Final Report

Phytosanitary irradiation: Building stronger pathways for domestic and international trade

Project:

Phytosanitary irradiation: Building stronger pathways for domestic and international trade (AM19002)

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CONTENTS

Roadmap for the adoption of phytosanitary irradiation

Phytosanitary irradiation is a sterilising treatment that uses wavelengths of energy including X-ray and gamma ray that kill or sterilise pests that are considered a biosecurity threat. Australia is a world leader in the commercial use of phytosanitary irradiation and the development of phytosanitary trade protocols and irradiation facilities. Australia engages in some of the most diverse domestic and international trade of irradiated fresh produce in the world, yet these volumes are relatively small in comparison to other phytosanitary treatments. Importantly, phytosanitary irradiation addresses many of the weaknesses associated with other phytosanitary treatments, assisting horticulture supply chains to meet increasing expectations around product quality, biosecurity, food safety, sustainability and climate change.

It has taken over two decades for Australia to reach this position, and many lessons have been learned along the way. With rapid growth in the use of phytosanitary irradiation in Australia, there remain opportunities to refine our domestic trade pathway and to seek improved export market access for irradiated fresh produce.

This Roadmap summarises the regulatory environment, major barriers and opportunities for irradiated fresh produce within domestic and international markets. Recommendations are presented to inform and guide government and horticulture sector efforts to overcome the barriers to the adoption of irradiation as a phytosanitary treatment.

This Roadmap has been developed with the support of an international research consortium comprising Australian, New Zealand and French research collaborators. Extensive reviews were conducted to identify and evaluate the impact of regulatory, cultural and commercial barriers on the adoption of phytosanitary irradiation by Australia and its international trading partners (Appendix A). This was followed by domestic and international workshops to test and validate the findings of this analysis with government, peak industry bodies, supply and retail chains.

Funding to develop this Roadmap was provided via the project ‘Building capacity in irradiation – pathways to export’ through the Hort Frontiers Asian Markets Fund (Project AM19002), part of the Hort Frontiers strategic partnership initiative developed by Hort Innovation, with co-investment from the Victorian Department of Energy, Environment and Climate Action, Steritech Australia, New South Wales Department of Primary Industries, South Australian Research and Development Institute, New Zealand Plant and Food Research, Aerial and the Australian Government.

Introduction

Drivers for change

Australia exported 753,779t of fresh horticulture produce worth $2.75 billion for the year ending June 2022 (Hort Innovation, 2023). As the Australian horticulture sector continues to grow, greater emphasis is being placed on seeking new markets to maximise returns on fresh produce. Both domestic and international trade in fresh produce is subject to broader global trends that influence the actions of producers, supply chains and retailers. These global trends can filter through to food standards and trade protocols that enable market access.

Australian horticulture has a global reputation for safety, quality and sustainability. However, Australia is also a high-cost producer. Growers and supply chains therefore seek access to markets with premium prices to remain competitive. Securing and maintaining access to premium markets requires constant vigilance, so that coordinated action can be taken by the sector to address potential risks and disruptions to market access. The horticulture sector must contend with ongoing geopolitical circumstances, increasing production costs, a growing focus on environmental sustainability, the impacts of climate change, and increasing consumer demand for safer, higher quality fresh produce. Consumers also remain sensitive to price.

The sector has already adapted to the removal of "older" groups of chemicals used in the control of regulated pests on-farm due to environmental and occupational health and safety concerns. Further reviews are underway, with the Australian Pesticides and Veterinary Medicines Authority (APVMA) currently reviewing use patterns for several chemicals used as part of interstate trade protocols. For this reason, post-harvest chemical dips, sprays and fumigants may be withdrawn or have their use restricted. Events such as these can trigger the loss of market access until alternate pathways can be negotiated. This is a process that can take significant time and relies on access to reliable information and the co-operation of supply chains and trading partners for a successful outcome.

