# IRRADIATING MANGO ?

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Mango can be marketed as fresh fruit or as processed products. The latter includes juice and puree, dehydrated slices and juice powder, canned, and frozen products. My discussion today will be on fresh mango, and on the question of whether or not we should consider irradiating mango.

As we know, mangos grown in Hawaii are prone to infestation by two groups of pests: fruit flies, of which there are three commercially important species in the islands, and mango seed weevils. Because mangos grown here are likely infested by these pests, USDA-APHIS has not allowed Hawaii-grown mangos to be exported to the U.S. mainland. For many years, this has persisted as a "catch-22" situation. Without an approved quarantine treatment procedure by USDA, growers are not considering large-scale cultivation of mangos in the islands. On the other hand, without adequate commercial planting, a market for fresh mangos from Hawaii cannot be developed.

As we also know, quarantine treatment of papayas grown in Hawaii for the export markets has shifted since September 1984 from chemical fumigation to thermal methods. While the thermal methods (vapor heat and dry heat) meet USDA approval, some aspects of these treatments have created some quality problems due to the effect of heat on the biochemistry and physiology of the fruit. Assuming the mango seed weevils can be inactivated by thermal means, the quality problem of the fruit will probably be similar to that of papaya and needs to be considered as a marketing problem.

The irradiation process is an alternative for treating mangos. The process can be described as simple, versatile, efficacious, and controversial. Foods can be placed next to a radiation source, either a gamma source such as Cobalt-60, or electron beams, for irradiation, exactly the same as treating a food or a medical product with x-rays. Therefore, it is a very simple process. Studies around the world have shown that different foods can be irradiated for various purposes: fruits and vegetables for disinfestation and shelf-life extension; grains and beans for disinfestation; potatoes and onions for sprout inhibition, a form of shelf-life extension; and meats and seafoods for decontamination by killing harmful bacteria. The process is therefore very versatile, much more so than any existing process in use today. Also, it is efficacious, meaning it is both efficient and effective. Consider the treatment of papaya, for example. If papayas are to be irradiated as a quarantine treatment, which has been approved, the dose required is 0.15 kiloGrays (kGy), which will take 10-15 minutes on the conveyor belt for cartons of papayas to travel from the entrance to the exit of the irradiator, and every papaya in the carton will be thoroughly irradiated. Therefore, the disinfestation process is both efficient and effective.

The controversial aspect of the irradiation process is due to two factors: first, the negative publicity we have heard for the past 50 years about nuclear bombs, nuclear reactor leaks, and radioactive fallout. Some people mistakenly relate food irradiation with these happenings, which is completely not true. And secondly, the misinformation spread by anti-food-irradiation activists about the safety of food irradiation. The facts are that irradiated foods, when handled and treated properly, are completely safe for human consumption and contain no radioactivity or toxic substances. As of 1992, irradiation has been approved in 37 countries for treating more than 45 foods or food groups for purposes indicated above. UN agencies such as the FAO, WHO, IAEA, and the American Medical Association are some of the organizations endorsing food irradiation, and urging countries to develop and use this process commercially. Currently, 22 countries are irradiating some 20 food items commercially or semi-commercially.

For mangos, irradiation can disinfest the two groups of pests as a quarantine treatment, and could also extend the shelf-life of the fruit. A study by Cornwell (1966) showed the non-emergence dose for mango seed weevils (*Cryptorhynchus mangiferae*) to be 0.33 kGy. Brodrick and Thomas (1978) reported the required dose to be 0.50 kGy. For sterilization of three species of fruit flies, the minimum dose is 0.15 kGy. Therefore, the disinfestation dose needed for mangos falls in the range of 0.33 to 0.50 kGy.

