red paprika, marshmallow roots, marshmallow leaves, birch leaves, mint leaves, thyme leaves, chamomile flowers, St. John's wort extract, mint extract, valerian extract. 37 tonnes.

Cuba: Beans, onions, potatoes.

Czech Republic: Dry food ingredients, spices. 850 tonnes.

Denmark: Spices.

Finland: Spices.

France: Spices and vegetable seasonings, frozen shrimp, frog legs, poultry (frozen deboned chicken). 25,000 tonnes.

Germany: Spices.

Hungary: Spices, dried vegetables. 800 tonnes.

Indonesia: Not specified. 4015 tonnes.

Iran: Spices.

Israel: Spices, condiments and herbs. 1000 tonnes.

Japan: Potatoes. 20,000 tonnes.

Korea, Republic of: Potato, onions, garlic, chestnuts, mushrooms (fresh & dried), spices, dried meat, shellfish powder, red pepper paste powder, soysauce powder, starch for condiments, dried vegetables, yeast/enzyme products, aloe powder, ginseng products, sterile meals. 2500 tonnes.

Malaysia: Spices, herbs and dried food ingredients.

Mexico: Dried food. 4600 tonnes.

Netherlands: Not specified. 30,000 tonnes.

Norway: Spices.

Peru: Spices, food additives, animal feed.

Poland: Spices, dehydrated mushrooms and vegetables. 300 tonnes.

South Africa: Cereal, buttermilk, cheese powder, dehydrated foods, dehydrated and fresh vegetables, dried fruit, egg products, fish, garlic, health preparations, honey products, marinade, jelly, shelf-stable foods, soya mixtures, spices and herbs, torulite yeast, vegetable powder. 11,492 tonnes.

Thailand: Fermented pork sausage (Nham), spices for manufacturing soups and other products. 880 tonnes.

United Kingdom: Spices.

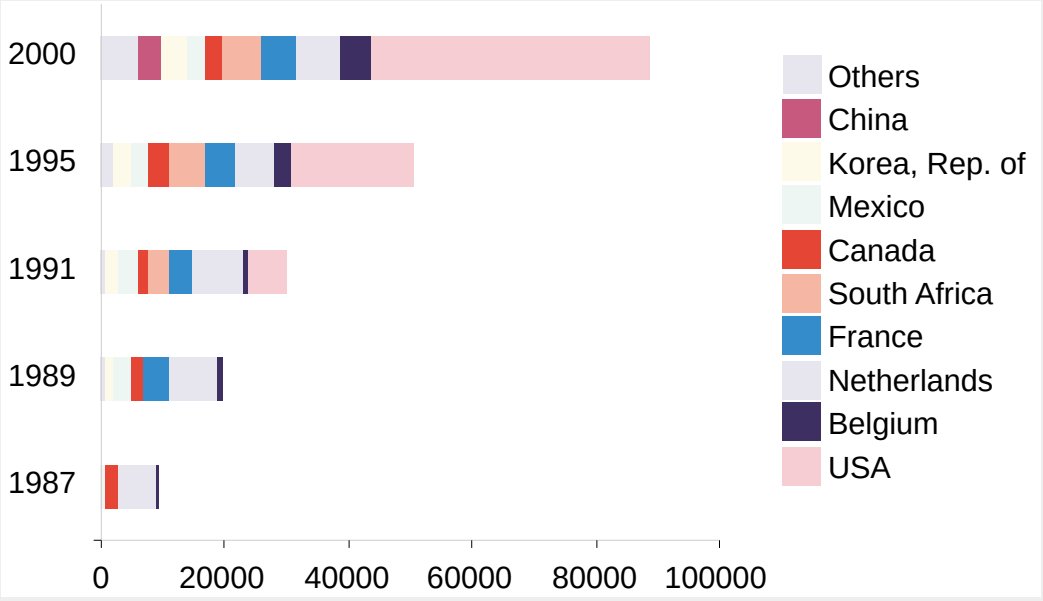
United States: Spices, fresh produce, chicken. 50,000 tonnes.

Viet Nam: Spices, dried herbs.

Yugoslavia: Spices.

Note: Estimates not reported by all countries.

ESTIMATED AMOUNTS OF GLOBAL PRODUCTION OF IRRADIATED SPICES AND DRIED SEASONINGS



testing of irradiated fermented pork sausages (locally called Nham which is often contaminated by pathogens such as *Salmonella* and is usually consumed raw in Thailand) was carried out in that country. The outcome showed that the consumers appreciated the microbiological safety of irradiated Nham and it outsold its non-irradiated counterpart by a ratio of 11 to 1. Irradiated Nham was put on sale on a regular basis in Bangkok, and ever since it has enjoyed widespread acceptance by consumers.

When irradiated papaya from Hawaii were market tested in California in 1987, the results showed that they outsold hot-water treated papaya (both treatments were used for killing eggs/larvae of fruit flies from Hawaii which are quarantined on the US mainland) by a ratio of 13:1. Irradiated papaya proved to be superior in quality to hot-water treated ones and consumers appreciated the benefit.

When irradiated strawberries from Florida were marketed in Chicago area starting in 1992 following the operation of the first commercial food irradiator in the USA, irradiated strawberries outsold the non-irradiated counterpart by a ratio of 10:1 to 20:1 depending on the time of purchase. Again, quality was the decisive factor to consumers and irradiated strawberries remain fresh up to two weeks while the non-irradiated ones started spoiling after a few days.

