Radiation Physics and Chemistry 81 (2012) 1203–1207

Contents lists available at SciVerse ScienceDirect

Radiation Physics and Chemistry

journal homepage: www.elsevier.com/locate/radphyschem

Current and potential trade in horticultural products irradiated for phytosanitary purposes

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ARTICLE INFO

Article history:
Received 8 July 2011
Accepted 31 December 2011
Available online 10 January 2012

Keywords:
Phytosanitary irradiation
Horticultural products
International trade

ABSTRACT

The current status of trade in horticultural products irradiated for phytosanitary purposes is examined, including trends, strengths and weaknesses. A strategy is proposed to take advantage of the best future opportunities for increasing trade in irradiated horticultural products by identifying best possibilities for expanding both the number and volume of commodities for irradiation and then applying appropriate business criteria in a general analysis of the commodities, commercial scenarios, and geographic regions where the greatest potential exists for expansion. The results show that fresh fruits such as mango, papaya, citrus, grapes, and vegetables such as tomatoes, onions, asparagus, garlic, and peppers from Asia and the Americas show the greatest potential. Substantial opportunities for additional growth exist, especially as regulatory conditions become more favorable.

1. Introduction

The evolution of irradiation as a phytosanitary treatment accelerated five decades ago with research demonstrating technical efficacy and feasibility. Extensive work followed to demonstrate the safety of irradiation treatments and study consumer acceptance, as research advanced on product tolerance and information on effective doses grew. Despite extensive research demonstrating that the irradiation of horticultural products offered significant benefits, interest in commercial applications was tempered by regulatory barriers. The publication in 2003 of International Standard for Phytosanitary Measures no. 18 "Guidelines for the use of irradiation as a phytosanitary measure" marked a significant step forward in overcoming regulatory barriers for the adoption of radiation technology as a means to facilitate international trade in horticultural products (IPPC, 2003). The implementation of this standard in practice has resulted in exports of irradiated mangoes from Australia to New Zealand and the export of mango, longan, mangosteen, rambutan, dragon fruit, and guava from India, Pakistan, Thailand, Vietnam and Mexico to the United States. Significantly greater potential exists for other countries and products, depending on the business opportunities and willingness to invest. This paper presents an analysis of the countries in Latin America, Asia, and Africa, and likely products for treatment to characterize the magnitude of the opportunities and highlight the geographic areas and products with the greatest business potential.

2. The irradiation of horticultural products and pests

Ionizing radiation alters certain physiological processes in fresh commodities and also produces changes in the biology of microorganisms and arthropods that may be associated with the products. Doses in the range of 0.050–2.5 kGy are useful for disinfestation and increasing shelf life can occur in some fruits and vegetables. The effects of irradiation on pests range from mortality (rarely) to prevention of development or reproduction. Phytosanitary irradiation (PI) is a viable treatment for phytosanitary purposes and an important alternative to other treatments, such as banned chemical fumigations. Most pest treatments fall into the range of 50–400 Gy depending on the pest and the required response (Hallman, 2011). Adult emergence of 3rd instar larvae of tephritid fruit flies is prevented with 150 Gy. Many other insects commonly associated with fresh horticultural products are effectively controlled at doses <400 Gy (Heather and Hallman, 2008).

3. Commerce in irradiated horticultural products

The first commercial food radiation facility was built in Germany in 1957 for the treatment of spices but it closed after

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doi:10.1016/j.radphyschem.2011.12.049

a couple of years when food irradiation was prohibited in that country (Diehl, 1995). A facility in Japan used exclusively to treat potatoes for sprout inhibition since 1973 is the longest continuously operating facility (Hayashi, 1986). South Africa was the first country to introduce the irradiation of fresh produce to local the markets in 1978 (Van der Linde and Brodrick, 1985). It was after the adoption of the General Standard for irradiated foods (Codex, 2003) by the Codex Alimentarius Commission (CAC), that the safety of food irradiated at 10 kGy or less was established. This motivated countries to include irradiation in their treatment legislation and prepare national standards based on CAC guidelines. There are now 60 countries with a regulatory structure to allow the use of irradiation to treat at least one type of food (IAEA, 2011).

