THE CASE AGAINST FOOD IRRADIATION

Graham M. Simpson Ph.D.(London), P.Ag.Sask.

An address to the Canadian Home Economics Association
Saskatoon, Saskatchewan, July 14, 1992

Good afternoon Ladies and Gentlemen. I intend to read my address to you. Everything that I say is referenced in this document that is available to the media.

Traditionally there have been many forms of food preservation based particularly on the research of Pasteur. There was a trend earlier in this century toward chemical preservatives and new approaches,such as inert atmosphere storage, widened the options. Irradiating food has been proposed as a way of preserving and making certain foods hygienic. My talk outlines the case against irradiation of food, a technique that has been widely questioned.

I will begin by asking the question “Who is making the case for food irradiation?” The answer is unequivocal. It is the nuclear industry. Under the Atoms for Peace Program founded by President Eisenhower in the 1950s the U.S. Army studied the use of irradiation to preserve rations but approval was withdrawn in 1968 because of deficiencies in the safety studies (1). Between 1971 and 1981 biological studies of irradiated wheat flour, starches, spices and dried dates were made by the **International Food Irradiation Project (IFIP)**. The study was supposed to include 25 countries cooperating under the aegis of the **Food and Agricultural Organization of the United Nations (FAO)** and the **International Atomic Energy Agency (IAEA)** (2). In fact only five countries were involved and the conclusion was that “in France, animal feeding studies have been performed with reassuring results” (2) but only three references were cited and two of them were from the **IAEA**. The **IAEA** made reports in 1964, -69, -76 and -80 claiming that there were no problems with the wholesomeness of irradiated food as a result of the judgement of “expert committees” and in 1980 the **IFIP** announced that “foods irradiated at doses up to 10 kGy overall average dose present no toxicological hazard and therefore no further toxicological testing should be necessary. Irradiated foods do not pose specific microbiological and nutritional problems” (2).

We are entitled to ask “How do we define what is a *problem?”* You are also entitled to know that the **IAEA** that issued this statement is not a scientific body but simply a consortium of nuclear industries and regulatory bodies from various countries that purports to set international standards and monitor the nuclear industry worldwide but is not responsible to anyone but itself.

The consumer has never asked for food irradiation as an improvement for food storage. In the United Kingdom, a country with a long-standing nuclear industry where the public has been exposed to promotion of food irradiation for 25 years, a 1987 poll indicated that 70% of those polled were concerned about food irradiation and not a single person wrote to the Food Producers Association in favour of food irradiation (3). In reality, many of the publications that have appeared favouring the technology of food irradiation and claiming that there are no risks are sponsored by the nuclear industry, or are selectively cited by the nuclear industry to support its viewpoint; some are either non-scientific or inadequate scientific studies. For example: An evaluation of the bioassay data on the wholesomeness of irradiated foods indicated hundreds of adverse effects on test animals (Table 1, (4)). A testimony to the Congressional Hearings in the U.S. in 1987 stated “ in fact, a substantial number of studies can be found in the open scientific literature indicating the presence of known mutagens, carcinogens, or cytotoxic substances in food or food components which have been irradiated. Furthermore, the radiation chemistry of foods is far from fully understood, as evidenced by a steady appearance in the literature of studies on new radiolytic products found in various irradiated foods" (5). The Health Protection Branch of the Canadian Government in its submission to the Standing Committee on Consumer and Corporate Affairs (**SCCCA)** about food irradiation noted that only five of the 441 studies evaluated by agency reviewers were considered to be properly conducted, fully supported by toxicological standards and able to stand alone in support of safety. It was for this kind of reason that the very first recommendation of the **SCCCA** was: "That irradiation of food continue to be regulated as a food additive, and be restricted to those foods and doses presently approved by the existing regulations until an in-depth scientific assessment of health implications and further toxicological studies indicate that no significant adverse effects would be expected to be found by the ingestion of irradiated foods......"(6). As I will point out later, there are substantial scientific arguments for concluding that irradiating food can alter its safety for humans.

