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Effect of gamma irradiation on indigenous fresh produce

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■ **Abstract :** Indigenous fresh produce has enormous potential to contribute in food and nutritional security. It also contributes with essential micronutrients in the daily diet. The indigenous fresh produce has a short shelf life and they get affected during storage and transportation due to microbial spoilage. Traditionally, this problem is addressed by providing a controlled atmosphere to the fresh produce, which is quite costly and effective only for short duration. Irradiation treatment could also be applied to mitigate this problem. Irradiation helps to eliminate various microorganisms, delay ripening, sprout inhibition and extension of shelf life of indigenous fresh produce. Cobalt-60 is the radioisotope used as a source of irradiation. Gamma radiation in a controlled amount about 1-3 kGy penetrates the pre-packed food commodities to extend the shelf life by 15-20 days without affecting nutritional quality and safety of food. This process is effective in reducing pathogens such as *E. Coli, Salmonella Paratyphi A*. Gamma radiations do not make food radioactive, change in appearance, texture or color and comprised nutritional quality. Also application of spent nuclear fuel in such processing unriddles the problems of nuclear waste disposal and management in some extent. Thus, such technology can augment processing of fresh produce and control post harvest losses in developing countries like India.

■ **Key words :** Cobalt-60, Gamma Radiations, Indigenous food, Irradiation, Post harvest losses, Shelf life

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The indigenous fresh produce has a significant role in food and nutritional security in India. The India is very diverse in climatic conditions, agricultural ecosystems, tribes, topography, altitudes and agricultural biodiversity where promotion of local indigenousfruits and vegetables is important as consumption is in raw or processed form, also can reduce the burden on government account malnutrition. The indigenous vegetables have a significant role in food and nutritional needs of the tribes and rural communities (Singh *et al*., 2013).

Dietary diversification is a proven, cost-effective strategy to improve malnutrition for rural people in India (Ghosh *et al*., 2016). The loss of dietary diversity has many implications for the nutrition and health of rural communities, including loss of income generation and decreased consumption of diverse foods and also multiple benefits of preservation and promotion of indigenous foods range from a corresponding benefit on biodiversity and environmental sustainability to improving micronutrient intakes for rural or tribal people at affordable prices (Bharucha and Pretty, 2010). However, systematic information was required for promotion of indigenous vegetables for ensuring sustainable food and

nutritional security to marginal communities.

Shelf life of perishable indigenous produce such as coriander, eggplant, onion, *Colocasia esculenta*, calabashis too short. Generally spoilage of orange, mango, lemon etc. is due to fast ripening. The spoilage of such produce leads to post harvest losses. Decay of fresh indigenous produce leads to a threat to food security. Perishable commodities like vegetables have less shelf life because of microbial load and self decomposition, but traditional methods are unable to contol the spoilage and decay of such fresh commodities. During transportation, storage and marketing of food having huge microbial load responsible for post-harvest loss. Many studies have indicated that for fresh produce and agricultural commodities the use of gamma radiation which is more effective than traditional preservation methods, including sterilization by heat, freezing, pasteurization, use of chemicals, refrigeration or canning processes. Many studies (Gunes *et al*., 2000, Golan and Follett, 2017) showed that, the application of gamma irradiation is one of the most effective technology in extension of shelf life and delay ripening. According to Golan and Follett (2017) indigenous fruits and vegetables, mostly consumed in raw or processed form, and due to lack of processing of fruits and vegetable based products, storage and transportation facility in India, there is more post harvest losses.

Gamma irradiation is a process in which food and agricultural commodities are exposed to a controlled amount of radiations. Ionizing radiation is used in this technique is energy that can be transmitted from atomic bonds of targeted food. Food and agricultural commodities in pre-packed form or in bulk are irradiated with specified amount of radiant energy to achieve desired effects. This is a hurdle technology to achieve desired effects such as inhibition of sprouting, killing of microorganisms, delay in ripening, killing of insects, pests, parasites, pathogenic and spoilage microorganisms (Diaonsio. *et al*., 2009). Gamma irradiation energy does not induce radioactivity in the food or its packaging (Farkasa and Mohacsi-Farkas, 2011).

Ehlermann (2016) stated that it is the responsibility of governments to make available and to promote any technology contributing to hygiene and safety of food, including processing of food commodities by ionizing radiations. Finten *et al*. (2017) clarified that acceptance of irradiated food id based on consumer's intention. Their study showed that half of consumers did not know about food irradiation. Such impact of unawareness followed by the unacceptance of irradiated food. Thus, public awareness regarding to food irradiation promotes the processing of fresh produce using irradiation technology, as well as acceptance of irradiated food. Food irradiation preserves food as well as employed to extend shelf life, food safety and maintain its quality (Nilsson, 2000).

