Food Irradiation - Problems and Promises

by J.R. Hickman

It has been stated that food irradiation represents the most significant discovery in food processing since Nicholas Appert invented canning in 1810. Certainly it is a process with great future potential; it is attractive because it works without heating the product, it is effective within sealed containers as well as for bulk usage, and it does not leave chemical residues on the treated food.

Of course, no one process can be expected to solve all problems relating to preservation of food. Ionizing radiation can be used effectively to solve many of these problems, but the process is no panacea to cure the world's food problems. Unfortunately, early ill-founded claims about irradiation led to expectations which have proved beyond the reasonable capabilities of the process. Nevertheless, the number of foods that have been successfully treated, and the broad range of effects that can be achieved by radiation processing is impressive *(Table I).*

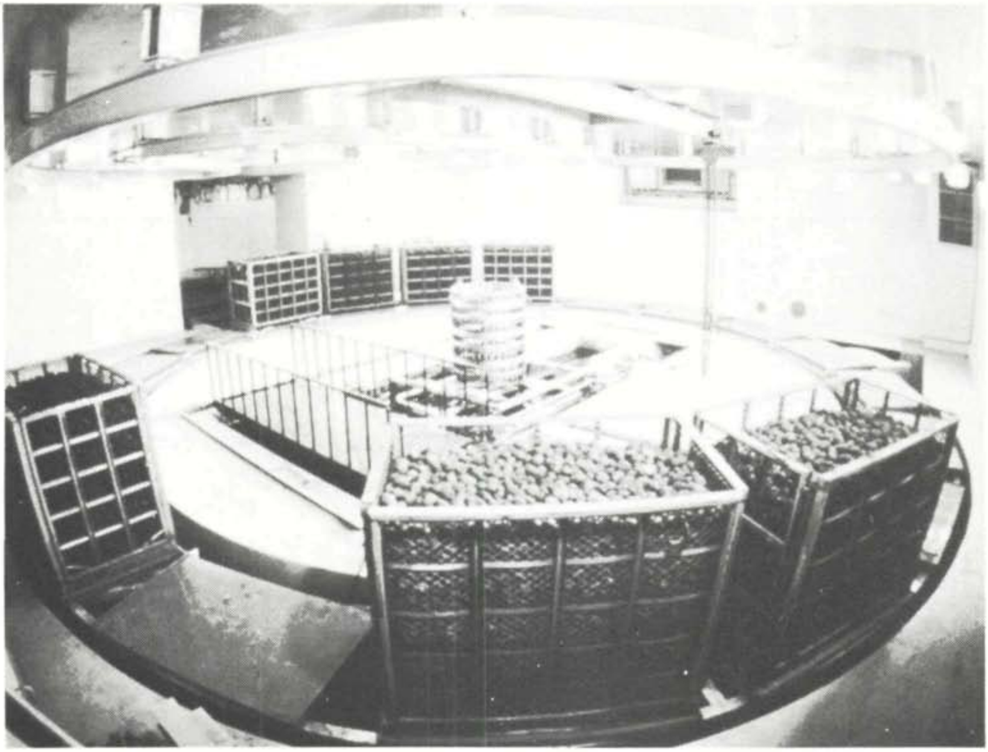
The potential advantages of food irradiation have been sufficient to arouse the interest of food scientists in more than 55 nations during the past 25 years. During the earlier years of this period, research was undertaken mainly in the developed countries, with emphasis on those processes aimed at improving food quality — a goal consistent with the demand for higher food quality that has accompanied rising affluence in these countries. More recently many of the developing nations of the world have realised the potential offered by irradiation for reduction of the tremendous losses which occur after harvest. Today, it seems probable that food irradiation may be first applied on a significant scale in developing nations where climatic conditions are often characterized by high temperatures and excessive humidity which are conducive to food spoilage, and where alternative technologies (e.g., freezing), which provide competition for irradiation, may not already exist.

Results of laboratory research on food irradiation have been impressive and a number of pilot scale food irradiation plants have been built throughout the world. These have permitted large scale quality assessment, market trials and the treatment of large quantities of food used in animal feeding trials (necessary to assess wholesomeness of the product). According to figures available to the IAEA, the number of pilot plants commissioned by 1972 was 27 - more than double the number that existed in 1966 [1]. Pilot plants are located in no less than seven of the world's developing nations.

Experience gained with pilot plants has been encouraging. Market trials in several countries, including Canada, Hungary, Israel, the Netherlands and Thailand, have demonstrated that the consumer will accept irradiated food. Experience has been gained in consumer education programs about irradiated food in several countries.