What about extending the shelf-life of mangos by irradiation? There certainly is incentive to do so if research results support this expectation. From the mid-60s to the early 70s, studies of irradiation of mangos for shelf-life extension by researchers from Thailand, the Philippines, India, Puerto Rico, Florida, and Hawaii have shown that shelf-life of mangos can be extended from 5 to 16 days when treated with doses of 0.25 - 0.75 kGy, depending on the variety of the mangos tested. The sum of all these data would suggest that a minimum dose of 0.50 kGy and a maximum dose of 0.75 kGy would give the 'Haden' variety a shelf-life extension of seven days or more, and, at the same time, would take care of all the fruit fly eggs that might be oviposited in the mango.

Quality retention of irradiated products must also be considered. Data from the irradiation project at the University of Hawaii at Manoa from 1965 to 1972 showed the 'Haden' variety could tolerate radiation dose up to 1.0 kGy, its sensory qualities are retained up to 1.5 kGy, and its nutrient qualities (Vitamins A and C) are retained up to 2.0 kGy. These figures are encouraging, because as long as the tolerance dose is higher than the disinfestation dose and the shelf-life extension dose, the process is useful. It was also found that irradiated mangos would ripen normally, even though the ripening might be delayed.

A market test of irradiated mangos was conducted in a supermarket in Miami in October, 1986. In less than three weeks, 4,000 kg (almost 9,000 lb) of irradiated Puerto Rican mangos were sold out, a good indication of consumer acceptance. In early 1992, Vindicator, Inc. in Florida, the only dedicated food irradiator in the United States, irradiated strawberries and citrus and marketed them in Central and South Florida, and in the suburbs of Chicago. All the irradiated fruits received very high consumer acceptance.

In the United States, government rules and regulations are in place to allow irradiation of Hawaii-grown papayas. In April 1986 the FDA approved irradiation of fresh foods for disinfestation and delaying maturation at doses up to 1.0 kGy. In January 1989 the USDA-APHIS approved irradiation of Hawaii-grown papayas as a quarantine treatment procedure at a minimum dose of 0.15 kGy. For mangos, the FDA rule will apply. A request to USDA-APHIS to modify the dose requirement for Hawaii-grown mangos will be needed.

Economic studies of irradiating various fruits indicate that the cost is not high, and is competitive with the cost of thermal treatment of fruits, especially if the irradiator can be used for several products at different seasons.

In conclusion, results of various studies mentioned above indicated a number of advantages and benefits in irradiating mangos for export markets. Therefore, if the question is raised as to why we want to irradiate mangos, the answer is that irradiation will efficiently and effectively serve as a quarantine treatment method as well as bringing the benefit of shelf-life extension of the fruit.

**References**

Brodrick, H.T., and A.C. Thomas. 1978. Radiation preservation of subtropical fruits in South Africa. Proc. IAEA Symp. Food Preservation by Irradiation, Vienna. STI/PUB/470, v. 1, 167.

Cornwell, P.B. 1966. Status of irradiation control of insects in grain. *In* Food irradiation. Int. Atomic Energy Agency, Vienna. p. 470.

Q: How is the radiation produced; what elements are involved?

A: There are three types of sources. The first are gamma sources, which include two radioactive elements, either cobalt-60 or cesium-137. Cobalt-60 has a half-life of 5.3 years, meaning after that time you lose half of its strength, so you have to replenish the source often, possibly every two years, in order to keep the dose rate up and have an efficient operation. Cobalt is a solid metal, insoluble in water, so it will not contaminate a pool. Even if it leaks out of the capsule, it can be recovered from the bottom of the pool. Cesium-137 is not available commercially; cobalt-60 is. The biggest supplier of cobalt-60 is in Canada, and they sell it for about $1.60 per curie. When we built our research irradiator in 1965 we began with 30,000 curies. A commercial irradiator would have about a million curies, and a pilot-plant sized irradiator should have about half a million curies. A problem with cesium-137 is that it is a byproduct of refining uranium and is in the form of a chloride. It has to be double-encapsulated in stainless steel tubes because it is highly soluble in water, as all chloride salts are. It is somewhat corrosive, and it generates a lot of heat. Standing at room temperature, a capsule of cesium-137 could reach 400°F. When used for food irradiation, it has to be raised up out of the pool to be in proximity to the food as the cartons of food move by; when the source is returned to the pool, the water sizzles. Cesium-137 has a half-life of 30 years, so it can be used for a long time without replenishment.

