

# **Food Irradiation Technology in India**

- Hemant Lagvankar

## **Need for food preservation**

Like any other developing country, where the population is growing, demand for the food is increasing and that too with limited resources like land and water. The success of green revolution has enabled India to produce over 160 million tones of food grains every year. Conservative estimates put post-harvest losses in food and agricultural commodities in India between 20-50 percent, which are worth thousands of crores of rupees. These losses are primarily due to insect infestation, microbiological contamination, and physiological changes due to sprouting, ripening, and senescence.

With progressive increase in the quantity of food grains and necessity for longer storage periods, these losses will escalate unless disinfestation measures are improved. Chemical disinfestations methods, such as fumigation, require repeated application, as these do not eliminate insect eggs. They may also leave harmful residues in the treated grains. Therefore, increased output from farming would also need effective post harvesting practices and very good storage facilities. For ensuring availability of good quality food to the people, the post harvesting technology of handling the agriculture produce should go hand in hand with increased agricultural output.

The problem becomes acute in case of perishable food items like potato and onion. India is the largest producer of onions in the world. It is the bumper crop for our country. In the year 2007 - 08 the country had harvested 7.45 million tones, which was also a record. India's onion export has also made a gradual growth during the last four and half decades. Onion is planted during winter (Rabi crop) in most parts of the country and harvested during April-May. In 2005, the prices of onion started going up after heavy rainfall affected the crop in Maharashtra's main growing areas in Lasalgaon, Satana, and Yevla. Thus, in spite of the largest producer of onion, India had to import onion from Pakistan and China to meet the demands. Similar crisis was experienced in 1998.

More than 1.5 lakh ton of onion is stored in Nashik district from June to October in conventional chawls. In Nashik, low ambient temperatures and high humidity conditions during the rainy season, beginning from July, lead to the sprouting of onions. Similarly, the sprouting of stored onions occurs following the rainy season in Mahuwa, a major onion production and storage centre in Bhavnagar district of Gujarat. Sprouted onions shrivel faster owing to increased water loss by transpiration.

The hot and humid climate of India is quite favorable for the growth of numerous insects and microorganisms that destroy stored crops and cause spoilage of food. Spoilage can also occur due to chemical and physiological changes in stored foods. Conventionally, post-harvest losses could be prevented by techniques such as cold storage, fumigation, and drying. Radiation technology can complement and supplement existing technologies to ensure food security and safety. It provides effective alternative

to fumigants that are being phased out due to their adverse effects on environment and human health.

### **Process of finding the Solution**

One of the beneficial applications of atomic energy is in preserving foods for extended periods. Food irradiation, as this process is known, is an important milestone in food preservation methodology since the successful development of canning in the 19th century. With the commissioning and operation of CIRUS atomic reactor, the used fuel rods, discharged from the reactor and stored in the water pool, provided a convenient source for initiating work on radiation processing of food products such as onion, potato and mango for determining optimum doses for inhibiting sprouting and delay in ripening.

In 1967, the food science group led by Prof. A. Sreenivasan started working on India's first pilot plant of food irradiation in Food Irradiation Processing Laboratory (FIPLY) at Trombay. The research work started for radiation processing on wheat and potato. In addition to the research work being done at Bhabha Atomic Research Centre (BARC), the studies were undertaken by the National Institute of Nutrition (NIN), under the Indian Council of Medical Research (ICMR). A lot of developmental work was carried out with fruits and vegetables, cereals and pulses, and seafood during 1967 to 1973. Large scale trials were carried out with the agencies such as Food Corporation of India, and the National Agricultural Marketing Federation (NAFED).

In 1975, Ministry of Health and Family Planning formed a two member committee comprising Prof. P. V. Sukhatme, an eminent statistician of international repute and Prof. P. C. Kesavan of Jawaharlal Nehru University for evaluating data pertaining to the studies conducted at BARC and NIN. After detailed discussion and analysis at BARC and NIN, Sukhatme's Kesavan Committee submitted its report to the Secretary, Ministry of Health and Family Planning in 1976. The committee found no evidences of any adverse changes upon feeding irradiated wheat to rats or children.

