Progress and Future Tasks in Food Irradiation

TWO RECENT MEETINGS IN INDIA

Six years after the first International Symposium on Food Irradiation which was held in Karlsruhe, FRG, the second similar gathering took place last November in Bombay, India. The Food and Agriculture Organization of the UN and the International Atomic Energy Agency convened the meeting to review progress made, as well as the tasks still ahead, in the use of atomic energy for preserving food.

A total of 106 representatives from 29 countries and 4 international organizations attended the Symposium which was addressed by His Excellency **Shri C. Subramaniam**, Union Minister for Industrial Development, Science and Technology. The Symposium was followed by a Panel meeting of 44 scientists from 19 countries and 2 international organizations. This Panel considered the application of food irradiation specifically in developing countries, and two thirds of the membership consisted of experts working in the less developed areas of the world.

From the total of 61 papers presented at the two meetings, as well as from the discussions, a clear picture of the present status of food irradiation emerged, and the tasks still to be solved to promote practical application could be delineated.

It is a recognized fact that, in order to secure successful application of any food processing method, it has to be proved (1) that it is technically advantageous, (2) that it is economically viable, i.e. the costs involved in the process are less than the benefits which can be derived from it and (3) that it is a wholesome procedure, i.e. that the food so processed is safe for human consumption.

TECHNICAL FEASIBILITY

In the field of radiation control of **physiological processes** in plants, the possiblity of preventing sprouting of **potatoes** and **onions** by low doses of ionizing radiation has long been demonstrated. Detailed information on the chemistry of some of these changes was presented at the Symposium. One of the papers reported on the analogous, successful application of gamma rays to treat **yams** against sprouting. In some developing countries, especially in Africa, this is of great interest to the national economy, since no alternative treatment with chemicals proved to be practicable for yams.

Another new application, reported at the Symposium, was the **combined treatment** (radiation + chemical) of potatoes and onions to prevent sprouting and rotting.

Radiation inhibition of sprouting of **soybeans** was shown to be applicable for a new purpose. Irradiation of soybeans in the process of germination resulted in the reduction of the oligosaccharide content of the beans leading to a product which does not cause the well-known phenomenon of flatulence (excessive gas-formation in the intestines of man after eating beans); at the same time, faster cooking soybeans can be produced in this way.

Bags of irradiated and non-irradiated onions: the latter have sprouted . . . . . University of Michigan, USA ▶

The **microbicidal actions** of radiation were shown to remarkably improve the quality of **maize starch** preparations, thus improving the **hygienic characteristics** of foods prepared with starch. The same was shown for **mixed seasonings** and **paprika powder**: meat products prepared with irradiated spices had to be heated less (at lower temperature or for a shorter heating time) and kept longer than those contaminated by the usually high bacteria content of the non-treated spices. Irradiation of **wiener sausages** and of a Japanese fish-paste product, called **"kamaboko"** – combined with heat treatment has been reported to prolong storage stability considerably.

Several papers have dealt with the radiation preservation of **fish** and other **seafoods** either held at temperatures below + 3°C, or in cooked or in dried state. All new evidence confirmed the technological feasibility of this treatment which is of utmost potential importance for the preservation of the main protein source of a number of developing nations. In an agreement with a few earlier reports (see also article "Storing Meat Products for Several Years" in this issue), it could be demonstrated that high-dose radiation sterilization (**radappertization**) of **meat, meat products** and **poultry** is a practical possibility if it is combined with a mild heat treatment to inactivate radiation resistant proteolytic enzymes of the tissues. Products of practically unlimited shelf-life can be produced in pouches; without the necessity of using refrigeration. On the other hand, a low-dose procedure was also developed for the prolongation of keeping quality (**i.e. radurization**) of refrigerated retail cuts of meat (to 3 weeks at 3°C). Furthermore, it was shown that low-dose treatment to control pathogenic bacteria (**radicidation**) could be of immense benefit to public health protection, an advantage similar in importance to milk pasteurization.

Basic aspects of the action of radiation on microbial cells were also exposed and some interesting combined treatments involving radiation and another, physical or chemical, agent suggested (**e.g.** application of high hydraulic pressures to promote germination of bacterial spores with subsequent irradiation of germinated spores which thus became sensitive to ionizing radiations and die off more rapidly and completely).