The disinfestation of spices, condiments and dried vegetables using irradiation was widely adopted commercially beginning in the 1980s. Nearly 30 countries presently irradiate dried food products, and 50% of the global volume of irradiated food is of this type, amounting to approximately 200,000 t/year. The United States, China, Brazil, South Africa and Mexico are the principal countries using irradiation for this purpose. Sprout inhibition treatments are applied to 88,200 t/year of potatoes (Japan, China and India) and onions (China and India). Slightly more than 4% of the total irradiated food (almost 19,000 mt) is for PI: sweet potatoes, some fruit and a small amount of curry leaf (Kume et al., 2009).

Table 1
Export volume of fruit irradiated for phytosanitary purposes.
Sources: Hallman, 2011 and FSANZ, 2011.

Country/ product	Volume (ton)	Comments
Australia	756	Start with 16 t in 2004, the cost of the papaya was higher respect to traditional treatment.
Mango		
Longan		
Papaya		Mango exported to New Zealand and Malaysia.
India	272	Shipment by boat to reduce costs.
Mango		
Thailand	4080	Shipment by boat 70% of the fruit.
Longan		Permission to irradiate and ship lychee and pineapple.
Mango		
Mangosteen		
Rambutan		
Vietnam	500	
Dragon fruit		
Mexico	10,298	89% correspond to guava.
Guava		The top exporter country.
Grapefruit		
Mango		
Sweet lime		
Manzano pepper		

4. The trade situation for irradiated horticultural products

The first commercial PI treatment was in 1986 when Puerto Rico sent irradiated mangoes to Florida (Hallman, 2011). One year later, Hawaii shipped irradiated papaya to California. Interest in further use of PI was interrupted by the development of other treatments and low acceptance of the technology. The ban of highly used chemical fumigants and resulting difficulties implementing alternative treatments brought attention back to PI. In 1992, the first gamma radiation facility for phytosanitary treatments was built in Florida with the objective of treating grapefruit against Caribbean fruit fly (FTSI, 2011). Although grapefruits were not irradiated commercially in Florida, the facility was later used to treat guava and sweet potato. Tropical fruit from Hawaii was only allowed entry to the colder northern areas of the United States due to concerns for fruit flies. From 1995 to 2000, Hawaii sent a total of 403.8 t of tropical fruit (mostly papaya) to be irradiated in Illinois and New Jersey and distributed without restrictions to retail markets in a number of states (Moy and Wong, 2002). Market and consumer response from these tests was positive, resulting in the construction of an X- ray facility in Hawaii, which started operation in 2000 and has dramatically increased the potential for trade in irradiated fruit inside the United States. The beginning of the millennium also saw the first international use of PI, 16 t of irradiated mangoes from Australia to New Zealand. These exports have steadily increased with mango and also lychee and papaya, although the export of this last item was interrupted because the cost of the radiation treatment of US $106/ton was considered too high compared to the traditional treatment (Hallman, 2011).

Trade in horticultural products represents one of the main contributors to the economy of both developing and develop countries, with direct contributions between 9 and 29% of gross income. The establishment of progressive irradiation treatment policies and regulations by the USDA Animal and Plant Health Inspection Service (APHIS) and the adoption of ISPM no. 18 have greatly facilitated the use of irradiation as a potential strategy to overcome quarantine restrictions on a wide range of products for both developed and developing countries seeking access to lucrative US markets.

APHIS regulations make provision for the application of generic doses of 400 Gy for all insects except for Lepidoptera pupa and adults (APHIS, 2006). This has resulted in preclearance export programs for five countries: India, Thailand, Vietnam, Pakistan and Mexico. Exports under the APHIS program for generic doses started in 2007 with the first shipments of irradiated mangoes from India. Since then, Thailand has exported mangoes, mangosteen, longan and rambutan, and has authorization from APHIS to also ship irradiated litchi and pineapple. PI treated dragon fruit has also been exported from Vietnam and guava, mango, grapefruit, sweet lime and manzano pepper from Mexico.

