Postharvest Quality and Physiology of Apples Subjected to Phytosanitary Irradiation

Anuradha Prakash
Chapman University
prakash@chapman.edu

Introduction

A major export barrier for US specialty crops is the incidence of pests on agricultural commodities which are endemic to parts of the U.S. and that are not established in potential export destinations. For apples exported from California to Mexico, a key pest of concern is the Oriental fruit moth, *Grapholita molesta.* In 2016, following a request by the California Apple Commission, an addendum to the Operational Work Plan for Import of Articles Intended for Irradiation in Mexico from the United States was signed for CA origin apples intended to be irradiated in Mexico. Irradiation offers an economically beneficial alternative for California apple varieties, especially those targeted to the Mexican market, when Californian producers can take advantage of the earlier harvest compared to Washington State season. It also offers an alternative treatment to methyl bromide (MB) fumigation which can affect quality of certain apple varieties. More importantly, methyl bromide is slated for phase-out under the Montreal Protocol and irradiation offers another alternative for growers to use given that the only other option allowed is a 40/90 day cold treatment. Thus, an alternative pest mitigation option is very important to this industry.

However, irradiation can induce physiological responses in fruits, some beneficial and others harmful to fruit quality. Studies of irradiated apples and many other fruit have shown that the response of fresh fruit respiration to irradiation is highly dependent on cultivar, maturity and irradiation dose levels. The results of this project will help develop quality standards that growers and shippers can implement to ensure that the fruit is harvested and treated at the optimum maturity stage for irradiation, assure high post-treatment quality and shelf-life during commercial distribution and to integrate irradiation as a viable phytosanitary option into commodity export systems.

Preliminary work

We conducted a preliminary study to evaluate the response of apples treated with phytosanitary irradiation and subject to temperature conditions during export to Mexico. Freshly harvested apples were irradiated at 250 (target dose for Mexico) and 1,000 Gy with electron beam at Steri-tek (Fremont, CA) and then stored for 7 days at 1 °C (to simulate transportation from California to Mexico) and 7 days at ambient temperature (to simulate distribution and retail).

Upon treatment, all three varieties exhibited similar responses. Apples treated with 800-1,000 Gy exhibited an increase in ethylene production and respiration rate as compared to the control. During storage, ethylene levels in the irradiated apples dropped and remained low even during ambient temperature storage. Respiration rate, however, remained higher than the control throughout storage. The differences in respiration rate were not manifested in any of the quality parameters tested- color, browning index, malondialdehyde (MDA), sugar content and organic acids. At 250 Gy, firmness was not impacted.

Recent work

1. **Physiological changes induced by irradiation do not affect sensory properties of early and late-harvested Gala apples**

Introduction: Research on other climacteric fruits have shown that maturity stage can influence fruit physiology and quality of irradiated fruit. However, there is no research that analyzes the effect of phytosanitary irradiation on the quality of apples harvested and treated at different maturity stages.

Objectives:

1. Evaluate the impact of maturity stage on the physicochemical properties of irradiated apples.
2. Investigate the relationship between physiological changes and quality parameters during storage under conditions (1 week at 0-1°C plus 1 week at ambient temperature) that simulate export to Mexico from California

Results: The only differences between 'Gala' apples harvested three weeks apart was 13% higher titratable acidity and lower electrolyte leakage in early harvested apples. Irradiation had a strong suppressive effect on ethylene production which can be related to a decrease in ACC oxidase activity, and a transient increase in respiration rate. Irradiation at 1000 Gy impacted electrolyte leakage initially, but other attributes showed no impact of irradiation. Unlike most irradiated fruit, including apples, the texture was unaffected by irradiation even at 1000 Gy. Consumers were unable to differentiate between control and 310 Gy irradiated apples.

Conclusions: There were minimal differences in quality parameters or metabolism between the Gala apples harvested three weeks apart. Although the climacteric was suppressed and respiration rate elevated, no quality changes were observed in apples irradiated even at 1000Gy and stored for 16 days, indicating that Gala apples are highly tolerant to irradiation. In terms of quality, irradiation is highly feasible for phytosanitary treatment for Gala apples exported to Mexico.

Next Steps: A longer span between harvests would enable a more accurate assessment of the interaction of maturity stage and irradiation treatment on the physiology of Gala apples. Also, internal browning was observed in apples stored for five months (0-1°C), so the impact of irradiation on quality of apples in long term storage should be evaluated.

2. **Irradiation as an Alternative to Methyl Bromide Fumigation and DPA treatment of 'Granny Smith' Apples.**

Introduction: Storage scald and internal browning are major disorders in 'Granny Smith' apples that cause concern to apple growers. Methyl bromide fumigation (MeBr), used for phytosanitary treatment on apples, exacerbates surface scald. To prevent surface scald, 'Granny Smith' apples are dipped in diphenylamine (DPA), which is theorized to control scald by inhibiting ethylene production. However, DPA is considered to be a carcinogen and prohibited in Europe. Irradiation at 250 Gy is approved as a phytosanitary treatment for apples destined for Mexico and can serve as an alternative to MeBr, which is an ozone depleter and in the process of being phased out. Irradiation has been shown to reduce ethylene production in apples. Thus, it could possibly eliminate the need for DPA treatment as well.

Objectives: To evaluate the effect of irradiation on 'Granny Smith' apples and determine if it can preclude the use of both, DPA and MeBr.

Results: Control and fumigated apples showed high levels of scald when cold fruit was warmed to ambient temperatures. Storage scald was significantly ($p<0.05$) lower in irradiated apples, consistent with the lower concentrations of conjugated trienols and α-farnesene concentrations. The reduction in the concentrations of alpha-farnesene between 3 and 6 months was correlated to the expression of ethylene and substrate degradation during storage. However, 43% of apples irradiated at 1000 Gy showed internal browning after 90 days, and 56% after 6 months at 0-1°C.

Conclusions: Fruit treated with 310 Gy had the benefits of both, reduced scald and low internal browning incidence after 6 months in cold storage. Thus, irradiation at 250 Gy can serve as an alternate to fumigation with methyl bromide as well as DPA, serving to provide both, an environmental as well as a health benefit.