Elimination of **insect damage** in a number of food items continued to absorbe the attention of several scientists working on food irradiation. It was confirmed in laboratories of various countries that radiation disinfestation is a highly practical proposition to control insects in **grain, flour, peanuts, walnuts, dried fruits** and **potatoes,** the latter being an interesting application aiming at the simultaneous inhibition of insect infestation and of sprouting. It was shown that radiation disinfestation of the above products did not deteriorate their technological properties. Special importance must be assigned to the radiation disinfestation of **fresh fruits** and **vegetables** for **quarantine** purposes, i.e. to facilitate intercountry trade of fruits without the risk of infesting the importing country with dangerous insects inhabitating the fruit.

To complete the review of progress in technical feasibility studies, new methods of **dosimetry**, especially suitable for food irradiation facilities, were also presented at the Symposium.

ECONOMIC FEASIBILITY

It appears from all that has been said above that, technologically speaking, a large number of practical applications of ionizing radiations is feasible and advantageous: irradiation could substitute a number of alternative traditional methods of food preservation and/or could cope with a number of special problems which cannot be solved by older procedures.

However, as with all technological processes, no practical application can be envisaged for a technologically advantageous procedure if its economics are not promising enough, at least in the not too distant future.

The study of economic feasibility of food irradiation, has, therefore, caught the attention of several experts who reported on the results of their calculations to both meetings.

Some **theoretical treatises** described the factors to be taken into account in economic feasibility assessment, as well as the methods of calculation. Special attention was drawn to the characterisation of the products to be processed, to the seasonality of certain agricultural produce, to the characterization of the irradiation facility and the energy sources as well as to the finances and investment requirements.

Some economic calculations based on limited-scale **practical experience** were also presented. Commercial application of radiation disinfestation of **papayas** – combined with hot water treatment – for quarantine purposes and to prolong keeping time was demonstrated. Also, economic calculations relating to a pilot plant, to be built in 1973, designed to treat **maize starch** in 50-kg sacks at a dose level of 250 ± 25 krad and a through-put capacity of 10 to 40 tons/day were presented. – Optimization studies on the economics of a disinfestation plant designed to treat **millet, sorghum** and **kidney beans** in an African country also were presented.

It was finally agreed that economic evaluation of all projects to irradiate food commodities should be carried out before larger-scale technological experiments are initiated. All developing countries starting such studies were urged to prepare a thorough cost vs. benefit study of the irradiation of every specific food item to be irradiated. It was found reassuring that such calculations already exist in a number of developing countries.

Theoretically, all aspects of a valid economic calculation have been envisaged, at least all those that can be thought of on the basis of present-day experience. It is clear, however, that economic feasibility can really be assessed on the basis of practical, large-scale tests only. As with all industrial processes, here, too **scaling-up** is an important exercise not only from the technological but also from the economic point of view.

It is apparent therefore, that factual evaluation of economic feasibility can only be carried out in an industrial-sized irradiation plant. This requirement again presupposes the availability of official public health acceptance of the irradiated product, since no large-scale experiment can possibly be performed without having the assurance that the processed product may be sold to the general public without restriction. It is therefore an absolute necessity to get prior public health clearance for the product concerned.

WHOLESOMENESS

Safety for consumption has, thus, become a central topic of both the Symposium and the Panel.

A number of original contributions have dealt with the subject and reported on the results of experiments carried out at various laboratories in the world on the wholesomeness of different food items as assessed by the usual animal tests.

Acute and **chronic toxicity tests** with irradiated **wheat,** dehydro-irradiated **shrimps,** irradiated **whole diets, enzyme-inactivated beef, maize starch, strawberries, mushrooms** and **chicken,** as well as model substances like **sucrose solutions** were reported. All of them indicated that no toxicity could be demonstrated for the irradiated items. The same was true for the sub-mammalian system **Tetrahymena piriformis,** as well as for the recently advocated new tests for dominant lethals and for the host-mediated assay and the observations on tissue formation during embryonic development.

It was reported that in certain countries irradiated complete diets were being tested for their wholesomeness. For the sake of comparison, feeding studies on heat-processed foods are normally carried out simultaneously.