I have concluded that the push for irradiation comes totally from the nuclear industry that hopes to gain some economic return from its nuclear waste (Cs-137) or from the production of Co-60 in CANDU reactors. This is aptly summed up by the International Organization of Consumer Unions in its statement on Food Irradiation (1987) when it said: "While there may be some limited, specific and controlled uses for food irradiation under certain strict environmental regimes, we are concerned that the potential benefits have generally been grossly over-rated, while the potential problems have been underplayed. Efforts at adopting misleading, vague and uninformative labelling and attempts to foist this technology , particularly on the third world, without the active and informed participation of independent citizens groups must be thwarted." (8).

The second question I wish to address is: Can we expect, on strictly scientific grounds, that irradiation can make any food components less hazardous to humans than fresh food, or food stored for prolonged periods of time, under the conditions of sanitation presently known and practised ? To answer this question without getting into too many technicalities I will attempt to show several principles that can allow us to come to a sensible conclusion.

Irradiation of organic molecules by gamma-rays, x-rays or accelerated electrons can damage these molecules. The main effect of these ionizing forms of radiation on living organisms is that they can damage DNA-synthesis in living cells so that firstly reproduction is distorted leading to genetic change, then is inhibited. At high doses the cell dies. Thus micro-organisms, insects and of course humans can be killed by ionizing radiation. The sensitivity to radiation injury increases with the complexity of the organism; humans and higher animals are very sensitive, and bacteria and viruses are very resistant. At low energies of gamma- and x-rays (up to 5 MeV) or accelerated electrons (up to 10 MeV), measured as the unit of absorbed radiation (up to 10 kGy) it is claimed (2) "that irradiation of food

1. Produces the desired effects in food (?)
2. Does not produce radioactivity in foods or packaging materials.
3. Is available in quantities and at costs that allow commercial use."

It is up to this level of 10 kGy that much of the European and our Canadian legislation has indicated "there are no problems". Irradiation dosage above 10 kGy increasingly produces chemical changes in food (radiolytic products that can be toxic or alter the physical properties) that have negative effects on quality that depend very much on the type of food. Vegetables and fruit with high water contents are more vulnerable to chemical changes than dry foods and every type of food has a different degree of sensitivity to the irradiation-induced changes (1, 3, 6, 8).

If the major reason for using irradiation is the preservation of foodstuffs for long

periods of time against micro-organisms, then using low doses of irradiation cannot ensure this because the response to irradiation is proportional to the size of the population of micro-organisms. Thus, a foodstuff that has a high population density of bacterial impurity will require a very high dose of radiation to reduce the population by one half, compared to that required to deal with a mild infestation. At low doses of radiation only mild infestations can be completely eliminated in sensitive species, and at moderate to high infestations only a reduction in numbers takes place rather than an elimination (2). This is illustrated in Table 2 which demonstrates that even above the generally permissible limit of 10 kGy, significant levels of micro-organisms remain in the irradiated food. Bacteria such as *Clostridium botulinum* found in fresh meats and fish, and *Salmonella*, found in poultry, require very high doses of radiation and would require in addition chemical preservatives to fully inactivate spores and this will not eliminate the presence of toxins already produced by the bacteria (5, 9). e.g. Eliminating the bacteria that give off odours fails to indicate that botulism may be present.

Several important implications arise from these facts;

1. It is essential to know the type and magnitude of contamination by micro-organisms (or insects) **before** designing an irradiation dose to reduce the level, or completely eliminate the organism from foodstuffs. This implies **mandatory examination of each sample by experts in microbiology and/or entomology** before the irradiation takes place. This involves a high cost and a delay in the delivery time from the producer to the consumer.

2. High doses are required to eliminate high populations with attendant deterioration in quality of the food due to chemical changes. High doses mean higher costs due to the long period required of exposure to a fixed gamma-radiation source such as C0-60 or Cs-137 which usually produce dose rates of below 10 Gy/sec, thus necessitating hours of exposure to achieve the required dose.

Hence to get high through puts it is smarter to use accelerated electrons that can achieve in one second what takes hours with nuclear waste sources (2). This isn't helping the nuclear industry though but it clings to its arguments that Co-60 and Cs-137 are useful.

