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Anuradha Prakash
Chapman University, prakash@chapman.edu

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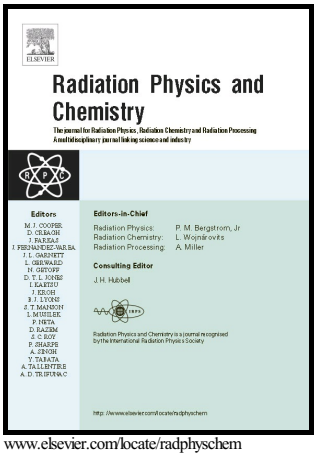

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Particular applications of food irradiation

Fresh produce

Anuradha Prakash
Food Science Program
Chapman University
One University Drive, Orange, CA 92866, USA
(714) 744-7826
prakash@chapman.edu

Introduction

On fresh fruits and vegetables, irradiation at low and medium dose levels can effectively reduce microbial counts which can enhance safety, inhibit sprouting to extend shelf-life, and eliminate or sterilize insect pests which can serve to facilitate trade between countries. At the dose levels used for these purposes, the impact on quality is negligible. Despite the fact that regulations in many countries allow the use of irradiation for fresh produce, the technology remains under-utilized, even in the light of an increase in produce related disease outbreaks and the economic benefits of extended shelf-life and reduced food waste. Putative concerns about consumer acceptance particularly for produce that is labeled as irradiated have deterred many companies from using irradiation and retailers to carry irradiated produce. This section highlights the commercial use of irradiation for fresh produce, other than phytosanitary irradiation which is covered in a separate section.

1. Enhanced safety: In many countries, the use of irradiation is limited to dehydrated vegetables, herbs, spices, and seasonings to reduce their bioburden. The report below by Gao Peng, China, shows the extent of irradiation use in China for plant based foods. In Vietnam, frozen cut vegetables such as eggplants, corn beans, red pumpkins destined for export are treated at 2-4 kGy in according to Ms. Doan Thi The of Vinagamma, Ho Chi Minh City in Vietnam.

   The use of irradiation to enhance safety of fresh produce remains unrealized. Fresh produce related outbreaks have increased significantly in recent years with tremendous

costs to human life, productivity, and economy, in large part due to the fact that many of these products are consumed raw or without treatment to achieve sufficient destruction of pathogens. Irradiation is highly effective against most produce-related pathogens. Irradiation offers the benefits of being able to reach internal pores and crevices where pathogens can attach away from the reach of traditional sanitization methods and the cold treatment maintains the fresh/raw character of produce that is consumed without further processing. Most fruit and vegetables tolerate the dose levels needed to achieve 3-5 log reduction of pathogens such as Salmonella spp., E. coli O157:H7, Listeria monocytogenes and Staphylococcus aureus with little impact on quality or nutritional value (Niemira and Fan, 2006). Therefore, following a multistate outbreak of E. coli O157:H7 in spinach in 2006, the FDA approved use of irradiation up to 4.0 kGy for iceberg lettuce and spinach, but treatment has not been utilized commercially. Similarly, irradiation can play an important role in controlling illnesses related to sprouts and could have prevented the 2011 outbreak of E. coli O104:H4 linked to fenugreek seeds that killed 53 people in Europe (Callejón and others, 2015). Irradiation is also effective against parasitic protozoa and helminths that pose particular challenges to vulnerable populations such as children, immuno-compromised patients, pregnant mothers, and the elderly. Despite its effectiveness on pathogens found on fresh produce and sprout seeds, irradiation is seldom used for these products.

2. Sprout inhibition: Inhibition of sprouting of tubers requires low levels of irradiation which enables a significant enhancement of shelf-life. In 2015, India treated ~115 tons of onion and 16 tons of garlic at a dose of 60 Gy (Mr. Pranav Parekh, Agrosurg Irradiators (I) Pvt.Ltd, India). China also treats garlic (see personal communication by Gao Peng below). Japan continues to treat potatoes for sprout inhibition, although volumes have steadily diminished since treatment first started in the early 1970's. A report by Setsuko Todoriko is attached below.

