Foodborne disease and the preventive role of food irradiation

Radiation processing of poultry, pork, and certain other foods could hold significant public health benefits

by Dr Gerald Moy

From the beginning, all civilizations have had to evolve systems for ensuring adequate supplies of safe and nutritious food to meet the needs of their people. Ideally, such supplies would be of high quality, be comprised of a wide variety of food items, and be affordable to even the most disadvantaged members of society.

To meet their food requirements, people have had to cope with a number of constraints. They include variations in agro-climatic conditions, insufficient technical knowledge, inadequate infrastructure, seasonality of production, and the perishable nature of most food products. While diverse solutions to overcome these difficulties have been devised, it may be said that adequate food supplies have only been achieved with some reliance on food processing and preservation technologies. This is particularly true of the contemporary world, where a growing proportion of the population now live in urban areas.

The technologies for safely keeping food include a variety of processes. Some of them, such as drying and salting, are of considerable antiquity, while others, such as fumigation, canning, freezing, and pasteurization, are of more recent origin. Treatment by ionizing radiation now is beginning to be used to supplement existing technologies for certain applications. One particular application, which has considerable public health benefits, is the reduction of pathogenic micro-organisms in foods.

As a process used to meet quarantine requirements, irradiation holds great promise as an alternative to chemical fumigation and other physical methods for disinfestation.

Dr Moy is a scientist in the Food Safety Unit of the World Health Organization, Geneva, Switzerland. This article is based on a paper he presented at a seminar on Food Irradiation in Europe, 28-30 September 1992, co-sponsored by the Commission of the European Communities (CEC) and International Consultative Group on Food Irradiation (ICGFI), a joint body of the WHO, Food and Agriculture Organization, and IAEA.

International consensus on safety

Before introducing any new food processing technology, adequate and reliable evidence must provide sufficient assurance that the process not only produces the desired results in food but also that it does not have any unacceptable toxicological, nutritional, and microbiological effects.

For food irradiation, the gathering of this evidence at the international level was co-ordinated by the International Project in the Field of Food Irradiation. Beginning in 1961, the data generated by this project and other sources were reviewed at several international meetings periodically organized by the World Health Organization (WHO), often in collaboration with the Food and Agriculture Organization (FAO), and the IAEA. In 1980, this series of international deliberations culminated in the convening at WHO Headquarters in Geneva of the Joint FAO/IAEA/WHO Expert Committee on the Wholesomeness of Irradiated Food.

In its landmark report, this Committee concluded that the "irradiation of any commodity up to an overall average dose of 10 kGy (10 000 gray) presents no toxicological hazard: hence, toxicological testing of foods so treated was no longer required". It also found that irradiation up to 10 kGy "introduces no special nutritional or microbiological problems". These conclusions, then, clearly established the wholesomeness of irradiated food up to this maximum absorbed dose of 10 kGy.

In subsequent years, a number of national and regional authorities convened their own expert committees to review and evaluate the data, independently of the international review and evaluation conducted by WHO in collaboration with FAO and IAEA. Reviews were conducted, for example, in Denmark, France, the United Kingdom, the United States, and the European Economic Community through its Scientific

Committee for Food. All these reviews arrived at conclusions similar to those reached in 1980 by the WHO, FAO and IAEA Expert Committee.

Since then, the use of irradiation as a food technology has been further reviewed. In 1983, the Joint FAO/WHO Codex Alimentarius Commission, in consultation with its member countries, adopted the Codex General Standard for Irradiated Food and the Recommended International Code of Practice for the Operation of Radiation Facilities for the Treatment of Food. With the endorsement of the Commission, the FAO and WHO hoped that countries would begin in earnest to apply food irradiation for the full benefit of their people, regardless of the country's stage of development.

Safety and quality of irradiated food

Although there is nearly unanimous agreement within the scientific and regulatory communities regarding the safety and nutritional adequacy of food irradiated under the conditions defined, those opposed to food irradiation have continued to raise what they believe to be important and unresolved issues. By exploiting the public's fear of "nuclear" technologies, opponents of food irradiation have been successful in delaying the enactment of legislation to permit or expand its use in a number of countries.

At the request of one such country, the WHO convened a consultation in May 1992 to prepare an update report on food irradiation. The report was based on a review of all relevant scientific studies carried out since the 1980 Expert Committee, as well as many of the older studies which had already been considered by previous international and national expert committees. Such issues as the discredited finding that polyploidy was induced in malnourished children fed irradiated wheat, as well as the assertions that irradiation destroyed the nutritional value of food, were given particular consideration. After reviewing all the evidence, including over 200 toxicological studies, the group reaffirmed the earlier findings. It concluded that irradiated food produced under established good manufacturing practices is to be considered safe and nutritionally adequate.