GENERAL SURVEY OF IRRADIATED FOOD PRODUCTS CLEARED FOR HUMAN CONSUMPTION IN DIFFERENT COUNTRIES

(Grouped according to product) November 1972

PRODUCT	COUNTRY	PURPOSE OF IRRADIATION	SOURCE OF RADIATION	DOSE (Krad)	DATE OF APPROVAL
Fruits & Vegetables					
POTATOES	USSR	sprout inhibition	^{60}Co	10	14 Mar 1958
	Canada	sprout inhibition	^{60}Co	10 max.	9 Nov 1960
				15 max.	14 Jun 1963
	USA	sprout inhibition	^{60}Co	5 - 10	30 Jun 1964
	(white potatoes)		^{137}Cs	5 - 10	2 Oct 1964
			^{60}Co + ^{137}Cs	5 - 15	1 Nov 1965
	Israel	sprout inhibition	^{60}Co	15 max.	5 Jul 1967
	Japan	sprout inhibition	^{60}Co	15 max.	30 Aug 1972
	WHO **)	sprout inhibition	^{60}Co or ^{137}Cs	15 max.	12 Apr 1969
	Spain	sprout inhibition	^{60}Co	5 - 15	4 Nov 1969
	Hungary *)	sprout inhibition	^{60}Co	10	23 Dec 1969
			^{60}Co	15 max.	10 Jan 1972
	Denmark	sprout inhibition	10 MeV electrons	15 max.	27 Jan 1970
	Netherlands	sprout inhibition	^{60}Co	15 max.	23 Mar 1970
			4 MeV electrons	15 max.	23 Mar 1970
ONIONS	Canada	sprout inhibition	^{60}Co	15 max.	25 Mar 1965
	USSR *)	sprout inhibition	^{60}Co	6	25 Feb 1967
	Israel	sprout inhibition	^{60}Co	10 max.	25 Jul 1968
	Netherlands *)	sprout inhibition	^{60}Co	15 max.	5 Feb 1971
			4 MeV electrons	15 max.	5 Feb 1971
	Thailand	sprout inhibition	–	–	Sep 1972
DRIED FRUITS	USSR	insect disinfestation	^{60}Co	100	15 Feb 1966
FRESH FRUITS & VEGETABLES	USSR *)	radurization	^{60}Co	200 - 400	11 Jul 1964
MUSHROOMS	Netherlands	growth inhibition	^{60}Co	250 max.	23 Oct 1969
			4 MeV electrons	250 max.	23 Oct 1969
ASPARAGUS	Netherlands *)	radurization	^{60}Co	200 max.	7 May 1969
STRAWBERRIES	Netherlands *)	radurization	^{60}Co	250 max.	7 May 1969
			4 MeV electrons	250 max.	7 May 1969
COCOABEANS	Netherlands *)	insect disinfestation	^{60}Co	70 max.	7 May 1969
			4 MeV electrons	70 max.	7 May 1969
SPICES & CONDIMENTS	Netherlands *)	radicidation	^{60}Co	800 - 1000	13 Sep 1971
			4 MeV electrons	800 - 1000	13 Sep 1971

