LECTURE 7

IONISING ENERGY TREATMENT OF FRESH FRUIT

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For the ionising energy treatment of fresh fruit to be economically and socially acceptable it must perform a function which is socially demanded, or at least attractive, in a superior manner to alternative treatments. The superiority of this treatment may not only be due to direct economic factors, but rather to its ability to perform specific functions without causing any detrimental effect on the commodity, or raising doubts about the wholesomeness or safety of the product for the consumer.

Specifically the main purpose of the ionising energy treatment of fresh fruit may be one or more of the following:

1. The extension of shelf life of the commodity due to a direct physiological effect on the particular product;
2. The extension of shelf life of the commodity due to a reduction in the development of moulds and rots which would normally render the product worthless;
3. The killing of insect pests of quarantine significance, to allow for normal marketing of fresh fruit without the risk of introducing insect pests to previously pest-free areas.

Extension of Shelf Life.

The physiological extension of shelf life of fresh fruit is associated with a retardation of ripening and senescence of the fruit. This is particularly relevant for climactric fruit such as bananas, mangoes and pawpaws, which undergo a significant postharvest rise in respiration and ethylene production associated with a direct senescence metabolism. In the case of such fruit the physiological shelf life can be significantly extended by low dose irradiation treatments. As an example, the treatment of bananas with between 250 to 500 Gy can increase the shelf life of the fruit from 25 to 45 days, in the absence of exogenous ethylene. This irradiation treatment apparently reduces the sensitivity of the fruit to ethylene, so that up to 24 hours extra exposure to ethylene is required for uniform ripening (Maxie et al., 1968). The eating quality of these fruit is not effected by such a treatment.

In general the irradiation of mangoes with doses between 250 and 600 Gy increases the shelf life of the fruit by delaying senescence. The degree of shelf life extension, as well as the maximum tolerable dose, varies between cultivars and locality. Studies carried out to date indicate that mangoes in India can tolerate 750 Gy, in Florida 100 Gy, in Hawaii 1000 Gy (Akamine and Moy, 1983) and common mangoes from north Queensland can tolerate 600 Gy without injury. "Nan Klang Wan" mangoes were recently treated in Thailand to a dose of 750 Gy, which delayed colour development, but had no adverse effect on fruit quality (Buangsuaron and Sukasen, 1985). An extension of shelf life of 7-9 days was seen with the north Queensland fruit treated with 600 Gy. Kensington Pride mangoes from northern N.S.W. were found to be more tolerant of irradiation than were the Common mangoes. This difference in radiation tolerance may be associated with the difference in fibre content, which is significantly higher in the Commons than in the commercial Kensington cultivars.

Extensive research over the past 20 years in Hawaii has indicated that ripening and senescence of pawpaws can be retarded by a dose of 750 Gy. In combination with a hot water dip at 49°C for 20 min, this irradiation treatment resulted in a further 3-4 days extension of shelf life. The research involved in the development of this combination treatment for pawpaws is of general significance for many fruits, since it indicates a highly suitable research approach. Much of this research was carried out by Akamine, Wong, Goo and Moy at the University of Hawaii and recently reviewed by Akamine and Moy (1983). The first of these studies indicated that treatment of pawpaws with more than 1 K Gy caused some surface scalding and 2 K Gy resulted in poor colour development of the ripe fruit. Doses of 4 and 5 K Gy caused poor flavour and aroma development, and tissue breakdown respectively. This data therefore indicated that a dose of 1 K Gy would be the maximum tolerable dose for pawpaws in Hawaii. However on ripening and storage, fruit treated with 1 k Gy were significantly softer than similar fruit treated with 750 Gy. It was therefore concluded that 750 Gy would be optimum for shelf life extension of these fruit.

The physiological effects of gamma-radiation on fruit is far from clear. Recent studies in China (Xu Zi-cheng, 1985) indicated that irradiation of apples with 500 Gy would extend the shelf-life of the fruit stored at 2°C to 9 months. Kovacs et al. (1985) suggested an interaction of irradiation and calcium metabolism in apples. However this interaction is unclear, especially since our recent studies with Jonathon and Granny Smith apples (Rigney et al. 1985) indicated that iradiation to 600 Gy did not alter the rate of softening of the fruit, which could be expected if there was a major change in calcium metabolism.