Irradiation sources :

There are various radiation and sources approved for processing of food. Several authors studies that gamma radiation emitted by cobalt-60 radioisotope and cesium-137 radioisotope is used as a radiation source. Kalyani and Manjula (2014) studied that, x-rays from machine sources of energies not exceeding 7.5 MeV and electron from machine source of energies not exceeding 10 MeV used as irradiation source. Depleted fuel rods from nuclear power reactors are also considered as the radiation source (Ehlermann, 2016). Such fuel can be utilized for the treatment of food at specified amounts to get the desired effect. Gamma radiations are capable to inhibit the microbial load and extension of shelf life of leafy vegetables. Food irradiation is the technology that improves the safety and shelf life of food by reducing or eliminating microorganisms and insects. Gamma irradiations emitted from Co-60 radioisotopes in controlled amount are capable of eliminating and reducing microbial load in food and agricultural commodities. This will unriddle the problem of post harvest quality losses of fruits and vegetables during storage in some extend. This study evaluates the effects of gamma irradiation dosses 0-900Gy. On quality parameters and phytochemical contents of strawberry fruits during storage periods at 10°C. Study conducted by Maraei and Elsawy (2017) revealed that irradiation significently reduced the fruit weight loss and decay rate at storage period comparisons to control *i.e.* unirradiated sample.

Effect of gamma radiation on food: A safe technology:

Many organisations such as FAO, WHO have reviewed that irradiated food do not pose any kind of health hazard to consumer who eat them. According to Patil *et al*. (1999) with increasing public awareness, consumption of raw and cooked vegetables increases.

Fresh indigenous produce has a short shelf life due to microorganisms which are responsible for spoilage and deterioration of food. Gamma irradiation is a processing technique involving ionizing radiation to eliminating the microbial load and extending the shelf life of fresh produce, food poisoning, delay fruit ripening, prevention from sprouting.

Studies (Crawford and Ruff, 1996, Golan and Follett, 2017) have shown that this technology can prevent the proliferation of microorganisms that causefood spoilage, such as bacteria and molds, by inducing gamma radiation in their cells. Mostfavi *et al*. (2012) stated that this technology offers a wide range of benefits to the food processing industry and theconsumer by ensuring the hygienic quality, safety of solid or semi-solid foods through inactivation offoodborne pathogens and also provide adequate nutrition. The use of gamma irradiation in food technologies is increasing because of persistently high food losses from infestation by insects and pests, contamination, and spoilage by bacteria and fungi (Follet, 2014).

According to BARC, Food Technology Division, Mumbai, the effective dose range of gamma radiation for various application is prescribed in Table 1. They also stated that, various classes of food commodities for treatment with irradiation source at a specified amount of a radiation energy. The use of gamma irradiation in food technologies is increasing because of persistently high food losses from infestation by insects and pests, contamination, and spoilage by bacteria and fungi (Follet. 2014).

Table 1 : Application of different doses of gamma irradition

Purpose of treatment	Technological dose range (kGy)	
	Min	Max
Inhibit sprouting in bulb, stem and tubers	0.02	0.2
Delay ripens in fruits	0.2	1.0
Insect disinfection in fruits and vegetables	0.2	1.0
Shelf life extension fresh produce	1.0	2.5
Quarantine application	0.1	1.0
Reduction of microbial load	1.5	5.0
Sterilization	5	25

*Source: BARC FTD

Ehlermann (2016) concluded that, with increasingly restrictive regulations or prohibition on the use of chemical fumigants for insect and microbial control in the food industry, irradiation is a best alternative to protect food against insect, pest damage and as a quarantine treatment for fresh produce (Ehlermann, 2016). As such, irradiation can help to ensure a safer and more plentiful food supply by extending food shelf life through the control of pests and pathogens (Abdullah *et al*., 2016).

Importantly, according to the World Health Organization (WHO) and the Food and Agriculture Organization (FAO), it is a safe technology for the processing of food commodities when the appropriate radiation dose is provided for the treatment of food commodities (Lacroix and Follett, 2015).

Effect of gamma irradiation on quality of fresh produce :

Irradiated food involves safety aspects regarding to its radiological safety, toxicological safety, microbiological safety and nutritionally satisfactoriness. Gamma irradiation averts nutritional losses than other preservation methods (Follet and sanxter, 2002). Predominantly proteins, fats, lipids and carbohydrate quality are not affected by gamma irradiation processing (WHO, 1997 and WHO, 1994).