Most of Australia's trade in fresh produce uses four end-point-treatments to access domestic and international markets. These treatments include cold disinfestation, methyl bromide (Group 8A Insecticide, Class 1 Ozone depleting gas) for fumigation, dimethoate (Group 1B Insecticide) for inline dips or sprays, and vapor heat treatment. While all four of these traditional treatments are highly valued by industry, they may have one or more of the following limitations:

- Treatment process may result in heating or chilling injuries in some fresh produce lines
- Treatment results in interruption to the cold chain, with the potential to reduce storage and/or shelf life
- Treatments may not be effective when used with various forms of packaging currently used in the retail sector
- Biosecurity efficacy data may not exist for chemical treatments applied to many commodities
- Chemical fumigants can contribute to greenhouse gas emissions where gas recapture systems are not employed
- Chemicals may be withdrawn subject to the APVMA review process where a registered use pattern is proven to be toxic to human health and/or the environment.

To avoid losing market access, Australia must continue to innovate and employ novel technologies to overcome emerging threats and retain competitive advantage globally. Phytosanitary irradiation is one such technology that offers a cost-effective end point treatment with few, if any, of the limitations mentioned above. Produce treated with phytosanitary irradiation has been proven to be safe for human consumption, is chemical-free, does not interrupt the cold chain, is effective with all forms of commercial packaging and has the capacity to be carbon neutral. Importantly, Golding et.al (unpublished 2022) demonstrated that impacts on product quality are few and are limited to a small number of commodities and cultivars. These findings have been reinforced through commercial trade.

Over the past five years, significant growth has occurred in volume and diversity of fresh produce treated with irradiation for phytosanitary purposes. Phytosanitary irradiation is used to regularly treat over 80 different horticultural crops, destined for domestic markets and six international markets. A growing list of crops including mangoes, table grapes and cherries have all demonstrated significant success using phytosanitary irradiation to grow export markets.

Approximately 20% of all Australian table grapes shipped to Vietnam in recent years have used phytosanitary irradiation in conjunction with air freight. This has generated a return higher than the same fruit shipped via sea freight and ensured that Australian grapes were the freshest offering in market by several weeks. The Australian mango industry has also celebrated growth in both market share and export volume to New Zealand, outperforming cheaper non-irradiated mango supply from the Americas.

However, not all trading partners have established the necessary food standards or trade protocols to allow trade in irradiated fresh produce.

Importantly, by overcoming these challenges, the Australian horticulture sector can gain an advantage over many of our competitors with respect to the reliability and efficacy of our end point treatment, product quality, sustainability and speed to market via air freight. The development of a Roadmap is considered a first step toward documenting the challenges to the widespread adoption of phytosanitary irradiation, and the identification of pathways to grow trade in existing and new markets.

Vision for 2030

The development of a vision for 2030 was informed by consultation with industry, regulators and researchers. To achieve this vision, key stakeholders will need to gain a strong appreciation of the benefits and opportunities associated with the use of phytosanitary irradiation and commit to coordinated action that will deliver improved biosecurity and trade outcomes for Australia's horticulture sector.

DOMESTIC

Improved domestic awareness and understanding

FROM: Limited and varied awareness of the benefits and advantages of phytosanitary irradiation

TO: Well informed biosecurity, industry and retail stakeholders, utilising irradiation for improved trade outcomes.

Improved domestic biosecurity

FROM: Complex and vulnerable treatment pathways that may be subject to future limitation or withdrawl.

TO: Simple and reliable treatment pathways providing improved security and continuity of interstate trade and biosecurity systems.

Improved domestic food standard

FROM: Complex labelling requirments.

TO: World leading food irradiation standards with effective, practical labelling requirments.

EXPORT

Improved export market access

FROM: Few trading partners with appropriate food standards and trade protocols that allow trade in irradiated fresh produce.

TO: Australia's major trading partners having appropriate food standards and trade protocols that allow trade in irradiated fresh produce.

Enhanced international mechanisms for engagement

FROM:Few and inconsistent international mechanisms to promote the use of phytosantary irradiation in global trade.

TO: Consistent and coordinated international approaches to promoting effective and harmonised development of phytosanitary irradiation.