3. The size of a dose given to foodstuffs is controlled by three factors: Distance from the source, energy of the source; time of exposure. In addition the shape and volume of the material to be irradiated will influence one or more of the above three factors. Thus to dose a large carton, a large turkey or bulk foodstuffs, sufficient energy must penetrate right through the material to be sure that the minimum effective level of energy reaches every part so that all organisms are reached with the energy *theoretically* required to eliminate them. C0-60 is favoured over Cs-137 because it has two forms of gamma radiation with the ability to penetrate deeply; both isotopes are favoured over accelerated electrons that have low penetrability. Monitoring actual doses of irradiation in foodstuffs has indicated levels as much as *250 per cent* greater than the required dose due to variations in the three factors outlined above. C0-60 has a half-life of 5.25 y which means that about 10 per cent decays in one year, reducing the irradiation capacity and requiring careful monitoring at all times to know exactly which length of time will be required. If monitors are not inserted within the food itself to determine exactly the irradiation dose received it is only a *theoretical estimate of dose based on calculations.*

4. Every different kind of food requires different specific doses of irradiation that in turn require modification of one or more variables in the equation. Changing the time of through put and the distance from the source , the only two variables that can be changed since the radiation source is fixed, are both costly and subject to error. Inserting monitors in all the irradiated food is also

expensive.

This kind of unreliability in achieving precise actual doses in irradiated food is combined with the high capital costs ($1.3-6.0 million) of building and maintaining an irradiation plant in a safe manner. Each plant must be of sufficient size to achieve economies of scale and for any plant having a capacity of through put of less than 20 million kgs/annum, the unit costs escalate rapidly (10). For example, the average poultry processor in Canada produces approximately 5 million kgs per year, with a maximum production per processing plant close to 25 million kgs. Thus only the largest plant would even approach the limit of economies of scale and it would be uneconomic for most to own an irradiation facility.

Because an irradiation facility using a fixed source should in theory be used 24 h /day, 365 days of the year in order to operate economically, it is clear that seasonally produced foods of low value have no attraction for the operator of an expensive irradiation facility. It is presumably for the above reasons that the food processing industry world-wide has been reluctant to adopt irradiation technology. This is aside from any sensitivity of the industry to public concern about food safety. An author in Agriculture Canada's Food Market Commentary has concluded that because of high costs "**food irradiation is not likely to have application in Canada in the near future**" (10). It is therefore even less likely to be economical in developing countries.

My third question is : How safe are irradiating facilities and their associated procedures of maintenance and waste disposal, given the experience of the last quarter of a century ? According to **Atomic Energy of Canada Limited (AECL),** the organization that was billed as "the world's biggest supplier of industrial food irradiators and cobalt- 60 as an irradiation source"(11), there were about thirty plants in existence in 1989. Another **AECL** brochure is quoted (13) as claiming over 65 commercial irradiators, over 600 research and clinical irradiators, and over 80 million curies of cobalt-60 in use in more than 50 countries for medical and food uses. It is clear that only a small number of irradiators are actually used for food irradiation and the rest have applications for sterilizing medical material with very high doses of radiation.

There have been two reported serious accidents due to lack of accounting for nuclear materials in irradiation facilities. The first, in Mexico in 1983, involved melting down for scrap a cobalt-60 unit containing 450 curies of radioactive material. It was only discovered by accident when a truck containing radioactive steel happened to take a wrong turn into Los Alamos Nuclear Weapons laboratory where it set off the alarm system (14). In 1987 in the Brazilian city of Goiania a scrap metal dealer unknowingly purchased a Cs-137 gamma-ray source from an abandoned radio-therapy clinic and, fascinated by the unusual substance, he distributed it to family and friends. Over 400 people were contaminated, 60 seriously, and four people died. Only 70 per cent of the caesium was ever recovered(14). This indicates the potential dangers of irradiation facilities in developing countries that lack infrastructure, regulatory sophistication and technical experience.

