Food irradiation: Facts or Fiction?

Claims about irradiated foods may be misleading

by Paisan Loaharanu

In modern history, people have witnessed technological progress in many fields, some of which has enabled countless human voyages in outer space, even to the moon. Some people are surprised to learn that foods processed by ionizing radiation have been on these voyages since the early 1970s, when they became part of the diets for US astronauts and Soviet cosmonauts. Considering the fears and emotions too often surrounding irradiated food on this planet, one wonders whether these outer space travellers ever asked, "What on earth are these people talking about?"

Few food processing techniques have undergone as much scientific evaluation, public scrutiny, political debate, and media attention as has the technology of food irradiation. During the course of it all, both proponents and opponents have, in many respects, made it difficult to separate the science from the fiction of food irradiation.

Proponents often call the technology a method to solve world hunger. Opponents, meantime, often claim that it is dangerous because eating irradiated food — or even living near an irradiation facility — can lead to cancer. They also think the technique will be misused to make unwholesome food appear fresh. Unfortunately, both groups far overstate the case. Food irradiation's benefits, as well as its limitations, are too well-documented in the scientific record to support such notions. In short, the record shows that the technique can help to address problems of food supply and safety — without being hazardous to the environment or human health.

Are irradiated foods safe to eat?

The most important issue raised by consumer groups, the mass media, and even a few governmental representatives is the safety of irradiated food. It covers a wide range of technical subjects, including free radicals, radiolytic products, mutagenic and carcinogenic substances, polyploidy, vitamin losses, dangerous bacteria, and toxins.

Many scientific investigations have been done on this issue:

- **Free radicals and radiolytic products.** Just like with other food processes — heating or drying, for example — chemical changes occur when foods are irradiated. The types of radiations used for treating food are energetic enough to cause ejection of electrons in the medium through which they pass. This process is called ionization. The ions and free radicals, which primarily form when ionizing radiation passes through a food, are mostly unstable. They can react with each other or with constituents of a food resulting in compounds called "radiolytic products". It is important to know that these compounds are identical or similar to compounds found in food processed by other techniques, or even in unprocessed food. There is no evidence that any of these compounds is dangerous for consumption. No compounds which are unique to irradiation of food have been identified.

- **Mutagenic or carcinogenic properties.** International groups of scientists have evaluated extensive data from safety studies of irradiated foods and have found no basis for concern. Studies include those analysing chemical changes in irradiated foods — no matter how minute — and whether they could give rise to long-term human toxicity. In these studies, extensive animal feeding tests have been carried out on a number of irradiated foods. The foods were treated at doses that would be used in practice, as well as at much higher doses. A number of sensitive tests were employed in such studies, including host-mediated assays, cytogenetic analysis, micronucleus tests and long-term multigeneration feeding studies using rats, mice, dogs, monkeys, and other animals. Many of these studies were carried out or co-ordinated by the International Project in the Field of Food Irradiation, based in Karlsruhe, Federal Republic of Germany, from 1971 to 1981. Data generated from them were evaluated by leading experts in toxicology, microbiology, nutrition, and chemistry appointed by the Food and Agriculture Organization (FAO), IAEA, and World Health Organization (WHO) in 1976 and 1980.

In 1980, a significant amount of new data on animal feeding tests and radiation chemistry were available for evaluation. On the basis of these data, the Joint Expert Committee on Food Irradiation (JECFI) of the FAO, IAEA, and WHO came to the conclusion that "irradiation of any food commodity up to an overall average dose of 10 kilogray presents no toxicological hazard; hence, toxicological testing of foods so treated is no

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longer required''. It also found that irradiation up to this dose level ''introduces no special nutritional or microbiological problems''.

Since 1980, a number of national scientific committees have been appointed by the Governments of Australia, Canada, Denmark, France, Netherlands, United Kingdom, and United States to evaluate the safety of irradiated foods. All these committees independently have come to the same conclusions, in principle, as JECFI did. In 1983, JECFI's recommendations were further adopted by the Codex Alimentarius Commission of the FAO and WHO as a Codex General Standard for Irradiated Foods and Recommended International Code of Practice for the Operation of Radiation Facilities for the Treatment of Foods.