What is phytosanitary irradiation

Phytosanitary Irradiation is a chemical-free, heat-free, sterilising treatment that targets regulated pests that could be present in domestic and international shipments of fresh produce. Phytosanitary irradiation uses wavelengths of energy including X-ray and gamma ray that pass directly through the product and packaging delivering energy that kills or sterilises the insect.

The treatment is an alternative to other existing end-point treatments including fumigation (e.g., methyl bromide, ethyl formate), chemical dips and sprays (dimethoate), vapor heat treatment and cold disinfestation. Phytosanitary irradiation is unique among phytosanitary treatments as a broad-spectrum end-point treatment for almost all important regulated arthropod pests (Follett and Neven 2006).

Domestic and international regulatory environment

Food standards

The Codex Alimentarius (the Codex) is a collection of internationally recognised standards, codes of practice and guidelines related to food, food production and food safety for the protection of consumer health. The standards and codes of practice inform policy and legislation, allowing governments to establish science-based, internationally acceptable food standards for the safe trade in food.

The Codex Alimentarius General Standard for Irradiated Foods (CAC, 2003) does not impose any restriction on the type of fresh produce that may be irradiated. It states, "For the irradiation of any food, the minimum absorbed dose should be sufficient to achieve the technological purpose and the maximum absorbed dose should be less than that which would compromise consumer safety, wholesomeness or would adversely affect structural integrity, functional properties, or sensory attributes". The maximum absorbed dose delivered to a food should not exceed 10 kGy, except when necessary to achieve a legitimate technological purpose." The Codex also makes recommendations on radiation sources, general food hygiene, packaging, re-irradiation, verification and labelling.

Approximately 60 countries have health or food safety regulations that permit the use of irradiation for one or more foods and purposes. Approximately 30 countries permit phytosanitary irradiation of fresh produce. While regulations are generally based on the Codex, national oversight of the use of irradiation is maintained by stipulating the foods or food classes that may be irradiated, the purpose of the treatment, and the maximum and minimum dose.

Standard 1.5.3 of the Australia New Zealand Food Standards Code

Standard 1.5.3 defines the general conditions and requirements under which food may be irradiated in Australia and New Zealand (FSANZ, 2022). It also specifies the foods that may be irradiated, the purpose of irradiation and any dose limits that must be applied. In a precautionary approach, the relevant authority Food Standards Australia New Zealand (FSANZ) initially considered applications to permit the phytosanitary irradiation of fresh produce on a case-by-case basis. However, in July 2021 a variation to the Standard (A1193) was approved that allows phytosanitary irradiation to be used as a treatment for all fresh fruits and vegetables. Under the Standard, a minimum dose of 150 Gy must be applied to the fresh produce with a maximum dose of 1 kGy.

Labelling

The Codex recommends that all irradiated foods be labelled. Domestic food standards have incorporated this recommendation, however the exact wording is not prescribed. Fresh produce labelling in Australia and New Zealand allows for flexibility to suit the product and supply chain. This may include labelling at the individual item level (e.g., a sticker on a mango), the display or shelf level, or signage at the point of sale. Labelling must be scientifically accurate and not be misleading, allowing the purpose and benefit of the treatment to be incorporated in the labelling.

Phytosanitary trade protocols

For fresh produce moving between countries (or states within Australia), phytosanitary protocols must be agreed between governments on how regulated pests will be treated in addition to any health and/or food safety regulations that permit the food to be consumed.

A framework of rules for the conduct of trade in irradiated fresh produce was not available until 2003 with the adoption of International Standard for Phytosanitary Measure 18 (ISPM 18) (FAO IPPC, 2003) by the International Plant Protection Convention (IPPC). In following years, ISPM 28 (FAO IPCC, 2006) and its Annexes specified minimum doses for treatment of many regulated pests. Of particular note was Annex 7 of ISPM 28 (FAO IPCC, 2009), which asserted that 150 Gy was sufficient to ensure the non-emergence of adults of all Tephritidae fruit flies on all host commodities, supporting the use of a generic dose for fruit fly.