The modern potato irradiation plant in Hokkaido, Japan. (Above) ▲

This appetising-looking meal has been wholly prepared with irradiated components: beef steak preserved by radappertization (4.7 - 5.7 Mrad) and baked potato treated after harvest with gamma radiation (5,000 - 15,000 rads) for sprout inhibition. Photo: US Army (Below) ▶



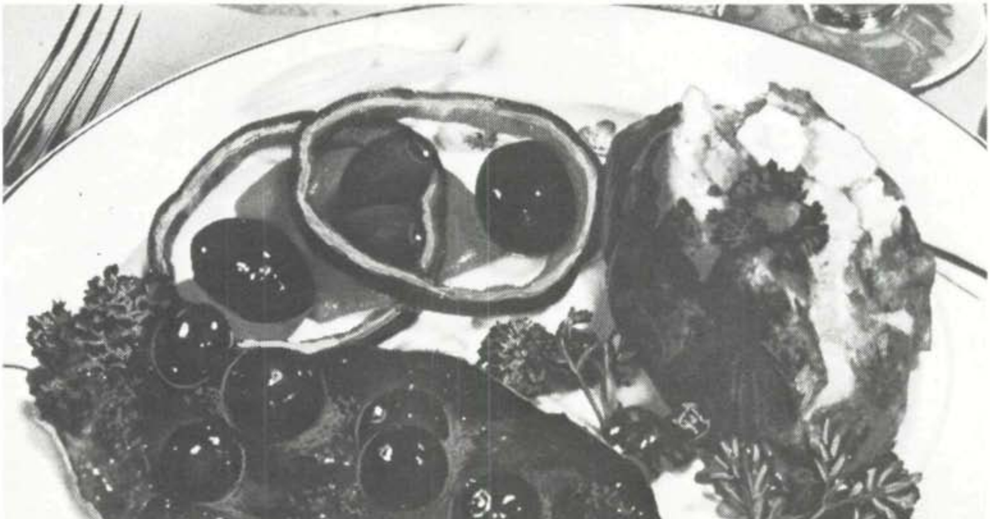


TABLE 1. – SOME POSSIBLE APPLICATIONS OF IONIZING RADIATION TO THE TREATMENT OF FOOD*

Group	Food	Main objective	Means of attaining the objective	Dosage (Mrad)
(a)	Meat, poultry, fish and many other highly perishable foods	Safe long-term preservation without refrigerated storage	Destruction of spoilage organisms and any pathogens present, particularly *Cl. botulinum*	4-6[1]
(b)	Meat, poultry, fish and many other highly perishable foods	Extension of refrigerated storage below 3°C	Reduction of population of micro-organisms capable of growth at these temperatures	0.05-1.0
(c)	Frozen meat, poultry, egg and other foods liable to contamination with pathogens[2]	Prevention of food-poisoning	Destruction of salmonellae	0.3-1.0[3]
(d)	Meat and other foods carrying pathogenic parasites	Prevention of parasitic disease transmitted through food	Destruction of parasites such as *Trichinella spiralis* and *Taenia saginata*	0.01-0.03
(e)	Cereals, flour, fresh and dried fruit and other products liable to infestation	Prevention of loss of stored food or spread of pests	Killing or sexual sterilization of insects	0.01-0.05
(f)	Fruit and certain vegetables	Improvement of keeping properties	Reduction of population of molds and yeasts and/or in some instances delay of maturation	0.1-0.5

Group	Food	Main objective	Means of attaining the objective	Dosage (Mrad)
(g)	Tubers (for example, potatoes), bulbs (for example, onions), and other underground organs of plants	Extension of storage life	Inhibition of sprouting	0.005-0.015
(h)	Spices and other special food ingredients	To minimize contamination of food to which the ingredients are added	Reduction of population of microbes in the special ingredient	1-3

1 There is evidence that a lower dose might suffice for certain cured products.
2 Including animal feeds.
3 A higher dose may be needed if pathogens with greater resistance to radiation are present.
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Legislation and Wholesomeness

It has always been recognized that a clear demonstration of the safety of irradiated food for consumption must precede any commercial application of the process. As early as 1954, officials of the US Food and Drug Administration published procedures which would permit an assessment of the wholesomeness of irradiated foods [2]. In 1964, an Expert Committee was convened by FAO, IAEA and WHO to recommend on the technical basis for legislation on irradiated food [3]. This was probably the first time in history that such recommendations largely preceded the commercial application of a food process in an attempt to influence legislation, and thus assume a common approach to legislation which will facilitate international trade in the future.