Subsequently, the data was also reviewed by Food and Agriculture Organization (FAO)/International Atomic Energy Agency (IAEA)/World Health Organisation (WHO) Joint Expert Committee on Food Irradiation (JEFCI). In 1980, JEFCI finally concluded that radiation processing of food with an overall average dose of 10 kilo Gray is safe and do not introduce any radiological, microbiological or nutritional problems in food.

In 1987, Dr. Raja Ramanna, then Chairman, Atomic Energy Commission (AEC) and Secretary, Department of Atomic Energy (DAE), succeeded in setting up of a high powered committee, called National Monitoring Agency chaired by Secretary, Ministry of Health and Family Welfare to oversee commercial application of radiation processing technology. By 1991, the Atomic Energy Rules were drafted and in 1994, the first approval for irradiation of onion, potato, and spices for internal marketing and consumption was received from the Ministry of Health and Family Welfare under the Prevention of Food Adulteration Act Rules.

The Food irradiation and Processing Laboratory of Bhabha Atomic Research Centre is one of the foremost laboratories of such kind in the world. For over the past two decades, it has carried out research and development work relating to radiation

preservation of perishable foods, particularly those of economic importance to India. Irradiation techniques developed at this Research Centre have been shown to be effective for inhibition of sprouting in potatoes and onions, delayed ripening of fruits such as bananas, mangoes and papayas, disinfestation of grains, extension of shelf life of fish and meat, elimination of pathogens from frozen sea food and microbial and insect decontamination of spices.

The irradiation process has been approved by the Food and Agriculture Organization (FAO), the World Health Organization (WHO), the International Atomic Energy Agency (IAEA) and the Codex Alimentarius Commission. About 100 countries have approved the process for application in more than 100 food items. India first approved them in 1994. Today, the Directorate of General Health Service, under the Prevention of Food Adulteration Act, has approved more than 20 commodities to be processed using this method. With the first approval for the process coming from the Directorate General of Health Services in 1994, DAE proposed to build a few technology demonstration units that could be forerunners for commercial plants to be set up by user industry.

The first technology demonstration plant was built at Vashi, Navi Mumbai, for medium and high dose applications for commodities such as spices and dehydrated onions. The plant is operational since January 2000. It has a capacity of processing 30 tones of material per day. Another technology demonstration unit, KRUSHAK (Krushi Utpadan Sanrakshan Kendra) was made operational in July 2003 at Lasalgaon, Dist. Nashik in Maharashtra state. The plant is built mainly for processing commodities such as onion, cereals, pulses and their products, and cut-flowers which require low dose irradiation. The plant has a capacity of processing 10 tones of onion per day.

### **How does it work?**

Radiation processing technology has been developed through worldwide R&D efforts of more than four decades. India is one of the few countries in the world having the necessary expertise and know-how for deployment of this technology. Irradiation processing of food involves the controlled application of energy from ionizing radiations such as gamma rays, electrons, and X-rays for food preservation. Gamma rays and X-rays are short wavelength radiations of the electromagnetic spectrum. Gamma rays are emitted by radioisotopes such as Cobalt-60 and Caesium-137 while electrons and X-rays are generated by gaseous discharge using electricity. Gamma rays are a part of the electromagnetic spectrum. They can penetrate deep into food materials and bring about desired effects.

Radiation processing of food is carried out inside an irradiation chamber shielded by 1.5 to 1.8 meter thick concrete walls. Food, either pre-packed or in-bulk, placed in suitable containers is sent into the irradiation chamber with the help of an automatic conveyor. The conveyor goes through a concrete wall labyrinth, which prevents radiation from reaching the work area and operator room. When the facility is not in use the radiation source is stored under 6 meter deep water. The water shield does not allow radiation to escape into the irradiation chamber, thus permitting free access to personnel to carry out plant maintenance.

For treating food, the source is brought to the irradiation position above the water level after activation of all safety devices. The goods in aluminium carriers or tote boxes are mechanically positioned around the source rack and are turned round their own axis, so that contents are irradiated on both the sides. Absorbed dose is checked by placing dosimeters at various positions in a tote box or carrier. The quantity of dose is measured in terms of unit, called Gray, abbreviated as Gy. It is the unit of absorbed radiation energy. One gray is equivalent to 1 Joule per kilogram. The old unit of dose is rad. 1Gray is equivalent to 100 rad.