In Australia, under the Interstate Certification Assurance Procedure 55 (ICA-55) a minimum dose of 150 Gy is recognized as a sterilizing treatment for all Tephritidae fruit flies, 300 Gy for mango seed weevil and 400 Gy for all insects except Lepidoptera that pupate internally (Agriculture Victoria, 2022). These minimum doses are applicable to all fresh produce.

ICA-55 has been used to facilitate domestic market access since 2011 with no treatment failure recorded in produce sourced from either the Queensland or Victorian facilities.

The IPPC recognises that provided the minimum dose is given to ensure death, non-emergence of adults or sterilisation of the pest, no other treatment is required. This point is important, as phytosanitary irradiation can result in live but sterile pests being present in consignments of produce.

Irradiation is the only phytosanitary treatment to have generic treatments for regulated pests for all fresh produce. This has been acknowledged by the IPPC and national plant protection organisations (NPPOs).

Recognition of irradiation as a generic treatment has the substantial benefit of reducing the amount of research data needed to support applications for market access using irradiation. It also ensures the treatment is an immediate domestic solution to maintain trade without compromising biosecurity in the event of a foreign insect incursion.

Facilities and accreditation in Australia

A commercial irradiation facility in Australia must first be accredited by the Australian Radiation Protection and Nuclear Safety Agency under the Irradiation Treatment Performance Standard before a Phytosanitary Certificate can be issued (DAWE, 2021), and then under ICA 55 before a Plant Health Assurance Certificate can be issued (Agriculture Victoria, 2022).

Both accreditation arrangements are based on ISPM 18, and include auditable requirements for the irradiation facility, the irradiator, dosimeters for dose mapping, load configuration, treatment times, equipment calibration and maintenance, segregation, traceability and post-treatment phytosanitary security. There are also requirements for process interruptions and treatment failure.

Australia has four irradiation facilities, located in Melbourne, Brisbane and Sydney. Of these facilities, two are equipped and registered to provide phytosanitary irradiation treatments for fresh produce. The first of these facilities opened in 2002, located in Brisbane. This world first facility was capable of treating whole pallets of fresh produce and uses a Cobalt-60 source to irradiate product using Gamma rays. The second fresh produce facility opened in Melbourne in 2020. This facility uses an electronic X-ray source with whole pallet capabilities. This again was a world first fresh produce application.

Trade in irradiated fresh produce

Trends and development

Australia's horticulture sector uses phytosanitary irradiation to facilitate a growing volume of trade. Growth accelerated significantly during the summer of 2017-18 (Figure 1.). The primary drivers of growth have been the development of new trade pathways, food standard approvals, and registration of the Melbourne facility in 2020.

During the past 7 years, trade through domestic and export irradiation pathways have diversified significantly. Fresh produce treatments have become a 52-week a year service, treating over 60 different horticultural crops. With phytosanitary irradiation recognised as a generic insect treatment available to all fresh fruits and vegetable crops, strong growth is expected to continue in years to come.

The progressive restriction and suspension of alternate phytosanitary treatment options is contributing the growth in trade volumes, with regulators seeking improved biosecurity outcomes and industry seeking simpler, more effective treatments that maintain product quality and shelf life.