Serious accidents have also happened in developed countries. In 1982 at International Nutronics, New Jersey, C-60 leaked into the shielding pool water which was then simply dumped into the public sewer system in an attempt to cover up the accident (14). A minor contamination in a C0-60 irradiator in Hawaii cost $0.5 million to clean up. In Norway a plant worker died in 1982 when exposed to the unshielded source. Between 1983 and 1988 the **Atomic Energy Control Board (AECB)** of Canada issued 181 warnings over unsafe storage and handling of radioactive materials but only one of Canada's 264 hospitals licensed to work with radioactivity has ever been prosecuted. A typical hospital irradiator has a gamma source only in the hundreds of curies but typical food irradiation plants contain millions of curies. For example, Isomedix facility in Whitby, Ontario, contains a 2-million-curie Co-60 source (14). The total radioactivity associated with the approximately 30 food irradiation facilities supposedly in operation world-wide, is of the same order of magnitude as the amount of radioactivity released from the Chernobyl accident i.e. between 25 and 50 million Curies (15) and much of this material is vulnerable to accidents during installation, replenishment and waste disposal, either during transport from nuclear reactors, human error, or , in this day and age, from terrorism, aircraft accidents and earthquakes. Proliferation of irradiation facilities, of whatever size, must inevitably lead to more accidental releases of radioactive contaminants to the environment.

My fourth question is: What are other countries thinking about the question of food irradiation? On October 11, 1989, the European Parliament voted (256 for, 65 against, 2 abstentions) to ban irradiated food throughout the European Community from the end of December, 1992, with one exception; for dried herbs and spices because of their high monetary value and often high levels of microbial contamination. Because these countries have experimented a long time with food irradiation this seems like a significant decision. Since then, the European Council of Ministers has been unable to reach a common position on food irradiation, even by a qualified majority (16) and the German Ministry of Health has made a firm commitment to oppose food irradiation.

In May, 1990, the **U.S. Food and Drug Administration (FDA)** granted approval of poultry irradiation at received doses of 3 kGy. Within one week of this approval, the 13 largest poultry companies in the U.S., representing over 65 per cent of the market, issued statements that they had no plans to use the process (16). On January 1, 1991, the U.K. lifted a ban on irradiated food despite widespread consumer opposition but a Food Commission survey of food industry leaders indicated that the vast majority have no intention of irradiating food and many of the largest (e.g., Safeway) have publicly stated that they will not allow irradiation of their foods. It is clear that many countries are firmly against any possibility of re-irradiation of previously irradiated foods. There is an unstated, but real, potential for producing toxic materials in the food from overdoses of irradiation. However, it is extremely difficult to determine whether food has been previously irradiated, and with what dose, unless it is carefully labelled in such a way that labels cannot be switched, thus the potential for deception and error is high.

This brings me to my fifth question: How dangerous to humans and other higher animals is the consumption of irradiated natural or processed foodstuffs ? The classical human study was a report from the National Institute of Nutrition in India published in a scientific peer-reviewed journal (17). It indicated the incidence of polyploidy (doubling or trebling of the normal chromosomal genetic DNA) in malnourished children fed irradiated wheat. Despite many attempts by the nuclear industry to refute these studies, no formal refutation of the findings of these workers has been published in a peer-reviewed scientific journal. While these particular studies can be criticised because of the small sample sizes, a more recent study in China (18) of seventy healthy subjects concluded that the group fed irradiated foods had a higher level of chromosomal abnormalities than the control group. Many studies have indicated that irradiated foods lose vitamin content, particularly vitamins A, C, E and some of the B complex (19,20,21). There is no question about the fact that irradiation causes the formation of free radicals (Highly reactive fragments of irradiated molecules) that can either immediately attach themselves to other molecules to form unique new molecules with unknown and perhaps hazardous properties, or remain free for periods of time to later attach themselves with similar effects. The debate has been over how much of these radiolytic products might be produced in specific foodstuffs by particular doses of irradiation and whether they remain as a potential hazard for long periods of time in irradiated food. The facts are that we know very little about the potential effects of any of these radiolytic products, even though it can be demonstrated that just cooking food may produce some of these substances. To evaluate these substances produced by irradiating food, in terms of their long-term effects on human health, would require a huge international effort over many years to reach any scientifically sound conclusion. It seems a silly thing for any country to embark on such expensive evaluation, just because a nuclear industry that is in technical and economic difficulties wishes to push a new technology that nobody really wants. There is no reason to adopt every new technology that is suggested, particularly if that technology cannot compete economically. At the present time most food processors consider that irradiation is too expensive and less effective than other existing methods of food preservation (10, 22).