Market testing and retail sales of irradiated food in other countries -- including Belgium, Chile, China, India, Indonesia, France, the Netherlands, and South Africa -- showed similar results. Whenever irradiated foods were put on sale, either for market testing or commercial purposes, consumers preferred the irradiated product on the basis of safety or quality.

The key factor which influences consumer acceptance of irradiated food appears to be proper information together with endorsement by national health authorities. In fact, there are no data to support the notion that consumers would be reluctant to buy irradiated food when they are given the choice and information.

COMMERCIAL APPLICATIONS OF FOOD IRRADIATION

Currently, over 40 countries have approved the use of food irradiation for one or more food or food groups and over 30 countries are using it for commercial purposes. *(See box.)* Several countries have used irradiation to ensure microbiological safety of different types of food products since the early 1980s. The total volume of irradiated food has increased significantly in recent years to nearly 250,000 estimated tonnes per year. *(See box, page 40.)*

Originally, food ingredients especially spices and dried vegetable seasonings attracted a lot of interest from the food industry. These products must conform to microbiological standards required for processing of ready-to-eat food or even canned food. Spices and dried vegetable seasonings, normally produced in developing countries using traditional methods of handling and processing, are highly contaminated by various types of spoilage and pathogenic micro-organisms. Unless treated either by chemical, heat or irradiation, food containing such contaminated ingredients will spoil quickly or will require extra heat for processing in the case of canned food resulting in lower food quality.

Since 1991, the European Union (EU) has banned the use of ethylene oxide and propylene oxide for killing microorganisms in spices and dried food ingredients on the grounds of carcinogen concerns and worker safety. Irradiation emerged as a viable alternative. However, the volume of irradiated spices and other food ingredients in Europe has not increased significantly since mid-1995 because of the strict labelling regulations imposed by the EU on irradiated food and food ingredients, no matter how minute the quantities. The food industry is compelled to use other less effective but more expensive methods that require no labelling to ensure microbiological safety of their products.

In contrast, irradiation of spices, dried vegetable seasonings and other food ingredients has increased significantly since the mid-1990s in the USA and other countries which do not have such strict provisions for labelling irradiated food ingredients. The volume of irradiated spices and other food ingredients produced in 2000 is about 90,000 metric

tonnes, the majority of which goes to the food processing industry to ensure microbiological safety and quality of their products.

Commercial irradiation of food of animal origin to ensure microbiological safety also has taken hold in Europe. Imported frozen shrimp and frog legs have been routinely irradiated in Belgium, France and the Netherlands since the early 1980s. As previously mentioned, Thailand has marketed irradiated Nham since 1986 with wide acceptance.

In the USA, irradiated meats are being marketed. The commercialization began after the approval of US-FDA in 1997 and the FSIS in 1999. A commercial electron accelerator began operation at a meat processing/storage complex in Sioux City, Iowa in May 2000. Commercial quantities of irradiated frozen meat, mainly ground beef are now marketed widely in some 20 states in the USA to ensure absence of *E. coli 0157:H7*. Additionally, marketing of gamma irradiated fresh and frozen ground meat started in July 2000 in several eastern states of the USA.

EMERGING TRENDS FOR FOOD SAFETY

Discoveries of thermal pasteurization and microwave cooking in the last two centuries provided mankind with technologies to enhance microbiological safety and quality of liquid food such as milk and fruit juices and to increase the convenience for food preparation. In many ways, concerns over the use of food irradiation to ensure the safety and quality of food resemble those of milk pasteurization and microwave ovens at the time they were introduced. Even some of early-day criticisms of these two technologies have been leveled against the development of food irradiation.

Today, there is increasing awareness of the risk from food-borne diseases from consumption of food of animal origin, fresh fruits and vegetables – either whole or pre-cut -- and minimally processed food. Greater demand is thus expected for technologies to protect the quality and enhance the safety of our food supplies.

Irradiation is being recognized as offering distinct advantages in terms of inactivating pathogenic microorganisms and extended shelf-life of food without changing significantly their sensory attributes. Together with the increasingly strict regulation on the use of chemical preservatives and fumigants in food, irradiation should therefore meet increasing consumer demand for foods which are fresh or fresh-like, with little or no chemicals, both for sanitary and phytosanitary purposes.

Public health authorities worldwide are reassessing existing methods of food safety assurance, applying a cost-effective method that is known as Hazard Analysis and Critical Control Point (HACCP). Scientific experiments carried out in the past four decades have amply demonstrated the effectiveness of irradiation as a method to ensure the hygienic quality of solid food in the same manner as pasteurization has done successfully for liquid foods. There is an increasing need to incorporate cold pasteurization or decontamination treatment, such as irradiation as part of HACCP, especially for foods to be consumed raw, ready-to-eat, or minimally processed.

Product liability issues for not irradiating food also may emerge in the near future. As irradiation becomes a more widely accepted method to ensure the microbiological safety of food, someone who becomes ill or survivors of those who died from eating food contaminated by certain pathogenic bacteria could file a court case against the food manufacturer or retailer for negligence in not using an available safe and effective technology to eliminate such bacteria. They could assert that irradiation would have killed the bacteria before the product reaches the consumers. Food manufacturers may find it more reasonable and economical to irradiate food rather than not doing so -- for safety, health, and legal reasons.

After decades of research, development, public debate and consumer acceptance trials in many countries, irradiation has emerged as a safe and viable technology for ensuring the safety and quality of food and for combating food-borne diseases. Because of its broad spectrum, its role as a method to ensure microbiological safety of solid food could have even a far greater impact than pasteurization has had since it was introduced more than a century ago. ❐