● **Nutrition.** Any food treatment — be it heating, freezing, drying, or even chilling — causes vitamin loss to a certain extent. Irradiation is no exception. Major food components such as protein, fat, and carbohydrates are relatively resistant to irradiation. Certain vitamins, such as A, E, and K, are relatively sensitive. Vitamin loss caused by irradiation is comparable to, or often less than, that produced by other food processes used to achieve the same purpose. A low irradiation dose required for sprout inhibition of potatoes and onions and for disinfesting insects in grains and fresh tropical and dried fruits will not cause significant loss of vitamins. For example, potatoes irradiated at 0.1 kilogray for sprout inhibition and stored at 15–20°Celsius retain more vitamin C than non-irradiated potatoes chilled at 4–5°Celsius for sprout inhibition.

It should be noted that constituents of food — for example, amino acids, vitamins, or sugars — can be sensitive to even a relatively low dose of irradiation when they are irradiated individually. These compounds are, however, more resistant to irradiation when they are present in a complex matrix of a food. Environmental factors, such as temperature and the oxygen atmosphere, are also important with regard to radiation sensitivity of such compounds. This phenomenon may explain the discrepancies in published reports on effects of irradiation on various food components.

● **Polyploidy.** No safety issue of irradiated food has been more sensationalized than ''polyploidy'', alleged to result from consumption of freshly irradiated wheat. Polyploidy means a multiple set of chromosomes that could imply abnormality. Human cells normally have 46 chromosomes. If they are polyploid they could have 92 or even 138 chromosomes. The incidence of polyploid cells varies among individuals. The biological significance of polyploid cells in humans is still unknown.

In the mid-1970s a number of reports were published by a group of scientists from the National Institute of Nutrition (NIN), India, on the increase in frequency of polyploid cells in rats, mice, monkeys, and even malnourished children, attributable to consumption of freshly irradiated wheat. No increase in polyploidy was seen when irradiated wheat was stored for 12 weeks, prior to consumption. A number of institutions in India and elsewhere have tried to repeat the studies conducted at NIN based on information made available to them. None of these institutions could come up with results similar to those found at NIN.

In view of the controversy on this issue, an independent investigation committee was appointed by the Government of India. The Committee concluded in its report in 1976 that the available data failed to demonstrate any mutagenic potential of irradiated wheat. The 1976 JECFI meeting, attended by the Director of the NIN, also considered all available data and came to the conclusion that there was no cause for concern and recommended ''unconditional acceptance'' of wheat irradiated up to a dose of 1 kilogray for insect disinfestation. A number of national scientific committees in Canada, Denmark, France, United Kingdom, and United States also have evaluated the alleged incidence of polyploidy; they all concluded that there is no cause for concern from consumption of irradiated wheat.

Additionally, in the early 1980s, eight feeding studies using several irradiated food items, including freshly irradiated wheat, were conducted using human volunteers in China. More than 400 individuals consumed irradiated food under controlled conditions for 7 to 15 weeks. Seven of the eight experiments involved investigation of chromosomal aberrations in 382 individuals. No significant difference between the number of chromosomal aberrations in the control and the test groups could be discovered in any of the experiments. The incidences of polyploidy in those who consumed non-irradiated food and those who consumed irradiated samples were within the normal range of the overall average value of polyploid cells in participants.

● **Microorganisms and toxins.** All foods intended to be processed by physical means — whether by pasteurization, canning, freezing, dehydration, or irradiation — should be of good quality and properly handled. Most of these techniques cannot eliminate all microorganisms and their toxins. Processing techniques, therefore, can neither replace good manufacturing practices (GMPs) nor are they applicable to all foods. Foods such as grain, meat, fish which can be contaminated by certain pathogenic microorganisms have to be strictly handled according to relevant GMPs — for example, chilling, ensuring low moisture content, and proper packaging and storage — before, during, and after processing by any technique. Food industries in general are fully aware of not only how to handle food but also what could happen if it is mishandled.

Despite the importance of GMPs, they alone cannot ensure the hygienic quality of a number of foods, including chilled and frozen poultry, pork and other red meat, some seafood products, and spices. Such foods can serve to spread contamination of pathogenic and spoilage microorganisms to other food, some of which are consumed raw, such as fruits and vegetables, during prepa-

MARKETING TRIALS OF IRRADIATED FOODS

The most vocal opponents of food irradiation would have people believe that consumers overwhelmingly reject the technology. This is far from the truth. Marketing trials conducted in 14 countries since 1984 have found that consumers not only buy irradiated foods when given the opportunity, but in many cases actually prefer the irradiated product. Earlier trials conducted in Canada (1966, 1967), Hungary (1980-84), Italy (1976), and South Africa (1978, 1979) found similar positive responses from consumers.