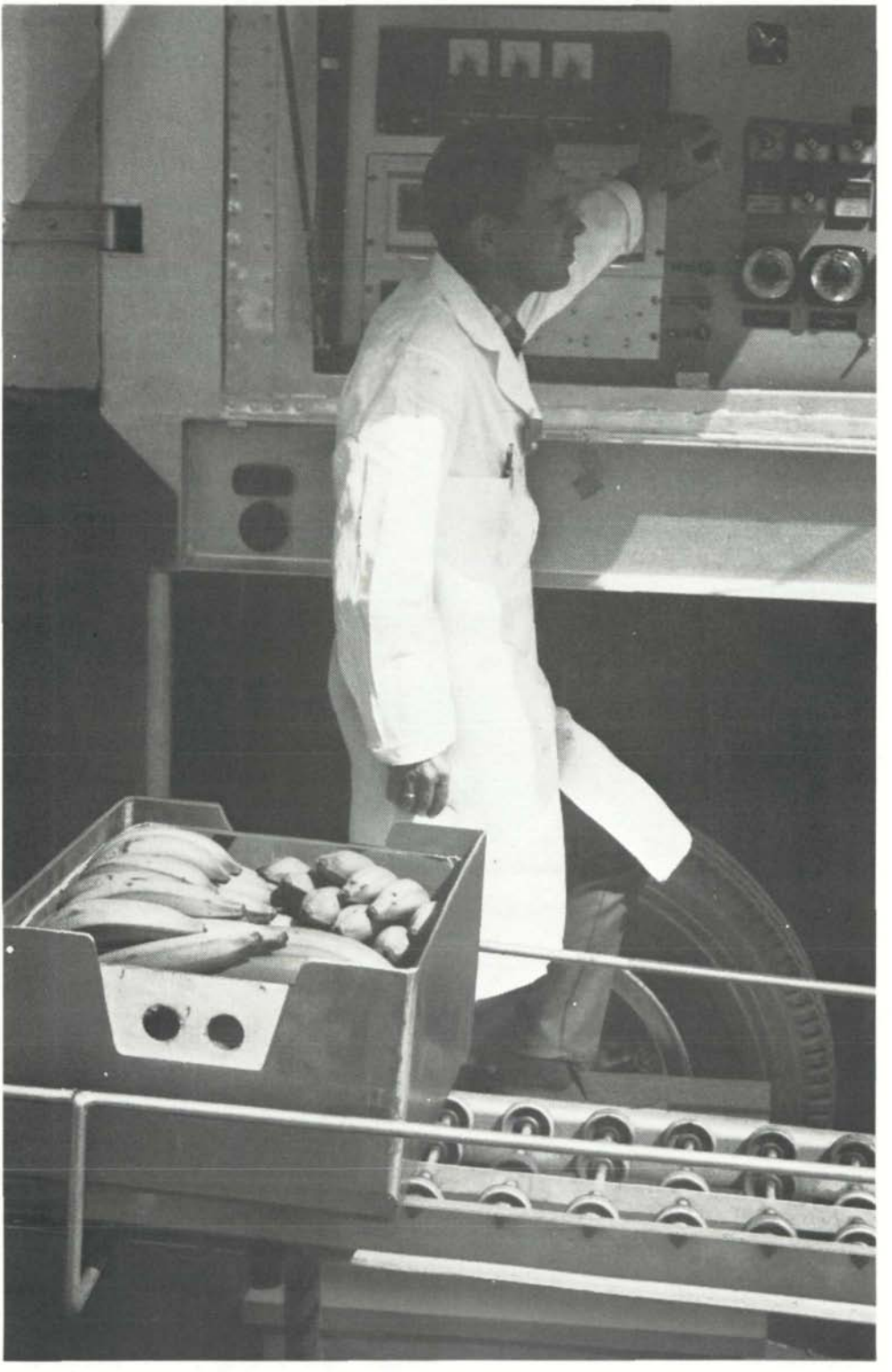
*) experimental batches **) temporary acceptance

It was further pointed out that large-scale animal testing of irradiated complete diets has been underway for at least the last 6 years due to the fact that the **laboratory animals industry** needs, and has ordered, sterile irradiated (radicidized or radappertized) diet to grow animals on feed which is free of specific pathogenic organisms (: SPF-animals) or on feed completely free of any living microorganisms (: germ-free, GF-animals).
In one country 250 tons of this radappertized diet is sold annually, in another, the figure is 100 t/yr.
In none of the tens of thousands of animals has any harmful effect been observed. In fact, these animals are greatly sought-after by an ever-growing number of commercial breeders of laboratory animals.

PRODUCT	COUNTRY	PURPOSE OF IRRADIATION	SOURCE OF RADIATION	DOSE (Krad)	DATE OF APPROVAL
Grain & Grain Products					
GRAIN	USSR	insect disinfestation	^{60}Co	30	1959
WHEAT & WHEAT FLOUR (changed on 4 March 1966 from WHEAT PRODUCTS)	USA	insect disinfestation	^{60}Co ^{137}Cs 5 MeV electrons	20 - 50 20 - 50 20 - 50	21 Aug 1963 2 Oct 1964 26 Feb 1966
WHEAT, FLOUR, WHOLE WHEAT FLOUR	Canada	insect disinfestation	^{60}Co	75 max.	25 Feb 1969
WHEAT & GROUND WHEAT PRODUCTS	WHO **)	insect disinfestation		75 max.	12 Apr 1969
Meat & Fish					
SEMI-PREPARED RAW BEEF, PORK & RABBIT PRODUCTS (in plastic bags)	USSR *)	radurization	^{60}Co	600 - 800	11 Jul 1964
POULTRY, EVISCERATED (in plastic bags)	USSR *)	radurization	^{60}Co	600	4 Jul 1966
	Netherlands *)	radurization	^{60}Co	300 max.	31 Dec 1971
CULINARY PREPARED MEAT PRODUCTS (FRIED MEAT, ENTRECOTE) (in plastic bags)	USSR *)	radurization	^{60}Co	800	1 Feb 1967
SHRIMPS	Netherlands *)	radurization	^{60}Co 4 MeV electrons	50 - 100 50 - 100	13 Nov 1970 13 Nov 1970
Other Products					
DRY FOOD CONCENTRATES	USSR	insect disinfestation	^{60}Co	70	6 Jun 1966
ANY FOOD for consumption by patients who require a sterile diet as an essential factor in their treatment	UK	radappertization			1 Dec 1969
DEEP-FROZEN MEALS	Netherlands ***)	radappertization	^{60}Co	2500 min.	27 Nov 1969
FRESH, TINNED AND LIQUID FOODSTUFFS	Netherlands ***)	radappertization	^{60}Co	2500 min.	8 Mar 1972