The second source is high-energy electrons. These are generated in a machine and shot out at almost the speed of light. The electrons are shot at the food as it passes on a conveyor belt. The problem with this source is that the penetration of electrons is very shallow. For every million electron-volts (Mev) of the machine, the penetration is only half a centimeter. The maximum we can use is a 10-Mev machine, due to the worry about radioactivity getting into the food. Beyond 10 Mev, there is a chance of causing some nuclear changes in the food by knocking some electron off the food's atoms. A 10-Mev machine would give a maximum penetration of 5 cm. There is also a problem of uniformity, or how to ensure that every part of foods on a conveyor belt gets the same amount of electrons. The advantage is that the machine is very compact and can be turned on and off, and people are much more comfortable about this kind of technology. The Department of Energy funded two electron machines, to Florida and Iowa, as part of a demonstration irradiator program mandated by Congress to help industries learn how food irradiation is done. This was supposed to have been established in six states, including Hawaii, but it was funded for only three years, and each state was to have submitted a proposal to get the funds. Our people did not move fast enough. Florida and Iowa obtained the funds and acquired the machinery, which was made in France. I saw the one in Gainesville. Two years after being received, it is still not working yet; it is very complex, and the French engineers are still working on it.

The third source is converted x-ray. If you take a strong metal, like tungsten or vanadium, and bombard it with electrons, they will emerge from the other side as x-rays. Like gamma irradiation, x-rays are very penetrating, and can be used to irradiate foods. The conversion efficiency, however, is very low: 5 – 8 percent; the rest is heat.

Q: What dosage would be useful for postharvest disease control.

A: Bacteria are easier to kill with irradiation; fungi are somewhat resistant. Pathologists find about seven different fungi invading papayas, and studies revealed that 1.5 – 5 kGy would be needed to kill these fungi, which is beyond the tolerance dose of most fruits. Irradiation is not a good way to treat postharvest diseases.

Q: If you use the sterilization dose on a fruit to sexually sterilize the fruit fly eggs, there will still be a live organism in there. How do you know that it is really sterile.

A: A task force of the International Atomic Energy Agency concluded that the generic dose necessary for sexually sterilizing the fruit fly at any of its stages is 0.15 kGy. They believe that even though the eggs might survive and grow, the next stage would not be normal. Therefore, USDA – APHIS accepted that dose and promulgated the regulation in January 1989. However, as a practical matter, if you have a fruit that contains a wiggling larvae, whether or not to accept that fruit is a difficult question for quarantine authorities to ponder.

There is a move to develop means to determine whether or not a food item has been irradiated. This is partly for the consumer, so that they can have informed choice in purchasing irradiated foods. However, it is most difficult to detect changes in foods given dosages under 1 kGy, particularly foods with high water content. Dry foods and bony foods can be detected if they have been irradiated, using techniques involving thermal luminescence or electron spin resonance. Really, there is no good way for a quarantine official at the arriving port to tell whether or not a papaya or mango has been irradiated.

Q: What could be the effect of over-irradiation?

A: Most likely this would result in undesirable chemical changes in the food. In fruits, it could cause depolymerization of the pectin, meaning that it would get soft. Higher doses could oxidize the food, turning it dark. There would not be any toxicity, no residual radioactivity whatsoever.

Q: Could you use dosimeters in the boxes to verify that the box had been irradiated.

A: Yes. That would be the way to do it. And based on that indicator, you could accept the results of research that at the dosage received by the box, the fruits within it would have been adequately disinfested.