3. Shelf-life extension: Reduction of spoilage organisms can extend shelf-life of irradiated fresh produce, however this benefit has not been commercially exploited. For products such as sliced mushrooms, diced celery, and whole strawberries, reductions in counts of

spoilage microorganisms can increase shelf-life significantly. Generally speaking, spoilage bacteria have lower D values as compared to fungi, thus higher doses may be needed to reduce spoilage related to mold and yeast. Irradiation can also delay ripening of fruit such as mangoes and papaya and can contribute to a few additional days of shelf-life of fruit by delaying the onset of senescence. The impact on irradiation on shelf-life and quality of fresh produce depends upon cultivar, maturity, and pre- and post-harvest handling. The tremendous fruit to fruit variability in stage of ripeness, even for fruit from the same tree, makes this application somewhat challenging. For climacteric fruit, irradiation treatment too early in the ripening process can interfere with the ripening process, and too late in the maturity cycle can accelerate decay. Below is the story of irradiation of bananas by Rocco Basson, HEPRO, South Africa.

Summary

The use of irradiation for fresh produce has been tested extensively and shown to be effective but other than a few niche applications and phytosanitary treatment, growers and processors have not embraced this technology. Concerns about negative consumer reaction and/or added costs have led to the exclusion of irradiation from the arsenal of tools used to ensure food safety or extend shelf-life. It is possible that consumer acceptance of fruit irradiated for phytosanitary purposes may extend to consumer acceptance of fresh produce treated for sanitary and other purposes. But unless the value proposition of this technology changes for the produce industry, such applications will not gain a foothold.

Food Irradiation in China

Personal communication by GAO Peng, 2016

Food irradiation technology in China is developing rapidly, and the throughput of irradiated food is the biggest of the world. China has leapt ahead in its use of irradiation for several foods. The total amount is estimated to be more than 500,000 t.
Garlic processed by irradiation is for sprout inhibition to prolong the shelf-life. Usually the product is exported to Southeast Asia and other regions, also it could be found in the market of China. A national standard was built as early as 2010.

Insect infestation is the most serious problem for grain storage in China leading to major economic loss. Other causes of loss are mildew and mice. The use of irradiation for insect disinfestation of grain is still limited. Several national and industry standards have been established, such as the Hygienic Standard for irradiated beans, grains and their products, the Code of good irradiation practice for insect disinfestation of cereal grains products, and technical regulations for electron beam processing of pulses and cereal grains. In addition to the 18 permitted items listed in the table, there are nine other foods permitted to be processed by irradiation, including dried pet foods, dried shitake mushroom, dehydrated vegetables, tea extract power, dried lotus seed, dried longan, the fruit of Chinese wolfberry, raisins, and dried red jujube. Additional irradiated foods contribute to the industrial standard or local standard, and these standards will eventually become codified in national standards.

List of produce related categories and items permitted in China, 1984-1994

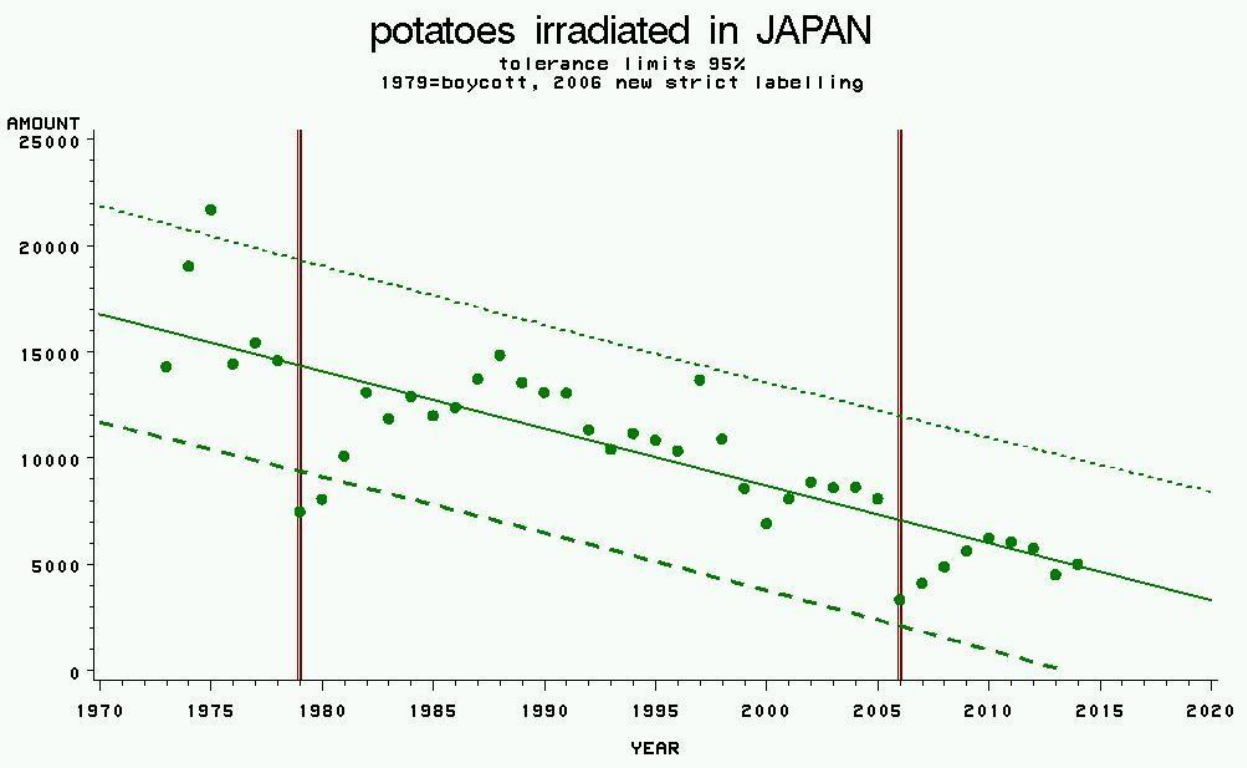
6 Categories	18 Items
Dried nuts and fruits Dried spice Beans, grains, and theirs products Fresh fruits and vegetables	Potato; Onion; Garlic; Rice; Mushroom; Peanut kernel; Apple; Pollen; Preserved fruits; Litchi; Mandarin; Orange; Sweet potato chips; Wine; Raw almonds; Tomato