I am a biologist, and deeply concerned about the build-up of radio-nuclides in the biosphere as a result of the deliberate and accidental contamination of air, water and soil. This has arisen from nuclear bombs, bomb-testing, high- and low-level nuclear wastes from military and commercial nuclear reactors and the numerous accidents associated with these activities. Chernobyl is the name, deeply etched on the public mind, that indicates what happens when things go wrong. It is important to understand that these highly toxic nuclear materials with long half-lives remain for tens, or hundreds of thousands, of years in the biosphere. Food irradiation plants are just extensions of the mind-set of nuclear physicists and engineers intent on pushing their technology to an often confused public. The ultimate biological implications of nuclear contamination are generally glossed over by those who have faith in technology. Large amounts of public monies have been spent by the nuclear industry in the rich countries to advertise to, and coerce, the public into acceptance of the "spin-offs" that help to stave off the inevitable bankruptcy of an inappropriate technology. I have studied the way **AECL** has attempted to pass off first a 'Slowpoke' nuclear reactor and more recently a CANDU III reactor on the people of Saskatchewan on the grounds that it creates jobs. The real purpose though is to use a Canadian province as a show-room for selling reactors to developing countries. An exactly similar approach has been used by **AECL,**using the Federal Government Agency **CIDA** to foist food irradiation plants on such countries as Thailand (16), Chile, Peru, Jamaica and Mexico (14).

The uranium pathway through mining, weapons, nuclear reactors and food-irradiation plants leads ultimately to high- and low-level, extremely toxic, radio-nuclide wastes for which there is no known way of ever eliminating them from the biosphere. At every step along this pathway accidents can, have, and will continue to happen so that step by step the radio-nuclide7. contamination of the globe spreads and increases year by year. There are moral, ethical, biological and even economic reasons why we should take every step to prevent further contamination of this planet. The one problem that everyone in the rich world can agree on, particularly in Canada, is that we are not starved of food because obesity (and associated heart attacks) is the number one health problem. Expensive methods of trying to preserve foods such as irradiation can help only those who profit from the sale of food. In developing countries there can be no argument at all for food irradiators because the great majority of people live in rural areas, producing and consuming their food in villages.

I will end by reminding you of the six points I have tried to explain.

1. Only the nuclear industry wants to irradiate food.
2. Irradiation of food cannot eliminate micro-organisms within the dose range that produces minimal change in food quality. Conversely, high irradiation doses that can eliminate a majority of microbial contamination cause serious reductions in the quality and nutritional value of foodstuffs and increase contamination with potentially toxic radiolytic products.
3. Irradiation plants are prohibitively expensive, unreliable and potentially hazardous to the general public in the event of a serious accident. High-level nuclear wastes from irradiation plants add to the overload of nuclear contamination of the biosphere.
4. In a majority of developed countries both the consumer and food industry are sceptical of the safety and economic viability of irradiation plants and irradiated foods.
5. Scientific evidence shows that food irradiation can induce the production of substances harmful to human beings and other higher animals.
6. National and international adoption of food irradiation inevitably leads to global contamination of the biosphere with radio-nuclides.

I end my arguments by suggesting to you that there is an analogy between the technology of food irradiation and the technology of the famous Trojan horse. There are more hidden dangers in food irradiation than meet the eye! In other respects we would be wise to remember an old parental admonition: “Beware of strangers bearing gifts, they could well be wolves in sheep's clothing”.

References:

1. Fillmore, N., Wordsworth, A. 1987. The Blast Supper. This Magazine. Mar./Apr. p. 16.
2. Farkas, J. 1988. Irradiation of dry food ingredients. C.R.C. Press, Boca Raton, U.S.A.
3. Blackholly, H., Thomas,P. 1989. Review of Food Irradiation in Context of U.K. and E.C. Legislation. Technological Implications; Consumer, Retailer and Manufacturer Attitudes.The Food Policy Research Unit. University of Bradford, West Yorkshire. ISBN 1-871099-13-7.
4. Barna, J. 1979. Compilation of bioassay data on the wholesomeness of irradiated food items. Acta Alimentaria 8: 205.
5. Piccioni, R. Testimony (June 19) before the Sub-Committee on Health and the Environment of the House of Committee on Energy and Commerce. U.S. Congress, Washington, D.C.,U.S.A.
6. Collins, M. 1987. Food Irradiation. Report of the Standing Committee on Consumer and Corporate Affairs on the question of food irradiation and the labelling of irradiated foods. House of Commons, Ottawa. Canada.
7. Sun, M. 1984. Renewed interest in food irradiation. Science 223: 667-668.
8. Abraham, M. 1987. International Organization of Consumer Unions; Statement on food irradiation. Regional Office for Asia and Pacific. I.O.C.U. Penang, Malaysia.
9. Anderson, A. W. 1967. The effect of additives on radiation-resistant spores of *Clostridium botulinum* in meat. Microbiological problems in food preservation by irradiation. Panel Proceedings. International Atomic Energy Agency, Vienna.
10. Krystynak, R. 1986. Current Concerns. Food Irradiation: An economic perspective. Agriculture Canada. Food Market Commentary 8: (3) 17-24.
11. Anonymous. 1989. Up front - a fresh approach to food irradiation. Atomic Energy of Canada Limited. Pamphlet.
12. Stirling, J. 1989. Food Irradiation. Bridges. Fall 1989. p. 21.
13. Fillmore, N., Wordsworth, A. 1985. Food Irradiation and the Nuclear Industry. This Magazine pp. 15-22.
14. Kock, I. 1988. The facts about food irradiation. Nuclear Awareness Project. Box. 2331 Oshawa, Ontario. ISBN 0-9693642-0-2.
15. International Atomic Energy Agency. 1991. International Chernobyl Project: An overview. IAEA. Vienna. ISBN 92-0-12091-8.
16. Morris, M. 1991. FIN LINK-3. Food irradiation network. Number three, p. 7. Food and Water Corporation Inc., Box 770, Blairstown, New Jersey, U.S.A.
17. Bhaskaram, C., Sadasivan, G. 1975. Effects of feeding irradiated wheat to undernourished children. Am. J. Clinical Nutrition 28: 130-5.
18. Shanghai Institute of Radiation Medicine and Shanghai Institute of Nuclear Research. 1987. Safety evaluation of 35 kinds of irradiated human foods. Chinese Medical Journal 100:715-18.
19. Wierbicki, E. *et al.* 1986. Ionizing energy in food processing and pest control. Part I. Council for Agricultural Science and Technology, July 1986.
20. Khattak, A. B., Klopfenstein, C. F. 1989. Effects of gamma irradiation on the nutritional quality of grains and legumes. Cereal Chemistry 66: 171-72.
21. Raica, N., Scott, J., Nielson, N. 1972. Nutritional quality of irradiated foods. Radiation Research Revue 3: 447-57.
22. Louria, D. B. 1990. Zapping the food supply. Bulletin of the Atomic Scientists 45: 34-36.

Table 1. An evaluation of scientific papers in the food-irradiation literature to identify adverse effects of irradiated food on animals. (Barna, J. 1979).

Focus of paper.	**Numbers of papers and type of effect.**		
	Adverse	**Neutral**	**Beneficial**
General	1,414	7,191	185
Bacon	31	86	Zero
Soybeans	60	26	Zero
Sucrose	39	38	1
Corn oil	13	5	Zero

Table 2. Effects of irradiation on total aerobic viable cell count (TAVC) of some dehydrated vegetables. (Farkas, J. 1988).

	Log TAVC/gram						
		Irradiation at kGy					
Product	**Control**	**4**	**5**	**7.5**	**8**	**10**	**15**
Asparagus powder	6.0	-	4.8	4.3	-	4.0	3.0
	5.9	-	-	-	4.1	4.0	-
	5.6	2.9	-	-	-	-	-
Asparagus tips	6.7	-	5.1	4.3	-	3.0	2.0
Carrots	4.8	2.7	-	-	-	-	-
Celery Roots	5.0	-	2.0		-	-	-
Mushroom powder	4.9	-	3.3	3.0	-	<2.0	-
	4.7	3.1	-	-	-	-	-
Mushroom slices	5.8	-	3.3	<3.0	-	<2.0	-
Tomato powder	5.8	-	-	-	3.0	-	-
Yellow Boletus							
Cut	5.3	-	3.7	3.0	-	2.3	2,3
Ground	7.0	-	4.3	3.3	-	2.0	2.0