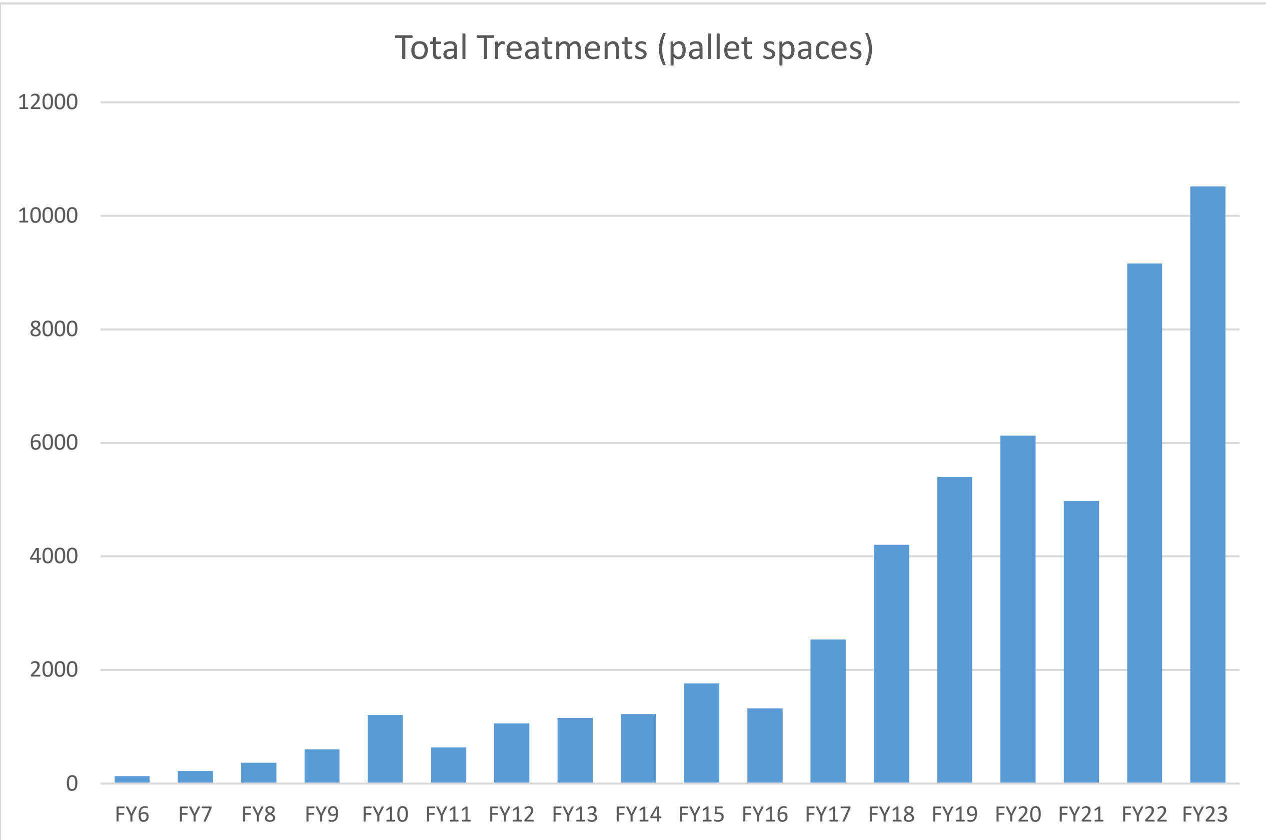


Figure 1: Total domestic and export treatments by pallet space (approx. 600-1000 kg) for horticulture fresh produce

(Data provided by Steritech Pty. Ltd.)

Domestic trade

Following the adoption of the Interstate Certification Assurance Procedure 55 (ICA-55), less than 100t of irradiated fresh produce per annum was moved between states in 2019-20. This was mostly Queensland fresh produce treated for fruit fly and shipped to Tasmania, South Australia and Western Australia.

Domestic trade increased rapidly from 2021, primarily driven by the amendment to Food Standard 1.5.3, access to the new Melbourne X-ray facility, and permission in Western Australia to use 400 Gy as an approved phytosanitary treatment for Serpentine Leaf Miner. Technical and commercial benefits proven through international trade also contributed to growth. By 2021-22, domestic treatment volumes had reached 1000t, and by 2022-23 had exceeded 3500t (Figure 2).

Much of this growth was driven by retail chains such as Costco, IGA and independent green grocers who commenced the retailing of irradiated fresh produce in 2021. In late 2023, Coles also commenced the sale of fresh produce treated by X-ray in several states. As of February 2024, the only notable supermarket brand that is yet to commence retailing of irradiated fresh produce is Woolworths.

Growth in domestic trade also saw the variety of crops accessing phytosanitary irradiation triple within 24 months. Larger volume crops traded domestically include mangoes, tomatoes, summerfruit and citrus to Tasmania; citrus, summer fruit, tropical fruit and Asian fruiting vegetable lines to South Australia; and mangoes, baby broccoli and cherries to Western Australia.

Baby broccoli is an example where irradiation has a technical advantage, treating sealed, ice-packed vegetables that cannot be treated effectively with fumigation.