	Irradiated food items	Quantity (tons)	Date of testing	Place	Comments on results
ARGENTINA	Onions	55	1985–88	Buenos Aires & Bahia Blanca	Consumers preferred irradiated onions. 95% said they would like to buy them again.
	Garlic	1	1985–86	Buenos Aires & Bahia Blanca	Consumers showed no objection to irradiated products.
	Garlic powder	2.3	1987–88	Buenos Aires	Consumers showed no objection to irradiated products.
BANGLADESH	Potatoes	60	1985–88	Dhaka & Chittagong	More than 70% of consumers preferred irradiated foods because of better quality.
	Onions	85	1984–88	Dhaka & Chittagong	More than 70% of consumers preferred irradiated foods because of better quality.
	Dried fish	3.5	1985–88	Dhaka & Chittagong	Consumers preferred irradiated products because of better quality.
	Pulses	8	1986	Dhaka	Consumers preferred irradiated products because of better quality.
CHINA	Spirit from sweet potatoes	12 478	1984–89	Sichuan, Beijing, Lanzhou, Lasha, etc.	Consumers showed no objection to irradiated products.
	Sausage	200	1984–86	Sichuan, Guangzhou, Beijing, etc.	Consumers showed no objection to irradiated products.
	Apples	500	1984–88	Shanghai, Tianjin	Consumers preferred irradiated apples.
	Potatoes	800	1984–89	Shanghai, Henan	Consumers showed no objection to irradiated products.
	Onions	1250	1984–89	Shanghai, Tianjin	Consumers showed no objection to irradiated products.
	Garlic	4200	1984–89	Zhengzhen, Shanghai	Consumers showed no objection to irradiated products.
	Hot pepper and products	200	1984–89	Sichuan	Consumers showed no objection to irradiated products.
	Oranges	35	1984–88	Beijing	Consumers showed no objection to irradiated products.
	Pears	5	1985–87	Shandung	Consumers showed no objection to irradiated products.
CUBA	Potatoes	82.3	1988	Havana	Consumers showed no objection to irradiated products.
	Onions	16.2	1988	Havana	Consumers showed no objection to irradiated products.
	Garlic	10.5	1988	Havana	Consumers showed no objection to irradiated products.
FRANCE	Strawberries	3 10	1987 1988	Lyon	Consumers preferred irradiated strawberries in spite of higher price.
GERMAN DEM. REP.	Spices	1	1985	Leipzig	Consumers showed no objection to irradiated products.
	Chicken	10	1987	Schönenbeck	Consumers showed no objection to irradiated products.
INDONESIA	Dried fish	1.4	1986–88	Jakarta	Consumers showed no objection to irradiated products.
PAKISTAN	Potatoes	8	1984	Peshawar	Consumers showed no objection to irradiated products.
	Onions	12	1986–87	Peshawar	Consumers showed no objection to irradiated products.
PHILIPPINES	Onions	7	1984–86	Davao & Manila	Consumers showed no objection to irradiated products.
	Garlic	6	1985–87	Manila	Consumers showed no objection to irradiated products.
POLAND	Onions	6.5	1986–88	Poznan & Warsaw	95% of consumers said they would like to buy them again.
	Potatoes	2.5	1987	Poznan	Over 90% of consumers preferred irradiated potatoes.
		5.7	1988	Poznan & Warsaw	Consumers preferred irradiated potatoes.
THAILAND	Nham (fermented pork sausage)	29	1986–88	Bangkok	Irradiated food preferred over the non-irradiated product at a ratio of 10:1 in spite of higher price. 95% of consumers said they would like to buy them again.
	Onions	800	1986–87	Bangkok	Consumers preferred irradiated onions and garlic because of quality.
	Garlic	0.4	1986–87	Bangkok	
USA	Mangoes	2	1986	Miami, Fl.	Irradiated mangoes (sold at same or higher price) were preferred because of higher quality.
	Papaya	0.068	1987	Irvine & Anaheim, Ca.	Irradiated papayas were preferred at a ratio of 11:1; 69% of consumers said they would like to buy them again.
	Apples	0.270	1988	Missouri	Irradiated apples were preferred because of quality, even though they were sold at higher price.
YUGOSLAVIA	Herbal extracts	0.250	1984–85	Belgrade	Consumers showed no objection to irradiated products.

ration for consumption. Also, there are strict microbiological specifications required for some of these food items, especially in international trade. In particular, the absence of pathogenic microorganisms such as *Salmonella* is required in most food products.