After the first shipments, exporters learned to adjust shipping parameters to maximize freight efficiencies and reduce costs. Some commodities endure shipping well while others do not. For example, 3 weeks in storage is practically the entire shelf life for mango, while longan fruit tolerate more than 3 weeks. These characteristics are important for understanding the costs associated with shipping and deciding whether to ship by air, sea, or truck. Vietnam, for example, wants to negotiate new conditions for entrance of longan, lychee and rambutan to maximize shipping efficiency.

In November, 2008, the first shipments of Mexican guavas began crossing the border to the United States (Hallman, 2011). By the end of the year, the export volume had reached 257 t. In the next year, 3623 t of guava and some other fruits were subsequently shipped. Table 1 shows the different commodities and volumes shipped for different countries. Mexico is currently the world's largest exporter of irradiated fruit.

5. Potential products and trading partners

Most countries have quarantine restrictions on the import of fresh fruits and vegetables due to concerns for exotic pests, which may be introduced on untreated products. Depending on the volume, seasonality, cost and shipping possibilities, many of these countries and commodities are good candidates for PI. Figs. 1 and 2 demonstrate the production for fruits and vegetables in the regions of Latin America, Asia and Africa (FAO, 2011). Mango, papaya, citrus, pome and stone fruits all have a high market value but face quarantine restrictions, which make them good candidates for PI. For mango and papaya, irradiation can also help to increase the shelf life, as it does for banana also. Strawberry can be treated to control decay fungi.

Many tropical fruit are good candidates for export with irradiation. Mexico is currently exporting several fruits to the United States, but has other fruit like mamey, chicozapote, cherimoya and others, which have markets but are limited by quarantines for different fruit flies. Colombia is another example with several regional fruit, including granadilla, gulupa, maracuya, pitahaya, lulu, and uchuva, which are potential exports using PI. Research has already been done to establish the feasibility of irradiation by determining the minimum dose needed for these fruit and the tolerance of the fruit to radiation.

Bulbs, roots, and tubers, like potatoes, onions, and garlic, all have the potential to be treated with irradiation for sprout inhibition, an important phytosanitary treatment because it prevents the propagation of commodities intended for consumption while also improving the quality and shelf life of the product (ICGFI, 1997). Chilies, peppers, and sweet potatoes can be disinfested for various internal feeding insects, (USDA-APHIS, 2011) and asparagus is easily treated against moth infestation but also benefits from shelf-life extension (Vargas, 2010). Radiation can also be applied to other vegetables like okra, baby corn, chaom, brinjal, eggplant, bitter cucumber, basil and more (Segsarnviriya et al., 2005; Fan et al., 2008).

6. Implementation of PI

Countries that want to use PI should first identify the products, volume and export seasons. The next step is to establish the national framework of regulations, policies, and procedures that provide authority for an operational program dealing with both consumer and facility issues. In the case where the country wants to export to United States, this regulatory background is important for establishing the required Framework Equivalency Work Plan, which ensures that the exporting country also establishes a regulatory structure to import similarly treated commodities. Many countries already have good organization among producers, packers, shippers and the government in most cases, they only need the agreement with the United States to obtain clearance for export.