To control organisms causing postharvest decay of pawpaws a dose of 6 K Gy is required. Since this dose was known to result in significant tissue breakdown a combination of hot water treatment and irradiation was examined; it had been previously found that a single hot water dip could reduce pawpaw decay. This combination treatment of 49°C for 20 minutes followed by a 750 Gy dose controlled postharvest storage decay and extended the shelf life. However, subsequent storage at 13°C, the normally optimum storage temperature for pawpaws, resulted in surface scald development. Raising the storage temperature to 16°C eliminated this scald problem. This series of experiments indicates that many factors may contribute to an optimum irratiation regime, and one should not be put off by an initially poor experimental result. The optimum storage temperature for irradiated fruit may be different from that normally used for storage of the non-irradiated product.

In the case of non-climacteric fruit, which do not undergo a significant postharvest rise in respiration, no physiological extension of shelf life could be anticipated. Such fruit include oranges and strawberries. Treatment of oranges with more than 1 K Gy may cause some peel injury, although organoleptic differences are not apparent with less than 3 K Gy (Grierson and Dennison, 1965). This treatment causes no change in soluble solids or citric acid content of the juice, and the ascorbic acid level is only slightly reduced.

Although there may be no direct physiological benefits resulting from the treatment of strawberries by ionising energy, an extension of shelf life does result from treatment of the fruit with 2 K Gy. This is due to the control of spoilage organisms, particularly transit rots such as Botrytis cinerea. This organism, which is responsible for the major postharvest losses of strawberries, can be retarded by a 2 K Gy dose. Strawberries thus treated and stored at 5°C can have a shelf life in excess of 14 days (Sommer and Fortlage, 1966).

Insect Disinfestation

A major benefit of the ionising energy treatment of fresh fruit is the disinfestation of fruit for export. In Australia, Queensland fruit fly (Dacus tryoni) occurs in eastern Queensland and New South Wales and its presence restricts, through quarantine, the marketing of fresh fruit in other states and overseas. Many countries face similar plant quarantine problems in the export of horticultural produce, be it oranges from Australia, mangoes from the Philippines or orchids from Thailand. In the disinfestation treatment of fresh fruit the life-cycle of the insect must be broken to satisfy the quarantine requirements, but the fruit must not be damaged by the treatment, or reduced in quality for the consumer. In this discussion of disinfestation I will use the Queensland fruit fly as an example, since the story is typical of many such insect pests.

For many years many different fruits have been fumigated with EDB as a disinfestation treatment against several fruit flies, including Queensland fruit fly. However, the use of EDB to fumigate fruit is being phased out throughout the world, due to suspicions that it is carcinogenic and causes reproductive disorders. An alternative to this fumigation treatment is urgently required to maintain present exports, as well as for the development of new markets. Such an alternative should have widescale applicability to most, if not all, fruit types, be effective against a range of insect pests, and leave no harmful residues in the fruit. In addition the treatment must be economically and logistically feasible.

The longterm potential of any chemical alternative is doubtful, since health authorities may at any time introduce more stringent control of chemicals applied to food after harvest. Heat treatment, be it hot water or saturated hot air storage, has very limited applicability. Similarly cold sterilization is limited to the treatment of those temperate fruits which are not chilling sensitive.

Low dose irradiation treatment is effective against a range of insect pests in fresh fruit. A dose of 75 Gy will disinfest fruit against Queensland fruit fly; 200-250 Gy should be suitable for Medfly (Ceratitis capitata) and Oriental fruit fly (Dacus dorsalis); 150-200 Gy should disinfest fruit against Codling moth (Cydia pomonella). A 600 Gy irradiation treatment is the only feasible means of disinfesting mangoes against the mango seed weevil. Most fruits are relatively unaffected by this low dose irradiation treatment, and since no residue from the treatment remains in the fruit, the consumer's health is safeguarded. Provided that the irradiation treatment can be economically applied, it should be not only the most feasible alternative to chemical fumigation, but a viable quarantine treatment in its own right.

CONCLUSION

In this discussion of ionising energy treatment of fresh fruit one should remember that some alternatives to this treatment do exist. For example, the shelf life of some fruits can be extended by refrigeration. However, many fruit types are susceptible to chilling injury, and thus cannot be stored at low temperatures. Pathogens can often be controlled by postharvest chemical treatments, but many of these are restricted by public health regulations in many countries. As mentioned above, ethylene dibromide fumigation of fresh fruit is a typical example of the use of a postharvest chemical which has only recently been found to cause cancer and reproductive disorders in mammals.

Although ionising energy treatment may not solve all the problems associated with storage, transport and marketing of fresh fruit, it must be considered as a valuable tool to be used either alone, or in combination with other acceptable treatments, to provide fresh produce for the consumer.

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