Public health benefits of food irradiation

At first glance, the rather heavy involvement of an international health organization in promoting a technological process might be surprising. However, it is quite understandable once it is recognized that the process of food irradiation produces two effects that can be highly beneficial to the health and well-being of humanity, namely:

- the destruction of certain foodborne pathogens, thus making food safer, and
- the prolongation of shelf-life of food by killing pests and by delaying the deterioration process, thus increasing the supply of high quality food.

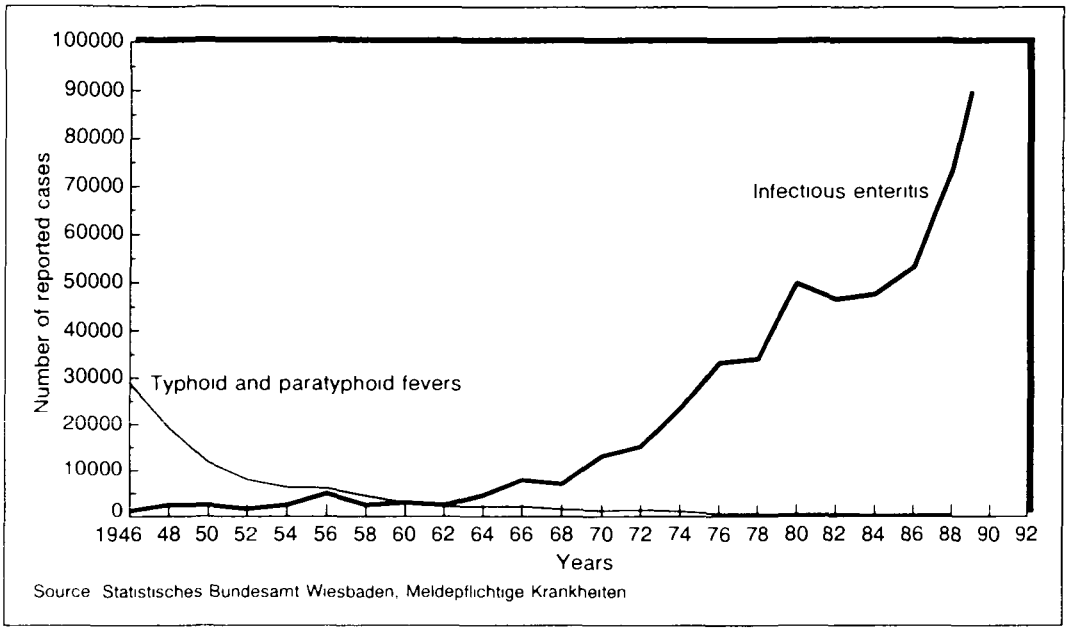
The food irradiation process, therefore, has the potential to help achieve one of the essential components of primary health care defined by WHO and the United Nations Children's Fund (UNICEF) in their Declaration of Alma-ata in 1978, namely the promotion of a safe, adequate, and nutritious food supply.

Improving the food supply

As mentioned earlier, food processing technologies have made healthy diets possible, especially for the world's urban populations. It is, therefore, not surprising that irradiation, by improving both the supply and diversity of foods, can serve to promote nutritional status and thereby contribute to public health. After all, good nutritional status is almost synonymous with good health. For example, it is known that good nutritional status can ward off infections and reduce the risk of certain non-communicable diseases, including cancer. Because good nutrition requires that food be both available and affordable, the food preservation capabilities of irradiation can make a significant contribution to extending the world's food supply which ultimately may translate into better nutrition and health for all.

While some are of the opinion that the world's food supply is adequate, especially in view of the agricultural over-production of many developed countries, the future is not as certain. The earth's population continues to increase at an alarming rate. At the turn of the century, the year 2000, the global population is expected to exceed the 6 billion mark and further increases are predicted. Just to sustain current consumption levels, it is estimated that world food production will have to increase dramatically over the next 20 years. In the face of limited arable land, declining soil fertility and water resources, and potentially disastrous environmental changes, it remains to be seen if all these people can be fed, much less fed nutritiously.

With these ominous signs on the horizon, prudence would dictate that we take all measures necessary to prepare for any shortfall in the world's food reserves. In this context, any preventable losses of food should be clearly tar-



Source Statistisches Bundesamt Wiesbaden, Meldepflichtige Krankheiten

Trends in reported cases of foodborne disease in Germany

		1983	1984	1985	1986	1987
Enteritis infectiosa	Salmonellosis	34 989	31 701	30 566	33 271	39 342
	Other forms*	10 067	15 313	15 690	19 508	22 932
Hepatitis A (infectious)		6 513	7 906	7 300	5 934	5 841
Shigellosis		1 611	1 637	1 599	1 635	1 871
Typhoid fever		212	205	227	230	228
Paratyphoid fever A, B, C		165	134	167	153	149
Botulism		30	32	26	30	18
Trichinosis		9	4	4	6	4
Cholera (el Tor)		1	1	0	2	0
ANNUAL TOTALS		53 597	56 933	55 579	60 769	70 385
FIVE-YEAR TOTAL , 1983-87: **297 263**						