Two main barriers to implementation in Latin American, Asian and African countries are the absence of a national regulatory framework and the lack of facilities. The second problem is resolved where the importing country has facilities and allows treatment on entry. The United States has recently implemented

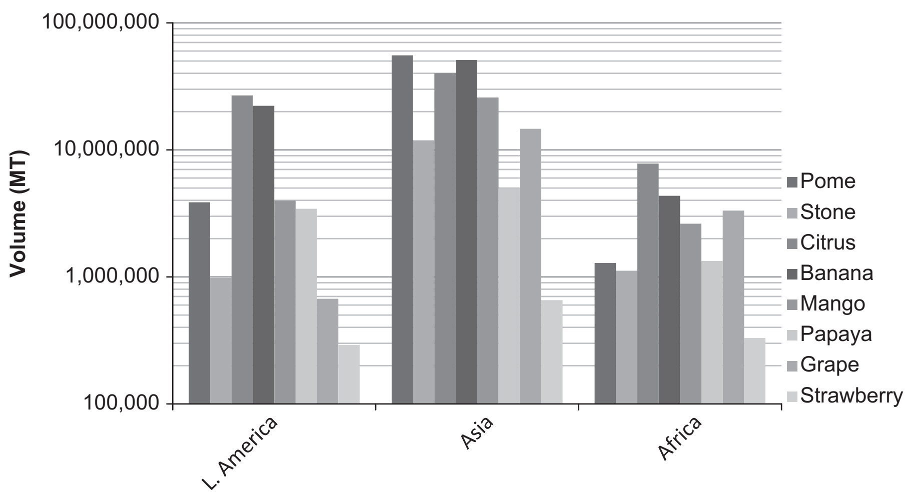

Fig. 1. Fruit production by region.

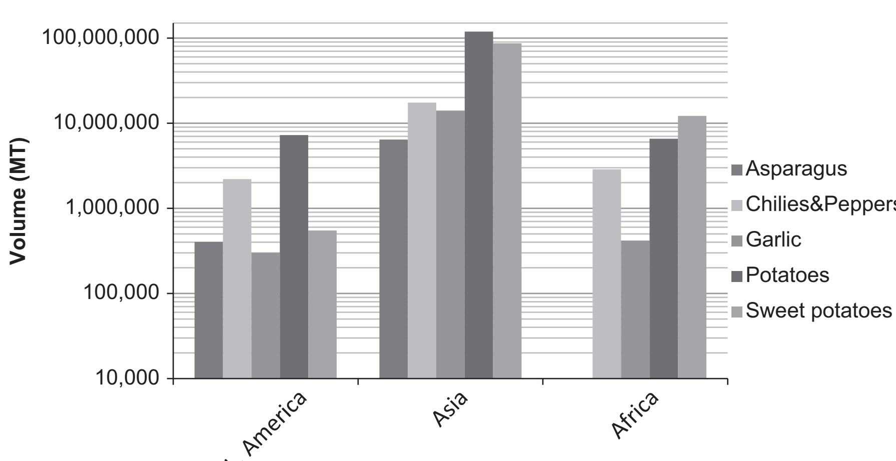

Fig. 2. Vegetable production by region.

such policies. This will allow countries to use PI to begin exporting without a large investment in new facilities.

The United States is an excellent market and geographically advantageous location for Latin American countries. Brazil, Colombia, Chile, and Peru have large volumes of high-quality tropical and temperate fruits, vegetables and flowers, which could be marketed in the United States, and they can implement the technology relatively quickly. They also have the facilities and technical capacity to implement the technology on a commercial scale. Ecuador, Venezuela and Cuba also have experience with irradiation treatments and have suitable volumes available, but do not have the regulatory framework or do not have adequate facilities for treatment. Other countries such as Honduras, Costa Rica, and Guatemala have little experience with irradiation and do not have the regulations or facilities. Haiti and Jamaica do not have either the technical capacity or the facilities but have a high level of interest in implementing the technology.

The Asian region is a major producer of fruits and vegetables of all types. China has more than 100 irradiation facilities, including both isotopic and machine sources. China also has a regulatory framework and strong trade connections with many countries. Bangladesh, Turkey, Philippines, and Syria have legislation in place, have experience with the technology and sufficient products, but they need to upgrade their facilities or they need a specific facility. Japan only accepts irradiated potatoes and has not provided clearance for any other kind of food. Pakistan and Malaysia need to elaborate regulations to allow the irradiation of fruits and vegetables, but Pakistan is currently exporting mango fruit to the United States based on treatment at the destination. India, Thailand, and Vietnam export irradiated food to the United Sates but want to increase the volume and variety of commodities. Thailand can also export to Australia as well as some other countries in Asia.