A large number of individual irradiated foods have been examined, using the extensive toxicological screening tests that were recommended by the 1964 Expert Committee and by a subsequent Committee convened by the international agencies in 1969 [4]. Three years ago an important international co-operative effort was initiated by FAO/IAEA and the OECD Nuclear Energy Agency to provide further wholesomeness data on irradiated potatoes and wheat for the World Health Organization's evaluation of their safety for consumption. To do this, the International Project in the Field of Food Irradiation was set up at Karlsruhe in the Federal Republic of Germany; twenty-two countries participate financially in this project. Additionally, fish, rice, spices and mangoes are being investigated now or will be studied in the immediate future. The FAO/IAEA Joint Division acts as a collection centre for information on wholesomeness data.

Health authorities in 17 countries have now examined evidence for wholesomeness and have given permission for one or more irradiated food items to be consumed by the general

TABLE 2. CLEARANCES GRANTED FOR IRRADIATED FOODS IN VARIOUS COUNTRIES*

A. CLEARANCES FOR PUBLIC CONSUMPTION (UNRESTRICTED AMOUNTS)	
Potatoes (g)**	Canada, Denmark, France*** Israel, Italy, Japan Netherlands, Spain, Philippines, Uruguay*** USA, USSR
Onions (g)	Canada, Israel, Italy, Thailand
Garlic (g)	Italy
Wheat flour and/or/wheat (e)	Bulgaria, Canada, USA, USSR
Dried Fruits (e)	USSR
Mushrooms (f)	Netherlands
Dry food concentrates (e)	USSR
B. CLEARANCES FOR EXPERIMENTAL BATCHES	
Potatoes (g)	Bulgaria, Hungary
Onions (g)	Bulgaria, Hungary, Netherlands, USSR
Fresh fruits & vegetables (f)	Bulgaria, USSR
Dried fruits & dry food concentrates (e)	Bulgaria
Asparagus (f)	Netherlands
Strawberries (f)	Hungary, Netherlands
Cocoa beans (e)	Netherlands
Spices & condiments (h)	Netherlands
Prepared & semi-prepared meat products (b)	USSR
Poultry (b,c)	Canada, Netherlands, USSR
Fish (b)	Canada
Shrimps (b)	Netherlands
Foods for hospital patients	Germany (F.R.), Netherlands, UK

* Status at 31 Dec. 1973
** Type of process by Group (see Table 1)
*** Temporary clearance for 5 years.

public *(Table 2)*. Among the irradiated commodities cleared in one or more countries are potatoes, onions, garlic, dried fruits, mushrooms, spices and wheat. It is noteworthy that there has been a considerable increase in the number of countries clearing irradiated commodities during the past 3 years, and that the variety of irradiated food items approved has increased also. This is an encouraging development; in the past, difficulties of obtaining clearances from the public health authorities have been regarded by some as major deterrents to progress in this field.

First steps in commercialization

There are signs now that we are about to enter the commercialization phase in the introduction of food irradiation technology. During 1973, there were two encouraging

(continued on page 43)

developments in this respect – the successful introduction of commercial onion irradiation in Thailand and the commissioning of a large commercial potato irradiator in the Hokkaido region of Japan. It is expected that economic feasibility will become evident from ventures such as these. If fears over the economic risks involved in the introduction of this new process and fears about consumer resistance towards irradiated products are dispelled, it may be expected that many more commercial ventures in food irradiation will occur in the next few years.

A role for irradiation in solving the world food problem

The world once more faces threat of famine. Man has increased agricultural production significantly in recent years. More land has been pressed into production through, for example, irrigation schemes, and varieties of crops have been developed which produce increased yields. However, such measures have achieved only limited succes. In spite of the much-acclaimed Green Revolution, the 92 developing nations of the world raised their food production by only 2.8% per year during 1961-71; during the same period, population increased by 2.6% per year in these countries [5].

The delicate balance that exists between food supply and needs was tragically demonstrated in the food shortages of 1973 which have led to proposals from FAO, supported by a number of governments, to set up and maintain an international food bank to manage food reserves.

The problems of food storage are, however, significant. Tremendous losses of food occur each year due to the ravages of insects, vermin and due to microbial spoilage. Various authors have been quoted by Goresline to show that food losses through spoilage after harvest can be estimated equivalent to the production from 12 million acres of land, or 33 million tons of grain; another estimate is that the world food supply could be increased by 25% - 30% if post-harvest losses could be avoided [6]. Such losses represent losses in soil fertility, manual labour and monetary expenditure as well as loss of product. Equally important in a world newly conscious of its limited energy resources, agricultural production is achieved only at the expense of vital energy reserves; in the United States, an average of 150 gallons of gasoline per person per year is required to grow and harvest food, and the fertilizer industry consumes about 3% of the natural gas supply [7]. Thus, very real gains are possible through prevention of losses presently suffered during storage of food. There is no doubt that irradiation preservation could play an important role in preventing a large part of these food losses.

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