Why food irradiation is used

Concerns about public health and the quality of food are among reasons why food irradiation is being used. Applications cover a range of products, including:

● **Spices and vegetable seasonings.** As early as 1986, international spice firms recognized the "irradiation technique as a unique means of controlling insect infestation and microbiological contamination", as stated at the First Meeting of the International Spice Group held in New Delhi in 1986. The group concluded that the use of irradiation on spices should be encouraged to eliminate spoilage, pathogenic microorganisms, and insects. The interest of spice trading companies in the use of irradiation has increased considerably since then, in view of the prohibition and restriction of the use of the chemical fumigant, ethylene oxide, in major spice importing countries. Irradiation now is being used to ensure the hygienic quality of spices in 17 countries.

● **Poultry and its products.** While many poultry producers do not like to admit that their fresh and frozen poultry meat are contaminated with *Salmonella* and related microorganisms, the problem is real worldwide. Between 30%–40% of poultry meat being sold in the market anywhere is contaminated with these organisms. The problem is not unique to poultry, as fresh and frozen red meat are also contaminated by these organisms, possibly to a lesser degree.

Many experts agree that the contamination of certain foods of animal origin, in particular poultry and pork, by organisms such as *Salmonella, Campylobacter*, and possibly *Listeria* cannot be avoided by using prevailing GMPs in the production, processing, and handling of these products without entailing an exceptionally high cost. They believe that, where such foods are important in the epidemiology of food-borne diseases, irradiation must be seriously considered as a valid option for pathogen control. Among the best arguments for irradiation of poultry is the one submitted by the Convention of Scottish Local Authorities in its comments on the Proposed Directives for Control of Irradiation of Foodstuffs issued by the Commission of the European Communities (CEC): "The Convention strongly supports the irradiation of poultry meats as the poultry industry has found it impossible to produce a product free from food poisoning organisms. The advent of irradiation of poultry meat, in the Convention's opinion, is likely to be as effective as the compulsary pasteurization of milk which took place in Scotland in 1983 and immediately brought about a large reduction in food poisoning from that source."

In the United States, the Food and Drug Administration (FDA) has estimated that up to 81 million cases of food-borne diarrhoeal diseases occur annually. The estimated economic loss due to *Salmonellosis* alone may be as high as US $2300 million per year. In comparison, the estimated losses due to *Salmonellosis* in Canada and the Federal Republic of Germany are close to US $85 million and US $110 million respectively, per year. Any effective treatment against such preventable food-borne disease should not only be encouraged but applied.

In 1987, the United States Department of Agriculture (USDA) Food Safety and Inspection Service petitioned the FDA to approve the use of irradiation of poultry meat, and the FDA has now given its approval. Commercial uses could follow. Currently, commercial-scale irradiation of poultry and poultry products has been carried out in Belgium, France, and the Netherlands.

● **Red meat and fishery products.** While incidence of *Salmonella* and *Campylobacter* contamination in red meat may not be as high as in poultry, parasitic infection of red meat by *Trichinella*, tapeworm, and *Toxoplasma* occasionally occurs in many countries. Such infection has made certain red meat culinary dishes, such as beef tartar, high-risk items. Veterinary inspection against these parasites in such meat prior to marketing is not foolproof. In Thailand, for example, irradiation is used to combat problems in a local delicacy called Nham, which is a fermented pork sausage, commonly consumed without cooking.

Frog legs are also a good candidate for irradiation. Frogs have the habit of living in an unhygienic environment and thus become contaminated by pathogenic microorganisms. Common GMPs used during processing cannot remove all contamination of these organisms. As a result, hundreds if not thousands of tonnes of frozen frog legs have been irradiated in Belgium, France, and the Netherlands in the past several years.

Seafood products normally are not contaminated with pathogenic microorganisms unless they are subjected to frequent human contact during processing. One item usually contaminated with pathogenic microorganism is cooked, peeled frozen shrimp. This product is cooked, hand peeled, frozen, and normally served as a prepared meal without further cooking. Irradiation is being used to ensure the hygienic quality of this product in Belgium and the Netherlands. Fish, especially fresh-water fish, can harbour a number of parasites. In the Far East, the population has the habit of consuming raw fish and millions of people are infected by various parasites, the most common of which is liver fluke. In Thailand alone, up to 7 million people in the Northeast provinces are infected by this parasite, which could result in an economic loss as high as US $600 million per year.