Note Data reflect reported cases of disease in West Germany, including West Berlin, that are or may be foodborne in origin
* Other forms include diseases caused by Arizona, E coli, Y enterocolitica, Staph aureus, Steptococus group A, Cl perfringens, B Cereus, V parahaemolyticus, and Campylobacter
Source Statisches Bundesampt (Fachserie 12, Reihe 2) and Pohn, h Ph & R Grosshann Offentl Gesundh - Wes 49 577 - 580 (1987)

geted. In many developing countries where a warm climate often favours the growth of spoilage organisms and hastens the deterioration of stored food, current losses are enormous. In such countries, the estimated storage loss of cereals, grains, and legumes is at least 10%. With non-grain staples, vegetables and fruits, the loss due to microbial contamination and spoilage is believed to be as high as 50%. With commodities such as dried fish, insect infestation is reported to result in a loss of 25% of the product with an additional 10% lost due to spoilage.

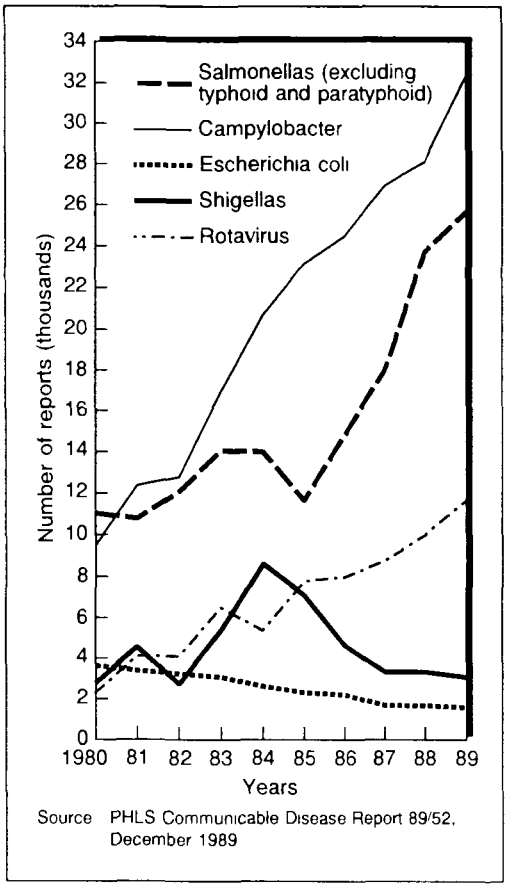
While all of these losses cannot be prevented by food irradiation, the technology offers unique potential to significantly reduce losses of certain foods, and thereby contribute to the overall security of the food supply. Consequently, food irradiation not only has possibilities for improving nutritional status and health today, but may someday mean the difference between life and death when it comes to the availability of food.

Improving food safety

For WHO, the loss of edible food is only one issue of the problems related to our food supply. In 1983, a Joint FAO/WHO Expert Committee on Food Safety concluded that foodborne diseases, while not well documented, are nevertheless one of the most widespread threats to human health and an important cause of reduced economic productivity.

Generally speaking, foodborne diseases are most often caused by biological agents that enter the body through the ingestion of food and which

Reported cases of foodborne disease in England, Wales, and Ireland



Source PHLS Communicable Disease Report 89/52, December 1989

are usually infectious in nature. The biological contamination of food is possibly responsible for up to 70% of the estimated 1400 million episodes of diarrhoea and 3.2 million associated deaths occurring annually among children under the age of five, mainly in developing countries. While not suffering the high mortality rate of children, the adult population also suffers a very heavy burden from such foodborne diseases as salmonellosis, campylobacteriosis, yersiniosis, hepatitis A, shigellosis, and diseases caused by Staphylococcus aureus, Bacillus cereus, and Clostidium perfringens, as well as other foodborne micro-organisms.

This burden has increased during the last 10 to 25 years. In the former Federal Republic of Germany from 1946 to 1989, there was a generally observable trend that, with increasing standard of living, diseases like typhoid and paratyphoid fevers decrease, while diseases like salmonellosis and other forms of infectious enteritis increase, at times rather dramatically. *(See graph and table.)*

Typhoid and paratyphoid fevers are diseases of undernourished, poor people living in unhygienic conditions. Salmonellosis and related gastrointestinal infections appear, at least in industrialized countries, to be related to increased consumption of food of animal origin and, perhaps, to sociocultural changes which have altered food handling practices.

