Proceedings:
International Symposium on
Prospects of Horticultural Industry in Pakistan
28th to 30th March, 2007
Institute of Horticultural Sciences, University of Agriculture, Faisalabad

THE USE OF IRRADIATION FOR POSTHARVEST AND QUARANTINE CONTROL IN MANGO AND OTHER HORTICULTURE PRODUCE

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Abstract

Irradiation is coming in WTO regime as a commercial technology for reducing post harvest losses in horticulture produce. It is considered low cost best way for controlling fruit fly infestation and extending shelf-life of fresh produce. Commercial irradiation does not affect the physiological attributes of the fresh commodity like skin and flesh color. But it is highly necessary to use the recommended dose of irradiation for attaining a good quality of produce. During irradiation, fresh produce is exposed briefly to a radiant energy source such as gamma rays or electron beams within a shielded facility. It helps to fulfill the quarantine requirement of importing country by reducing potential hazards of insects, harmful pathogens, and in certain fruits and vegetables it inhibits sprouting and delays ripening. Being a cold process, nutrient losses are less than those associated with other methods.

INTRODUCTION

In both domestic and international agricultural markets, expanding the use of irradiation can help to reduce the need for chemicals use for the postharvest control of insect pests. Currently, the U.S. Food and Drug Administration (FDA) have approved irradiation treatments for a variety of foods. The United States Department of Agriculture (USDA), Plant Protection and Quarantine Service (PPQ) and WTOs' regime has outlined policy positions regarding the development and use of irradiation treatments for quarantine pest control, and is actively seeking ways to incorporate additional irradiation uses into their plant protection program (USDA 1995, USDA 1996a, 1996b, 1996c). Furthermore, research has been conducted to determine optimal irradiation dosages for controlling pests and maintaining produce quality, a variety of irradiation technologies have been commercialized worldwide, and there is extensive data available on the capital, operating, and per unit treatment costs associated with irradiation projects. In addition, recent market studies have generally found that consumers are willing to buy irradiated produce (Morrison 1992). In fact, research conducted in Florida indicated that consumer acceptance for such commodities is high, and many actually prefer the methods to traditional chemical fumigation (Marcotte, 1992).

Food irradiation is a process by which products are exposed to ionizing radiation to sterilize or kill insects and microbial pests by damaging their DNA. The FDA permits three types of ionizing radiation to be used on foods: gamma rays from radioactive cobalt-60 and cesium-137, high energy electrons, and x-rays. Although all three have similar effects, gamma rays are most commonly used in food irradiation because of their ability to deeply penetrate pallet loads of food (Forsythe and Evangelou, 1993; Morrison, 1989). Gamma irradiation equipment irradiates packaged or bulk commodities by exposing the product to gamma energy from cobalt-60 in closed chambers, which range in size from single modular pallet irradiators to large research or contract irradiation facilities. Absorbed dose is measured as the quantity of radiation imparted per unit of mass of a specified material. The unit of absorbed dose is the gray (Gy) where 1 gray is equivalent to 1 joule per kilogram (ICGFI, 1991; NAPPO, 1996).

Benefits of Irradiation

There are several benefits of expanding the use of irradiation treatments to control pests infested perishable and non-perishable commodities. First, irradiation may be useful for preventing the movement of quarantine species possibly present in trade commodities into areas where such pests are not established (USDA, 1996b). From an economic standpoint, irradiation, therefore, has the potential to increase trade opportunities between nations, especially from major fruit and vegetable producing countries with high infestation rates (ICGFI, 1994). Irradiation also can be used to reduce the risk of infection and disease caused by food borne pathogens (Moy, 1991). Although consumers have concerns associated with the safety of irradiation technology and its effects on food, research indicates that properly irradiated food does not pose a risk to consumers (Thorne, 1983; OTA, 1985). In fact, the potential for human health impacts from exposure to food borne pathogens is believed to be substantially reduced through the use of irradiation (OTA, 1985; Morrison et al., 1992). In addition, by interfering with cell division, irradiation inhibits sprouting in tubers, bulbs, and root vegetables (potatoes, onions) and can delay ripening of some tropical fruits, resulting in an extended shelf life for many foods. In Pakistan as the mango is famous for its taste, flavor and shape due to the climatic conditions, which are dry as compared the other zones like Thailand, Bangladesh etc. The environment is conducive for the production of mango, and a large variety of germ plasma is available in this region. Pakistan is the Sixth largest mango growing country in the world. The mango orchards are spread over 118810 acres in more than ten Punjab districts include Rahimyar Khan, Bahawalpur, Multan, Vehari, Muzaffargarh, Kahnwal, Sahiwal, Jhang, Faisalabad and Okara etc.Due to persistant demands from the international importers on the control of quarantine pests like fruitfly and weevels The Pakistani traders haves urged the demand that the fruit should be treated with radiations to extend the shelf life and to overcome the quarantine barriers. The market is ripe for the business. The longer shelf life will enhance trade opportunities between nations by extending time constraints under which fresh produce must be delivered to more distant geographic markets or by allowing the use of slower and less expensive modes of transportation (Kader, 1986; Moy 1991; OTA, 1985). Food irradiation technology may be a long way to socioeconomic up lift of countries like Pakistan where most of the employments comes from agriculture sector.