Irradiation is a direct, simple, and efficient one-time process. It works by disrupting the biological processes that lead to decay. Application of low doses of radiation (0.15 kilo Gray) can arrest the sprouting of potatoes and onions. The process consists of exposing potatoes or onions to gamma rays in a shielded room for a specified duration. Then they are brought into and taken out of the room by conveyors or carriers. As a result, storage losses of tubers and bulbs due to sprouting, and their dehydration can be reduced substantially. Low-dose applications (less than one kGy) also lead to the disinfection of insects in stored grain, pulses, and food products, and the destruction of parasites in meat and meat products.

A medium dose (one to ten kGy) eliminates microbes in fresh fruits, meat, and poultry products, destroys food pathogens in meat, and helps in the hygienization of spices and herbs. A high dose (above 10 kGy) produces shelf-stable foods without resort to refrigeration, and the sterilization of food for special requirements.

Low dose applications	Less than 1 kilo Gray	<ol style="list-style-type: none"> <li>1. Inhibition of sprouting in potato and onion.</li> <li>2. Insect disinfection in stored grain, pulses and products.</li> <li>3. Destruction of parasites in meat and meat products.</li> </ol>
Medium dose applications	1 to 10 kilo Gray	<ol style="list-style-type: none"> <li>1. Elimination of spoilage microbes in fresh fruits, meat and poultry.</li> <li>2. Elimination of food pathogens in meat and poultry.</li> <li>3. Hygienization of spices and herbs.</li> </ol>
High dose applications	Above 10 kilo Gray	<ol style="list-style-type: none"> <li>1. Sterilization of food for special requirements.</li> <li>2. Shelf-stable foods without refrigeration.</li> </ol>

## **Cost of Irradiated Food**

Any processing will add to the cost of food. In most cases, however, food prices may not necessarily rise just because a product has been treated. Many variables affect food costs, and one of them is cost of processing. But processing also brings benefits to consumers in terms of availability, storage life, distribution, and improved hygiene of food. Irradiation costs may range from Rs. 0.25 to Rs. 0.50 per kilogram for a low dose application such as sprout inhibition of potato and onion, and insect disinfestation in cereals and pulses. It costs from Rs. 1 to Rs. 3 per kilogram for high dose applications such as treatment of spices for microbial decontamination. The costs could be brought down in a multipurpose facility treating a variety of products around the year.

## **Applications**

Radiation processing technology can be used for :

1. Inhibition of sprouting in bulbs and tubers
2. Disinfestation of food grains and pulses
3. Extending shelf-life under recommended conditions of storage
4. Ensuring microbiological safety
5. Overcoming quarantine barriers to international trade

The application of low doses of radiation can arrest sprouting of potatoes and onions. As a result, storage losses due to sprouting of the tubers and bulbs and their dehydration can be reduced substantially. Adoption of the new technology, especially for onions, could mean significant benefits to this country that is the largest producer of onions in the world. The development of high-yielding, short duration and disease-resistant varieties of potato in recent years has led to increased production and consequently problems of storage and conservation. Chemical sprout inhibitors are difficult to apply and are not always effective. Sprout inhibiting dose of radiation is also effective in destroying tuber moth, a devastating pest of potato. Irradiation, therefore, offers a satisfactory solution to the storage problems of potatoes.

Low dose irradiation completely kills or sterilizes the common grain pests, and even the eggs deposited inside the grains. Moreover, only a single radiation exposure of grains is sufficient for disinfestations. This, therefore, is ideally suited for large-scale operations, thereby offering substantial economic benefits. Irradiation can also serve as an effective process for disinfestation of certain pre-packed cereal products like atta, soji (rava) and premixes.

Low doses of radiation are effective in delaying the natural processes of ripening in fruits. Thus shelf life of mangoes can be extended by about a week and that of bananas up to two weeks. This could improve the scope for internal trade and augment export of these commercially important fruits of India. Furthermore, gamma radiation can eliminate the seed weevil, an insect that lodges deep inside the stone of the mango. This can be a satisfactory solution to vexing quarantine problem.

India is a major spice producing and exporting country. Spice export trade is always faced with stringent quality requirements relating to insect infestation and microbial contamination. Fumigation of spices with chemicals like methyl bromide, ethylene oxide and propylene oxide, has inherent disadvantages, especially retention of chemical residues. Single treatment of gamma radiation can make spices free of insect infection and microbial contamination without the loss of flavour components. The treatment can also be used for pre-packed ground spices and curry powders.