Data concerning salmonellosis and other foodborne diseases from England, Wales, and Ireland present a very similar situation to that in Germany. *(See graph.)* The seriousness of these trends is heightened by the fact that such diseases are highly under-reported. Estimates of gastrointestinal infections in the United States suggest that foodborne diseases represent a major public health problem and, with its attendant untold suffering of millions, cost that society, directly and indirectly, billions of dollars a year. *(See table.)*

Data reflected in the official health statistics are nothing but the tip of the iceberg. WHO has reason to believe that the actual incidence of foodborne disease is up to 100 times greater than that reported.

In countries where reasonably good epidemiological services are operating, poultry meat has been identified as the vehicle most often responsible for causing foodborne salmonellosis and possibly campylobacteriosis as well. Both foodborne pathogens are sensitive to an irradiation treatment in the order of up to 7 kGy. The irradiation of poultry meat is expected to produce similar results for public health as has the pasteurization of milk, but only if it is accepted by the public.

In this regard, food irradiation is not the first instance where public health advice on a new food technology has not been immediately accepted. Pasteurization of milk is a good case in point. When it was introduced about 100 years ago in North America, Europe, and other parts of the world, many milk consumers, as well as scientists, voiced objections based on perceived hygienic, nutritional, and economic concerns. Today, pasteurization of milk is almost universally accepted as an essential public health technology that enjoys the confidence and support of the consuming public.

Reported gastrointestinal infections in the United States

Disease or agent	Incidence	Fatality/ case ratio (%)
Campylobacteriosis	2 100 000	0.1
Cholera	25	1.0
E. Coli- enteric	200 000	0.2
Salmonellosis	2 000 000	0.1
Shigellosis	300 000	0.2
Hepatitis A	48 000	0.3
Norwalk/other	6 000 000	0 00001
Listeriosis	2 000	19.0

Data for 1985 Sources "Infectious and parasitic diseases", by J V Bennett et al , Closing the gap the burden of unnecessary illness, Oxford University Press, New York (1987), and "Epidemiology of Listeriosis in the USA, by A Schuchat et al , Listeria and Food Safety, ASEPT, Laval, France (1991)

Perhaps in a case where the exception proves the rule, milkborne salmonellosis was a particular health problem in Scotland during the period from 1970 to 1982 when more than 3500 people fell ill and 12 died. After the introduction of milk pasteurization in Scotland in 1983, milkborne salmonellosis virtually disappeared and can now only be found among those in the farming community who continue to drink raw milk.

Whereas pasteurization was introduced mainly to interrupt the transmission of bovine tuberculosis and brucellosis, the most important public health applications of food irradiation are to destroy or reduce the ubiquitous and largely unavoidable pathogens that contaminate raw foods, especially those of animal origin. A Task Force on the Use of Irradiation to Ensure Hygienic Quality of Food concluded that at present, and in the foreseeable future, no known technology can guarantee the production of certain raw foods, such as poultry or pork, to be free from certain pathogenic microorganisms and such parasites as Toxoplasma and Trichinella.

In view of the declining quality of coastal waters in many parts of the world, shellfish also may be considered likely candidates for irradiation to assure their safety and availability for human consumption, especially in reference to Vibrio paraheaemolyticus and Vibrio cholerae. Therefore, this Task Force believes that where certain foods are important in the epidemiology of foodborne diseases, irradiation treatment must be seriously considered.

WHO has incorporated this recommendation into its Golden Rules for Safe Food Preparation. The first of these ten Golden Rules advises the consumer to purchase foods processed for safety reasons and gives as an example the recommendation to buy pasteurized as opposed to raw milk and to select fresh or frozen chickens which were treated with irradiation.

Since only one of the ten Golden Rules refers to irradiation, it is obvious that this technology can't be expected to totally assure the safety of the food supply. For this and other reasons, WHO has stressed that food irradiation may not be seen as a panacea to all the various food safety and food security problems humanity is facing. On the other hand, WHO actively encourages its Member States to consider the appropriate use of all safe and effective processing technologies, including food irradiation, to reduce foodborne disease and food losses.

In view of the enormous health and economic consequences of foodborne diseases, irradiation decontamination/disinfection of foods containing these pathogens must be considered as one of the most significant contributions to public health to be made by food science and technology in recent years.

Food irradiation has important roles to play in both the promotion of food safety and the reduction of food losses. Because the promotion of a safe, nutritious and adequate food supply is an essential component of the primary health care approach, WHO is concerned that the unwarranted rejection of this process, often based on lack of understanding of what food irradiation entails, may hamper its use in those countries that may benefit most. ❐

Irradiation's potential health benefits was one topic commanding attention at a recent seminar for journalists and consumer representatives in France co-sponsored by the CEC and an expert group under auspices of the FAO, WHO, and IAEA. (Credit: Wedekind, IAEA)