Current Uses of Irradiation

Foods' Irradiation is used as a pest control tool in over 40 countries, including the United States, Russia, Great Britian and Brazil (Nordion, 1995). The disinfestations of grain as it enters the Soviet Union at the Black Sea Port of Odessa, estimated at over 500 thousand tonnes per year, is one of the largest documented commercial industrial applications (Giddings, 1991). In the United States, the FDA approved low-doses irradiation for wheat, wheat flour, and potatoes in the early 1960s. In 1984 and 1985, the FDA approved irradiation of spices and pork, and in the following year, approved low-dose irradiation (up to 1 kGy) to control insects in foods and extend the shelf life of fresh fruits and vegetables (Kader, 1986; Morrison, 1989). Irradiation has also been used to sterilize food for U.S. hospital patients and astronauts (Morrison, 1992). Further, irradiation disinfestations has been found to be effective for treatment of dried fruits, spices, nuts, cut flowers, lumber, and wood chips (ICGFI, 1994, Marcotte 1992; Morrison, 1989; OTA, 1985). At doses below 1 kGy, irradiation is an effective treatment against various species of fruit flies, mango seed weevils, naval orange worms, potato tuber moths, codling moths, and other insect species of significance to quarantine situations (Kader, 1986). Some work on the mango irradiation was started in food science Division of NIAB, Faisalabad in late seventies. The aim of this research work was to extend the shelf life of mangoes up to 15 days on the mango variety Dosahri. This research was of preliminary nature and then with the inception of NIFA Peshwar in 1982 (whose primary objectives includes the use of gamma radiation for post harvest quality conservation in foods) the work was discontinued at NIAB. The work on mango fruit irradiation for shelf life could not be continued at NIFA since mango was not the crop of the area. However during 1985 Farooqi et all, tried low temperature storage of Samar Bahisht mangoes for shelf life extension (7-9°C). Gamma radiation of fruits done for post harvest quality conservation with very specific goals i.e. sprout inhibition in onions (Mumtaz et al., 1970) shelf life extension in Guava (Ahmad et al., 1973), shelf life extension of mangoes (Ismail et al., 1974).

Effective Dosages and Impact on Produce Quality

Because foods differ in their radiation dose requirements, densities, as well as specific packing configurations (Kunstadt et al., 1990), research has focused on insect mortality, morbidity, and sterilization, as well as the effects of ionizing radiation on fruit quality. The effects of irradiation depend on the dose absorbed. Low doses (up to 1 kGy) inhibit sprouting in tuber, bulb and root vegetables, inhibit the growth of pathogenic fungi on asparagus and mushrooms, and delay physiological processes (ripening, etc.) in fruits such as banana, mango, and papaya. Medium doses (1 to 10 kGy) extend the shelf life of commodities, eliminate spoilage and pathogenic microorganisms, and improve the technical properties of food. Lastly, high doses (10 to 50 kGy) can be used for industrial sterilization and decontamination of certain additives or ingredients (Morrison, 1992; ICGFI, 1994; OTA, 1985; Kader, 1986). In 1984, the International Consultive Group on Food Irradiation (ICGFI) convened in Washington, D.C., to develop a set of harmonized guidelines for the irradiation of fresh produce. The group established minimum doses that could provide effective treatments against most arthropod pests (ICGFI 1994). Doses recommended to disinfest foods and agricultural products are usually between 0.15 kGy (minimum dose for fruit fly sterilization and to prevent larval development) and 0.30 kGy (to control other species of insects and mites), but may go as high as 1 kGy (Forsythe & Evangelou 1993; Marcotste, 1992). While research has proven irradiation to be effective at sterilizing pest insects, there is growing concern as to how quarantine inspectors would tell the difference between sterile and non-sterile insects because they physically appear the same. Unless already established, the correct dose required for a specific commodity infested with a specific pest must be determined through testing. Results of some of the studies that have investigated dose requirements include:

- Research on the mango seed weevil in the U.S. has shown that irradiation at doses of 0.30 kGy prevented adult emergence from infested fruit (ICGFI, 1994).
- USDA researchers in Florida found that radiation doses as low as 0.30 kGy were effective in eliminating plum curculio (*Conotrachelus nenuphar),* and blueberry maggot (*Rhagoletis mendax),* without altering overall fruit quality (Hallman & Miller 1994).
- Researchers at Washington State University conducted a series of tests on 'Rainier' cherries and determined that irradiation levels as high as 0.30 kGy had no effect on composition, color, or taste. They also concluded that doses of 0.15 and 0.25 kGy were effective in controlling cherry fruit flies and codling moths, respectively (Drake et al., 1994).
- Studies done at the U.S. Horticultural Research Laboratory in Florida (USDA/ARS, Orlando) showed that irradiation doses up to 0.75 kGy were sufficient in controlling apple maggot (*Rhagoletis pomonella*), blueberry maggot (*Rhagoletis mendax*), and plum curculio (*Conotrachelus nenuphar*), without doing any damage to the fruit's composition or taste (Miller & McDonald, 1994).

Factors influencing the response of fresh fruits and vegetables to irradiation include the type of commodity and cultivar, production area and season, maturity at harvest, initial quality, and post harvest handling procedures. Similarly, environmental conditions during irradiation (temperature and atmospheric composition), and dose rates are also influencing factors (ICGFI 1994, Kader 1986, OTA 1985, Morrison 1992). The relative tolerances of fresh fruits and vegetables to irradiation doses below 1 kGy are listed in Table 1 below.

Table 1: Relative tolerance of fresh fruits and vegetables to irradiation below 1 kGy

High sensitivity	Apple, mango, date, guava, longan, muskmelon, nectarine, papaya, peach, rumbutan, raspberry, strawberry, tamarillo, tomato
Medium sensitivity	Apricot, banana, cherimoya, fig, grapefruit, kumquat, loquat, lychee, orange, passion fruit, pear, pineapple, plum, tangelo, tangerine
Low sensitivity	Avocado, cucumber, grape, green bean, lemon, lime, olive, pepper, sapodilla, soursop, summer squash, leafy vegetables, broccoli, cauliflower

Costs

The actual cost of food irradiation is influenced by dose requirements, the food's tolerance of radiation, handling conditions (i.e. packaging and stacking requirements), construction costs, financing arrangements, and other variables particular to the situation (Forsythe & Evangel, 1993; USDA, 1989). Irradiation is a capital-intensive technology requiring a substantial initial investment, ranging from $1 million to $3 million (or possibly more for special applications). In the case of large research or contract irradiation facilities, major capital costs include a radiation source (cobalt-60), hardware (irradiator, totes and conveyors, control systems, and other auxiliary equipment), land (1 to 1.5 acres), radiation shield, and warehouse. Operating costs include salaries (for fixed and variable labor), utilities, maintenance, taxes/insurance, cobalt-60 replenishment, general utilities, and miscellaneous operating costs (Kunstadt et al., 1990; USDA, 1989). Based on a review of public information on the costs of treating a variety of food items with irradiation, Table 2 presents data on the per-unit costs for gamma irradiation and methyl bromide treatments for selected crops. Although irradiation is more expensive than fumigating with methyl bromide, the cost of irradiation may be offset by its many benefits, including reduced damage to fruits and vegetables, no pesticidal residues and an extended shelf life. Furthermore, it is likely that irradiation costs will decrease in the future as the number of commercial irradiators and volumes of treated commodities increases. In addition, the relative proportion of the treatment cost is small when compared to the value of the commodity. Furthermore, other related costs (i.e. harvesting, packaging, storage, processing, and transportation costs to bring the commodity to market) further reduce the percent contribution of irradiation treatments, making it a relatively insignificant cost overall.

Table 2: Comparison of estimated postharvest treatment costs for selected crops

Crop	Methyl Bromide (cents per pound)	Irradiation (cents per pound)
Strawberries	0.88 to 0.94	2.5 to 8.1
Papaya	0.88 to 0.94	0.9 to 4.2
Mango	0.88 to 0.94	Data not available

Sources: Forsythe and Evalgelou 1993 and 1994, Morrison 1989.

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