The New Zealand Ministry of Agriculture and Forestry approved access for Australian mangoes in 2004, papaya in 2006 and litchi in 2008. The minimum dose required by New Zealand for the insect pests of concern is 250 Gy. In 2009 and 2010 Australia exported 263 t of irradiated mangoes to Malaysia. The USDA is considering access for Australian mangoes and litchi irradiated at 400 Gy. Biosecurity Australia has approved irradiation as a treatment for mangoes imported from India (FSANZ, 2011).

South Africa is the country in the African region, which is most advanced in use of irradiation. The country has had facilities for the treatment of fruits and vegetables for more than three decades and markets irradiated food locally. Countries like Algeria, Egypt, Morocco and Ghana have both facilities and regulatory frameworks. Tanzania, Kenya, and Uganda are interested in using radiation technology but have no legal framework and no facility to do the treatment. These countries however have done economic and business studies to demonstrate the commercial feasibility of implementation. Countries like Burundi, Nigeria, Congo, Tunisia, Ethiopia, and Tanzania are very good producers of fresh fruit but do not have regulations or facilities or enough experience with the technology. Technical capacity building is most important for such countries to take advantage of the opportunities presented by this technology.

7. Facilities and cost of the process

Ideally, every country would be able to invest in PI for its fruit and vegetable exports, but the uncertainty associated with recovering the investment and concerns about consumer acceptance continue to trouble investors. US$3–6 million is required for a facility, depending mainly on the size of the plant and the type of equipment to be used. Despite this seemingly high initial investment, economic studies consistently show that this technology is profitable because the cost of the treatment is a small percentage of the product value in the market. For example, the market value per kilogram for passion fruit after packing and freight from Kenya to the United States is US $ 5.00. Irradiated passion fruit would cost maximum US $5.02–$5.16/Kg (Bustos-Griffin, 2007).

A key design factor for facilities is the ability to handle a limited product density range at an established dose with a steady throughput. The most efficient system uses a density for fresh fruit between 0.4 and 0.7 g/cm3 and an established dose of 0.15–2.5 kGy with a throughput rate of 60,000 t/year (Kunstadt, 2001). The most economical application of radiation involves the treatment of finished pallet loads. The larger size and density of such treatments results in a greater dose being absorbed by much of the load to ensure that the minimum required dose is absorbed by the entire load. The higher doses required for such treatments can be problematic for fresh commodities, which have a low tolerance to radiation. Where new facilities are contemplated, the location should be as close to producers as possible or near good transportation routes and distribution centers in order to save time and costs related to transportation.

8. Barriers to overcome

The social barrier continues to be a concern in the commerce of irradiated food. It is necessary to find strategies for consumers in some countries to overcome their fear of irradiated food and begin to see the advantages of having this option available. Disparity in the level of regulatory development around the world is still a challenge. Differences in the legislation system and regulatory approach make harmonization difficult for trade in irradiated food. Finally, and most importantly, there needs to be a greater understanding by the business community in the potential and advantages of irradiation for the necessary investment to occur.

9. Conclusion

After decades of development, the implementation of radiation technology to horticultural products is finally emerging as a commercial reality, but current trade in irradiated horticultural products involves only seven countries. New Zealand and United States are the importing countries and Australia, India, Thailand, Vietnam and Mexico are the exporting countries. Chile could soon be receiving irradiated fruit from Vietnam and Mexico may import irradiated peaches from the United States mid 2012. The decision by the US to allow for treatment upon arrival should open many new possibilities for countries without facilities, but the most important long-term need is greater awareness and interest by the business community to see the potential and make the investments needed for growth. Increasing the understanding and interest of the business community to stimulate investment is the key to future expansion of the technology on a larger scale.

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