Fan and Sokorai (2002) studied on the loss of vitamins in some vegetables, mostly ascorbic acid as affected by irradiation processing. Zhang and Deng (2014) studied on storage of some fruits and vegetables which shows no reduction in vitamins during storage and most of vitamins, losses occurs due to heat. Firmness of fresh produce such as fruits may loss after irradiation processing (Palekar *et al*., 2004). To prevent the softening of tissue dipping tomatoes, fresh cut apple in a calcium solution before irradiation process. Such pre-treatment asset to prevent softening of fresh produce (Prakash *et al*., 2007).

In developing countries like India, Bangaladesh vegetable production provides an economic opportunity for reducing rural poverty and unemployment and is a major component of farm diversification strategies. Vegetables are mankind's most affordable source of vitamins and minerals needed for good health. Indigenous fresh produce is easily available as well as affordable forconsumers. After irradiation a linear relationship was found between irradiation dose and firmness (Schreinemachers *et al*., 2017) Irradiation had no effect on fruit skin or flesh color of papaya fruit also showed no significant changes in pectin. The various studiesindicate the firmness of these irradiated fruits were

retained for two days longer than the nonirradiated control (Zhao *et al*., 1996).

Jadhav *et al*. (2013) studied the shelf life extension of leafy vegetables by the application of ionizing radiations. This study shows that ionizing radiations between 1-5 kGy are capable of extending the shelf life of leafy vegetable such as coriander, spinach, fenugreek. It is observed that freshness and acceptance of such leafy vegetables are improvedupto 20-30 days. Overall appearance, tissue browning, sogginess, moisture content is acceptable after irradiation processing.

Abdullah *et al*. (2016) studied that gamma irradiation as a quarantine treatment to prevent post harvest spoilage of *Daucuscarrota*. This study presents the effect of gamma irradiation in which samples were subjected to various irradiation doses 1.0 to 2.0 kGy. After irradiation products were kept in a refrigerator for 21days and results indicated that bacterial mold and yeast count was reduced. This study also concluded that a dose of 1.5 kGy was the most effective, which enhanced shelf life to 7 days without causing any deterioration to vegetable.

The extension of shelf life of tomatoes by gamma radiation. Gamma radiation significantly decreases the microbial load and decay of tomatoes by applying an optimum dose for control of rotting. Radiation dose by 0.75 to 1.0 kGy was effective in keeping quality parameters and sensory attributes and this study indicates irradiation at low dose can improve the shelf life of tomatoes without adverse effects. Quality parameters such as pectin, titrable acidity, pH, anthocyanin content was not affected by irradiation processing (Singh *et al*., 2016).

The influence of irradiation of processed cucumber and cabbage on quality was investigated by Khattak *et al*. (2014). The study shows the inhibition of pathogenic bacteria such as *Escherichia coli, Salmonella Paratyphi A* with the application of irradiation dose range between 0 to 3 kGy. Bacteria and fungi are not susceptible to irradiation hence the quality parameters are adequate, and some losses due to irradiation such as softening of fruits and vegetable at certain levels are acceptable. The specific purpose of the study will carry out to investigate the effect of gamma irradiation in the enhancement of shelf life of various indigenous fresf produce which is an indigenous root crop. An ancient crop grown throughout the tropic and subtropic, from South East Asia, including India.The young leaves of indigenous plants rich in vitamins, folate, carotenoids, and minerals. Bhabha Atomic Research Centre Trombay, Mumbai provide a facility for irradiation processing. Such processing helps to extend shelf life, storability and transportation of fresh produce for long distance. Also, it aims to follow the irradiation processing for different indigenous species in different part of India, and this process helps to resolve the problems of indigenous fresh produce.

Conclusion :

Evidence has shown that gamma irradiation is an effective technology in enhancing the shelf life of fresh produce by eliminating the microbial threat. By the application of a specified amount of irradiation desired results can be obtained. This technology could also unriddle the problem food borne illness and the capacity of treatment of food in bulk in economical way. Preservation and promotion of indigenous foods range from a corresponding benefit on biodiversity and environmental sustainability to improving micronutrient intakes for rural and tribal people. Additionally, many studies shown that irradiation technology in combination with other treatments can be used as innovative method. Irradiation is an effective method for microbiological decontamination and nutritional quality of food not change significantly with gamma irradiation which is economical as well as assure food safety.

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