Irradiation of potatoes in Japan to inhibit sprouting

Personal communication by Setsuko Todoriki, 2016

In Japan, potato is the sole commodity approved to be irradiated. The purpose of irradiation is to prevent sprouting and ensure a suitable shelf-life. Potatoes have been commercially treated in Japan since 1973. In 2014, 5008 t of potatoes were irradiated at Shihoro Isotope Center, Hokkaido, and sold with proper labeling at retail outlets. The quality of the irradiated potatoes is very good and most of the consumers who have a chance to try an irradiated potato gave positive and favorable comments on their qualities. However, the recognition of consumers to the irradiated potato is not necessarily high. The distribution of irradiated potatoes is limited and

there are many consumers who have not seen irradiated potatoes. In addition, there exist consumer activist groups who oppose food irradiation. Regardless, the 40 year history of irradiated potatoes proves the continued need for irradiation and acceptance in Japan.



Commercial Experience with banana irradiation in South Africa

Personal communication by Rocco Basson, 2016

Research and development at the South African Atomic Energy Board showed that low dose irradiation of bananas had significant positive effects on quality. In commercial practice, bananas are picked at the mature green stage in order to minimize mechanical damage during transport. They are then ripened to point-of-sale acceptability, in ethylene ripening chambers. As the production area is remote from the major markets it was decided to conduct trials on mature green fruit.

Small scale trials demonstrated:

- Irradiation has no effect on ripening behaviour.
- After ripening the irradiated bananas showed a delayed onset of senescence (spotting)
- Fully ripe fruit had a firmer texture.
- Saleable shelf-life was several days longer.

These results were presented to a major supermarket chain who agreed to take part in limited commercial trials. Bananas were sourced in the Letaba area of Northern South Africa and transported in their final packaging to the pilot plant irradiation facility in Tzaneen where they received an average dose of 600-700 Gy at an ambient temperature of 20^0C to 25^0C. The irradiator was a small (100KCi) batch-type unit accommodating 48 x 22kg boxes per batch with an irradiation time of 50 minutes.

The supermarket chain was highly satisfied with the in-store results and placed a permanent order for a 12 ton truck load to one of their outlets every week-day. This continued until the end of the banana season. Unfortunately legislation came into effect at this stage making labelling of irradiated produce compulsory. The marketing executives of the chain took fright at putative consumer resistance and a promising application died a premature death. Since then the marketing of irradiated spices, herbs, honey and garlic, have demonstrated virtually no consumer resistance. Unfortunately the Tzaneen plant has been relocated to Durban so the banana adventure cannot be re-embarked on.

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Highlights

- Frozen and dry vegetables and herbs are treated in some countries for pathogen reduction.
- Small amounts of potatoes, onions, and garlic are treated to inhibit sprouting.
- Despite its efficacy, use of irradiation to enhance safety and shelf-life remains underutilized.