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Popular Article

Gamma Irradiation in Insect Pest Management- A Promising Approach towards Food Security

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Introduction

India holds a prominent position in global food grain production. The storage of agricultural commodities has been given utmost importance in our country. However, the damage caused by pests, both at the farm level and in storage facilities, is significant. According to the Food and Agriculture Organization (FAO), insects alone are responsible for causing 10-50 percent of the overall damage, primarily due to improper storage practices.

There is a continuous need to safeguard commodities from deterioration, particularly in terms of quality and quantity, during the storage process. The widespread and indiscriminate use of insecticides to control insect pests has resulted in the development of resistance in the targeted species. Additionally, this practice has led to various issues such as residual effects, environmental hazards, and threats to non-target organisms.

In our agricultural nation, globalization has facilitated the free and rapid exchange of goods between countries. Despite having strict quarantine regulations, we frequently encounter various introduced insect pests, which pose a significant threat to our nation's bio-security. To address this issue, fumigation has emerged as the most widely accepted method for phytosanitary treatment and pest control in our country. Methyl bromide (MBr), a highly effective broad-spectrum fumigant, has gained increasing popularity for pest control purposes. However, in 1992, Methyl bromide (MBr) was classified as an Ozone Depleting Substance (ODS) under the Montreal Protocol, an international agreement aimed at protecting the Earth's stratospheric ozone layer.

The use of Methyl bromide (MBr) was phased out for most phytosanitary purposes by the United States and around 60 other countries in 2005. Despite this, certain countries, including India, continue to use methyl bromide for quarantine and pre-shipment treatments due to the absence of effective alternatives. This has raised concerns about the escalating use of methyl bromide globally, as it poses a risk to ozone depletion.

Fortunately, radiation technology, particularly gamma irradiation, has gained significant importance in recent years as an alternative method for controlling insect pests, especially in stored products. This technology offers a viable solution without harming the environment or compromising the quality of the produce.

Regulatory status on the use of gamma irradiation

Over 100 nations have embraced irradiation technology, and various irradiated food products are now accessible in the market. The following authorities have granted approval for the irradiation of foods:

- Codex Alimentarius
- Food Safety and Standards Authority of India (FSSAI)
- Food Standards Australia New Zealand
- American Medical Association
- Institute of Food Technologists
- International Atomic Energy Agency (IAEA)
- Food and Agriculture Organization (FAO)
- World Health Organization (WHO)

These reputable organizations have recognized and endorsed the use of irradiation for food safety purposes.

Gamma irradiation technique

Gamma rays are a type of electromagnetic radiation characterized by their shorter wavelength and higher photon energy. The term "gamma ray" was coined by Ernest Rutherford in 1903. Irradiation is a process used to either sterilize target insects (such as fruit flies) by releasing sterile adults or to expose grains in agricultural commodities to eliminate stored product pests. This process requires controlled dose exposure and adherence to safety measures specified by national and international organizations, making it of utmost importance.

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When gamma rays interact with organisms, they damage the structure of cell membranes or disrupt critical elements within cells. This, in turn, affects metabolic enzyme activity and often causes damage to Deoxyribose Nucleic Acid (DNA), which is essential for growth and replication of organisms. Radiation sources used for irradiation can include cobalt-60 or cesium-137 radioisotopes, as well as electrons generated from machine sources (e-beam), which are commonly used for insect sterilization. The absorbed dose, measured as the amount of radiation imparted per unit of mass of specified materials, is typically expressed in grays (Gy), where 1 gray is equivalent to 1 joule per kilogram.

Gamma irradiation in pest management

Irradiation is widely employed in biological studies and agriculture to enhance crop production. It has proven to be effective against a broad range of insects and mites, without compromising the quality of the commodities, when used at standard dose levels. This technology is particularly valuable in combating quarantine pests like tephritidae (fruit flies), which pose a significant threat to horticultural crops. The Sterile Insect Technique (SIT), introduced by E. F. Knipling in 1937, utilizes irradiation as a generic treatment method. Gamma irradiation is currently the predominant approach for sterilizing mass-reared insects for SIT. The success of SIT depends on the production of high-quality sterile insects that are released into target wild populations, and the required sterility doses can vary across different species. Both CODEX and FAO recommend the use of gamma irradiation for grains, such as cereals and pulses, with a maximum dose of 1 kGy for disinfestation.

Existing literature suggests that gamma radiation doses ranging from 25 to 1200 Gy can effectively suppress various pests, including grain weevils, Mediterranean flour moths, Indian meal moths, cigarette beetles, medflies, onion flies, fall armyworms, tobacco budworms, and African cotton leafworms (Timbadiya *et al*., 2018). Gamma radiation demonstrates greater efficiency in eliminating insect pests affecting stored grains and field crops. Notably, research indicates that irradiating last instar larvae of fall armyworms (*Spodoptera frugiperda*) with a dose of 200 Gy resulted in significantly reduced pupation rates and adult emergence. The emerged adults exhibited deformities, inability to fly, and mortality within approximately two hours (Arthur *et al*., 2016).

In several countries, including India, invasive pests pose a significant threat to food security. Irradiation can provide valuable support in suppressing pest populations and addressing this critical challenge.

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Advantages of gamma radiation in pest management

Gamma irradiation offers several advantages in pest management:

1. Effective Pest Control: Gamma irradiation is highly effective in controlling and eliminating a wide range of pests, including insects, mites, and pathogens. It can target pests at various stages of their life cycles, such as eggs, larvae, pupae, and adults. This technology helps reduce pest populations and prevent infestations in agricultural crops, stored grains, and food processing facilities.
2. Wide Spectrum of Activity: Gamma irradiation has a broad spectrum of activity, making it effective against a wide range of pests. It can target both surface-dwelling and internal pests, including hidden pests that may be difficult to reach through other pest management methods.
3. Resistance Management: Unlike chemical pesticides, gamma irradiation does not lead to the development of pest resistance. Pests cannot build up a tolerance or immunity to radiation, making it a sustainable and long-term pest management solution.
4. Quality Preservation: Gamma irradiation does not compromise the quality, taste, or nutritional value of treated products. It helps maintain the freshness, appearance, and sensory attributes of agricultural commodities, ensuring that they meet market requirements and consumer expectations.
5. Safety and Environmental Considerations: Gamma irradiation is a safe method of pest management. It does not leave behind harmful residues in treated products, making it a preferred choice for food safety. It is also an environmentally friendly option as it does not contribute to pollution or environmental degradation.
6. Compliance with Regulations: Gamma irradiation is approved by international organizations, regulatory bodies, and food safety authorities such as the Codex Alimentarius, FAO, WHO, and national regulatory agencies. Its use in pest management aligns with stringent regulatory requirements for food safety and phytosanitary measures.
7. Application Flexibility: Gamma irradiation can be applied to various commodities, including fresh produce, grains, spices, nuts, seeds, and processed food products. It can be implemented at different stages of the supply chain, including pre-harvest, post-harvest, and during storage and transportation.
8. Sterile Insect Technique (SIT): Gamma irradiation is integral to the Sterile Insect Technique (SIT) for pest control. By sterilizing pests, such as fruit flies, and releasing them into the wild, it disrupts their reproductive cycle, reduces pest populations, and helps manage pest outbreaks effectively.

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In summary, gamma irradiation provides an efficient, safe, and environmentally friendly approach to pest management. It offers effective pest control, helps preserve product quality, ensures compliance with regulations, and contributes to sustainable pest management practices.

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