Fish, an important source of animal protein, is available in plenty all along the 5000 km Indian coastline. However, the existing inadequate preservation facilities cannot cope up with the rapid spoilage of the catch and thereby limit the availability of seafood in the interior regions. By selective destruction of spoilage bacteria, moderate doses (2 kilo Gray) of radiation can extend the acceptability, and, in turn, marketability of iced fish by about two weeks. Combination processes with heat and radiation can also increase the shelf life at room temperature by several weeks. Besides, this is the only method of removal of pathogens from pre-packed frozen product. The technology can also be used for hygienization and sterilization of non-food items including cut-flowers, pet food, cattle feed, aqua feed, ayurvedic herbs and medicines and packaging materials.

### **Misconceptions about Irradiated Food**

There are misconceptions in the minds of consumers regarding irradiated food. However, scientific research has proved that consumption of irradiated food is absolutely harmless. The safety of food processed by radiation has been examined carefully, both at the national and international levels. On the basis of extensive studies with laboratory animals carried out in different countries including India, FAO/IAEA/WHO Joint Expert Committee has recommended that the food items irradiated up to an average dose of 10 kilo Gray be accepted as safe from the health angle and do not present any toxicological hazards. In fact, the doses of irradiation required for the treatment of commodities are far below this stipulated limit. The committee has further recognized radiation as a physical process like thermal processing and not as a food additive.

The irradiation process involves passing of food through a radiation field allowing the food to absorb desired radiation energy. The food itself never comes in contact with the radioactive material. Gamma rays, X-rays, and electrons prescribed for radiation processing of food do not induce any radioactivity in foods. In comparison to other food processing and preservation methods the nutritional value is least affected by irradiation. Extensive scientific studies have shown that irradiation has very little effect on the main nutrients such as proteins, carbohydrates, fats, and minerals.

Vitamins show varied sensitivity to food processing methods including irradiation. For example, vitamin C and B<sub>1</sub> (thiamine) are equally sensitive to irradiation as well as to heat processing. Vitamin A, E, C, K, and B<sub>1</sub> in foods are relatively sensitive to radiation, while riboflavin, niacin, and vitamin D are much more stable.

The change induced by irradiation on nutrients depends on a number of factors such as the dose of radiation, type of food, and packaging conditions. Very little change in vitamin content is observed in food exposed to doses up to 1 kGy. The Joint Expert

Committee of the Food and Agriculture Organization (FAO), World Health Organization (WHO), and International Atomic Energy Agency (IAEA), in 1980 concluded that irradiation does not induce special nutritional problems in food. The committee also rejected the possibility of development of chromosomal abnormalities by the consumption of irradiated food.

### **Merits over Conventional Methods**

Food irradiation technology has unique merits over conventional methods of preservation such as canning, dehydration, salting, etc. as this process does not lead to loss of flavour, odour, texture, and freshness. Unlike chemical fumigants, irradiation does not leave any harmful toxic residues in food and is more effective. It is efficient and can be used to treat pre-packed commodities. Since gamma rays have high penetrating power, spices can be irradiated after packaging, irrespective of the size of the carton.

Poor post harvest practices including inadequate storage and preservation facilities, as well as adverse climatic conditions, cause heavy losses in India's agricultural and marine produce. Food irradiation promises to offer an effective means for minimizing these losses, thereby increasing their availability, and stimulating exports. It can make Indian agricultural produce globally competitive. Export development authorities, commodity boards, food industry, farmers, traders, and exporters of agricultural commodities can be benefited from the use of radiation processing technology.

Pasteurization was discovered by Luis Pasteur in 1860. There are similarities between the objections made to food irradiation and the objections to milk pasteurization. In fact, in 1906, a milk pasteurization process in New York City was outlawed. Only in 1920s milk pasteurization became common in the U.S. Today, milk pasteurization and chilling plants are the common sites, even in rural India. The benefits of food irradiation technology could be similar to, if not greater than, pasteurization of milk.

### ***References :***

- Material published by the Department of Atomic Energy, Mumbai
- Material published by the Scientific information Resource Division, BARC, Mumbai
- Technology Transfer & Collaboration Division BARC, Mumbai
- Reports published by Department of Atomic Energy

-----