*) experimental batches **) temporary acceptance ***) for hospital patients in reversed barrier isolation

It was apparent that, in the future, more wholesomeness studies on complete diets should be carried out on a comparative basis, **i.e.** irradiation should be **compared with other,** now accepted **technological processes,** such as heating. Also, the growing tendency to apply **analytical** and **integrated approaches** to replace testing individual food items was noticed, in other words, tracing specific effects and applying integrated diets was advocated.
It was recognized with satisfaction that despite all difficulties, over the last 6 years, the **number of irradiated food items authorized,** with or without restriction, **grew from 8 to 19** and the **number of countries** accepting one or more irradiated foods for human consumption **increased from 3 to 11** (see list of clearances). It is significant that most of this increase occurred during the last 3 years.



TASKS AHEAD

The general conclusions of the two meetings can be summarized as follows.

Radiation preservation of a great number of food items is a viable proposition from the point of view of technological advantages.

In order to be able to assess the viability of the process from the economic viewpoint, larger-scale technological experiments should be carried out in greater numbers in pilot plants to be erected specifically for economic evaluation.

The economic benefits of the process of food irradiation should always be assessed very carefully before embarking on large-scale industrial trials. These should be based on actual economic facts, but envisaging development that can be expected in the near future. In these studies, due consideration should be given to all public health, agricultural, technological, commercial and psychological factors which may influence economic feasibility under local conditions.

Industrial-sized experiments can only be performed after public health authorities have accepted the safety for human consumption of the irradiated food item to be examined for economic feasibility of its processing.

Public health acceptance of the **process** of food irradiation, rather than that of individual irradiated food items, should be aimed at.

The criteria on which public health acceptance must be based should be declared clearly to facilitate complying with public health requirements in wholesomeness testing.

In view of the already existing health clearances as well as of the urgent need for the preservation of their inadequate food supplies, developing countries should increase their efforts to apply food processing by ionizing radiation in practice. Less developed nations should promptly move forward in introducing this process regardless of the progress in developed countries where the need for any new method of food preservation may be less acute and where the existence of other established alternative technologies has made it difficult at present for the introduction of a new process.

In this connexion, the statement made by **Glenn T. Seaborg**, in his Presidential Address to the 4th Geneva Conference on Peaceful Uses of Atomic Energy, September 1971, was recalled with satisfaction: in food preservation "as in some other areas, I suspect that our priorities have become disordered through a failure to balance risks against benefits. With tens of millions of the world's people still suffering from hunger and its more insidious partner, malnutrition, the ability of radiation to extend the storage time of food, and to reduce losses due to infestation and sprouting has not been given the role which it deserves." Hopefully, activities in this field will be increased and intensified in the near future.

Education of the public and especially of those capable of influencing public opinion has to be attempted as regards the potential economic and nutritional benefits of food irradiation.

The sponsoring organizations of the meetings, FAO and IAEA were asked to assist international collaboration further on technological and economic feasibility of food irradiation in developing countries and to convene a panel of experts, with WHO participation, to make a critical review of the evaluation of wholesomeness of food irradiation.

◀ Green bananas are loaded onto automatic conveyor for irradiation, in an experiment on the preservation of fruits at the University of California's Davis Laboratory . . . . USAEC