● **Tropical fruits.** Tropical and semi-tropical fruits are naturally infested by several species of fruit flies which prevent them from entering into countries with strict plant quarantine regulations, such as Australia,

Control of irradiation facilities

At the international level, the Codex Alimentarius Commission of the World Health Organization (WHO) and the Food and Agriculture Organization (FAO) of the United Nations, which represents 137 governments, has issued provisions for controlling irradiation facilities.

What has been done to promote adherence to these provisions?

A joint body of the FAO, IAEA, and WHO known as the International Consultative Group on Food Irradiation (ICGFI) and the Joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture have initiated a number of activities. They include:

- *International Register of Licensed Food Irradiation Facilities.* The register identifies facilities that meet ICGFI criteria for operation. It is maintained and updated by the Joint FAO/IAEA Division. Information can be made available to governments upon request.
- *Food Irradiation Process Control School (FIPCOS).* ICGFI organizes training courses for operators, plant managers, and technical supervisors of irradiation facilities, as well as for food control officials.
- *Certification of Treatment.* The Codex Standard requires that irradiated foods, whether prepackaged or not, are accompanied by relevant shipping documents to identify who has irradiated the food, when, and where. ICGFI now plans to develop and recommend a standard certificate which includes all this information for use in food trade.
- *Detection.* A number of national authorities have demanded detection methods to identify whether food has been irradiated and, if so, whether the treatment was done according to regulations. Recent research carried out in some countries has shown that a few methods — such as chemo-. and thermoluminescence and electron spin resonance (ESR) spectroscopy — may be suitable to identify some irradiated spices and food containing bones. The Joint FAO/IAEA Division and the European Commission are sponsoring research work in this area to develop more methods for detecting irradiated food items destined for international trade.

Japan, and USA. Ethylene dibromide, a widely applied fumigant against fruit fly infestation, has been banned in most countries. An effective alternative treatment is urgently required to overcome this problem. Among several alternatives available, irradiation appears to be the most promising in view of its effectiveness on most fruits. Fruit exporting countries such as Chile, Mexico, Philippines, and Thailand show strong interest in the use of irradiation. The USDA recently allowed irradiation for treating papaya from Hawaii to overcome fruit fly infestation. FAO has already published a recommendation on the use of irradiation as a quarantine treatment in its International Plant Quarantine Treatment Manual.

Who uses food irradiation

Twenty-four countries are irradiating foods or food ingredients destined for commercial use. The list includes a number of countries in Europe. The Federal Republic of Germany, while prohibiting the sale of irradiated food in the country, is irradiating commercial quantities of spices for export. Other European countries which are also irradiating different food items for commercial use include Finland, German Democratic Republic, Hungary, Norway, USSR, and Yugoslavia.

The number of countries which use irradiation to treat certain food items is growing, as are the quantities of food treated. Three more countries (Bangladesh, Côte d'Ivoire, and Viet Nam) plan to use food irradiation when the construction of their facilities is completed. Other countries, including Algeria, India, Malaysia, Pakistan, Peru, Philippines, and the United Kingdom have serious plans to use food irradiation commercially.

Currently about 160 multi-purpose irradiators are being used worldwide, mostly for sterilizing disposable medical products; about 50 of these also process food part of the time. By the end of the 1990s, an estimated 80 facilities could be in use in about 40 countries to irradiate food or food ingredients for commercial use.

Though still small, the commercial use of food irradiation has become significant enough to warrant a new direction in diffusion of this technology. National and international organizations are giving emphasis to issues such as harmonization of regulations, trade control, process certification, and irradiation registration. The safety and effectiveness of the technology have firmly been established internationally.

At a crossroad

Food irradiation is at a political crossroad. In one direction, it is moving forward supported by overwhelming scientific evidence of its safety and benefits to economy and health. In the opposite direction, it threatens to be derailed by misleading claims about its safety and usefulness. Whether people will ultimately benefit from the use of irradiation to help fight serious food problems, or whether they will allow the technology to go to waste, will be determined by how successful people are in separating the facts from the fiction of food irradiation.