

## **Irradiation**

### **Expected Learning Outcome**

- Meaning of Irradiation
- Working of irradiation plant
- Advantages of radiation processing of food
- Meaning of cryogenic
- Liquid nitrogen freezer

### **8.1.Introduction**

Radiation processing of food involves exposure of food to short wave energy to achieve a specific purpose such as extension of shelf-life, insect disinfestations and elimination of food borne pathogens and parasites. In comparison with heat or chemical treatment, irradiation is considered a more effective and appropriate technology to destroy food borne pathogens. It offers a number of advantages to producers, processors, retailers and consumers.

Radiation processing of food has been thoroughly and extensively studied in order to ensure its toxicological, nutritional and microbiological safety. The data available from the world wide research including that from India over the last four decades was jointly reviewed by the experts of WHO, FAO and IAEA in a series of international meetings. In 1980, the joint FAO/IAEA/WHO Expert Committee on the wholesomeness of radiation processed food, convened in Geneva concluded that any food irradiated up to a maximum dose of 10kgy is safe for human consumption. Independent technical and scientific committees constituted by several countries including Canada, Denmark, France, India, Sweden, the UK, European Economic Community (EEC) and the US FDA have declared that radiation processed food is safe for human consumption.

Radiation 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 which includes radio waves, microwaves, infrared, visible and ultra violet light. Gamma rays are emitted by radioisotopes such as Cobalt-60 and Caesium-137 while electrons and X-rays are generated by machines using electricity.

### **8.2.Working of irradiation plant**

Irradiation works by disrupting the biological processes that lead to decay. In their interaction with water and other molecules that make up food and living organisms, radiation energy is absorbed by the molecules they contact. The reactions with DNA cause the death of microorganisms and insects and impair the ability of potato and onion to sprout.

Radiation processing of food is carried out inside an irradiation chamber shielded by 1.5-1.8m 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 6m deep water. The water shield does not allow radiation to escape in to 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 aluminum 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. The absorbed dose is determined by the residence time of the carrier or tote box in

irradiation position. Absorbed dose is checked by placing dosimeters at various positions in a tote box or carrier.

### **8.3. Advantages of radiation processing of food**

Irradiation is a cold process and can be used to pasteurize and sterilize foods without causing changes in freshness and texture of food unlike heat. 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 prepacked commodities. Four major functions achieved by radiation processing of food are:

- Disinfestations of insect pests in stored products.
- Inhibition of sprouting of tubers and bulbs and delay in ripening of fruits.
- Destruction of microbes responsible for spoilage.
- Elimination of pathogens and parasites of public health importance.

Laws and regulations enacted by Atomic Energy Regulatory Board govern operations of irradiators used to process non-food products, such as medical supplies. Three such irradiators are operating in India and about 160 around the world. The plants which must be approved by the Government before construction are subject to regular inspection, safety audits, and other reviews to ensure that they are safely and properly operated. Similar controls would be applicable for radiation processing facilities.

At the international level, the Codex Alimentarius Commission, of the United Nations Food and Agriculture Organization (FAO) and the World Health Organization (WHO) have laid down standards for good manufacturing practices (GMP) and good irradiation practices (GIP) for a number of foods. They cover all aspects of treatment, handling, storage and distribution of food. The guidelines emphasize that, as with all food preservation techniques, effective quality control systems need to be installed and adequately monitored at critical control points at the irradiation facility.

### **8.4. Cryogenic**

The term 'cryogenic' is derived from the Greek word Kryos which means cold or frost. It is frequently applied to very low temperature refrigeration applications such as in the liquefaction of gases and in the study of physical phenomenon at temperatures approaching absolute zero.

The first low temperature refrigeration system was primarily developed for the solidification of carbon dioxide and the liquefaction and subsequent fractional distillation of gases such as air, oxygen, nitrogen, hydrogen and helium. Oxygen was liquefied in 1877 by Coilletet and Pietet. Hydrogen was liquefied in 1898 by Dewar using Joule-Thomson expansion of gases. The liquid oxygen boils at 9.02K (-182.8°C) and the liquid hydrogen at 20.4K (-252°C). The liquefaction of helium was accomplished in 1908 by H. Kamerlingh Onnes in the famous cryogenic laboratories of the University of Leiden. Initially, by evaporation of liquid helium under high vacuum, the temperature as low as 1.1K (-271.9°C) was obtained. But by making improvements in the apparatus, a temperature of 0.7K was reached by the year 1928. In 1933, Giauque and Debye proposed the adiabatic demagnetization of paramagnetic salts for attaining the lower temperature and 0.1K was reached through their methods. Now-a-days, the lowest temperature successfully achieved by this method is 0.001K (i.e. very close to absolute zero).

*Note: In refrigeration, the temperatures from -100°C to -273°C (or absolute zero) are treated as low temperatures.*

### **8.5. Liquid nitrogen freezer**

In this freezer, the product is brought into direct contact with the refrigerant. The fish on the stainless steel conveyor belt initially come into contact with the counter current flow of nitrogen gas at a temperature of about  $-50^{\circ}\text{C}$ . As the fish progress through the freezer, the temperature of the cooling gas progressively falls to  $-196^{\circ}\text{C}$ . This initial stage of cooling in the gaseous nitrogen partially freezes the fish and also preconditions the product before it is passed below the liquid spray where freezing is completed by the boiling liquid. During this pre-cooling stage, up to 50 percent of the product heat is extracted and the remainder of the heat transfer takes place in the small area below the sprays. After leaving the spray zone, the last stage in the freezer is used for the fish temperature to reach equilibrium before the fish are discharged. If fish are cooled directly below the sprays without preconditioning, they are physically damaged due to the sudden change in temperature which sets up thermal stresses within the fish.

The main advantage of the nitrogen freezer is that freezing is very quick and the physical size of the freezer is correspondingly small. The freezer is operated without the need for compressors, condensers or coolers; therefore maintenance requirements are minimal and the power required to operate the freezer is very low. Liquid nitrogen cannot be retained economically in a pressure vessel and continuous venting is required to keep the contents cool and the internal pressure down. One estimate given is that 0.5 percent of the stored contents is lost each day by this method. In addition, about 10 percent has been estimated to be lost during the transfer of liquid from the tanker to the storage vessel although the customer is not charged directly for this loss. This method of freezing is more expensive than most others, being at least four times more costly than conventional air blast freezing, or even higher if the freezer is only used intermittently with partial loads.

Although the freezer is small and there is no refrigeration machinery requirement, storage space and access is required for the liquid nitrogen tank. The main disadvantage of this type of freezer in most developing countries is that delivery of nitrogen would be expensive and there may be no guarantee of regular supplies.