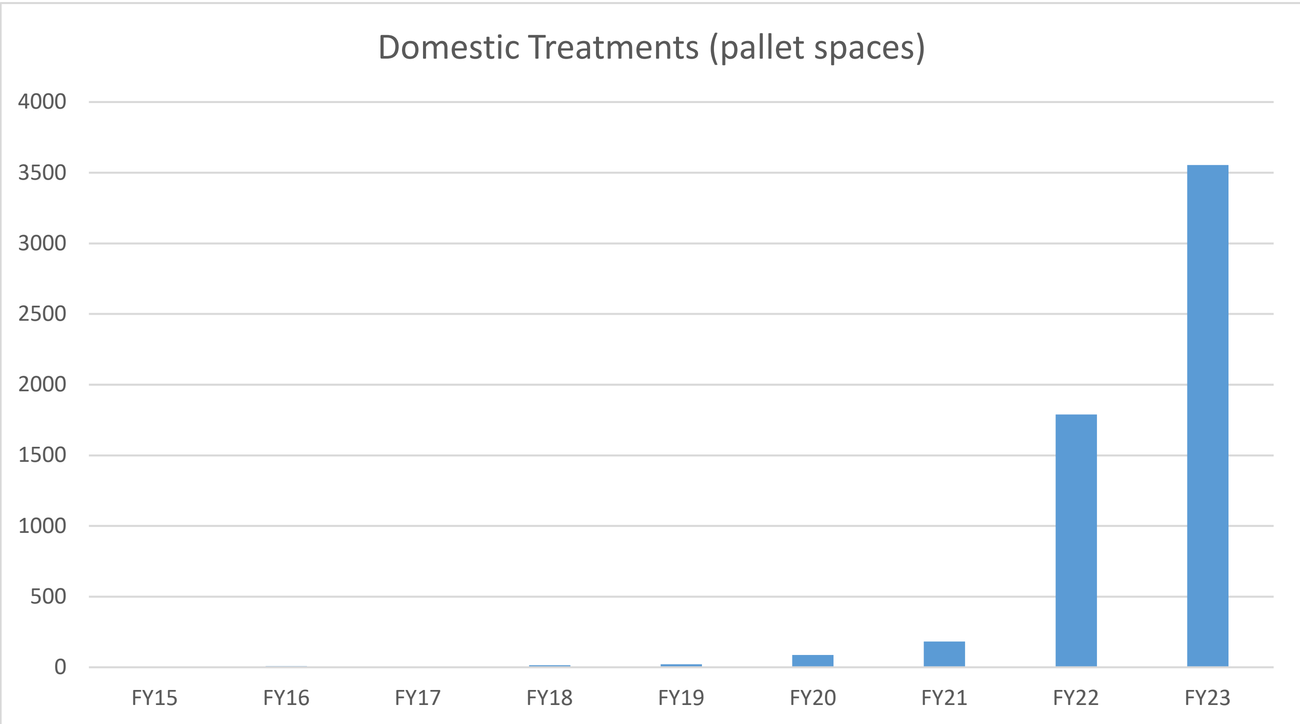


Figure 2: Total domestic treatments by pallet space (approx. 600-1000 kg) for horticulture fresh produce 2015-2023

(Data provided by Steritech Pty. Ltd.)

International trade

Exports

Australian exports of irradiated fresh produce commenced with mangos to New Zealand in 2004-05 and have steadily expanded to include new markets and crops. In recent years, export markets in the USA, Vietnam, Indonesia, Malaysia and Thailand have developed, with Vietnam a particularly successful new market. Although volumes may still be low in several markets, gaining market access offers potential for future growth.

Export volumes have seen substantial growth since 2017 and have now reached an average of 7000 pallets (Figure 3). Nevertheless, events such as the temporary loss of air-freight due to the COVID-19 pandemic in 2020-21, and rain affected production conditions during the summer of 2022-23, have resulted in temporary declines in the volume of pallets undergoing treatment. Importantly, new trade protocols negotiated with New Zealand during this time helped to offset these impacts.

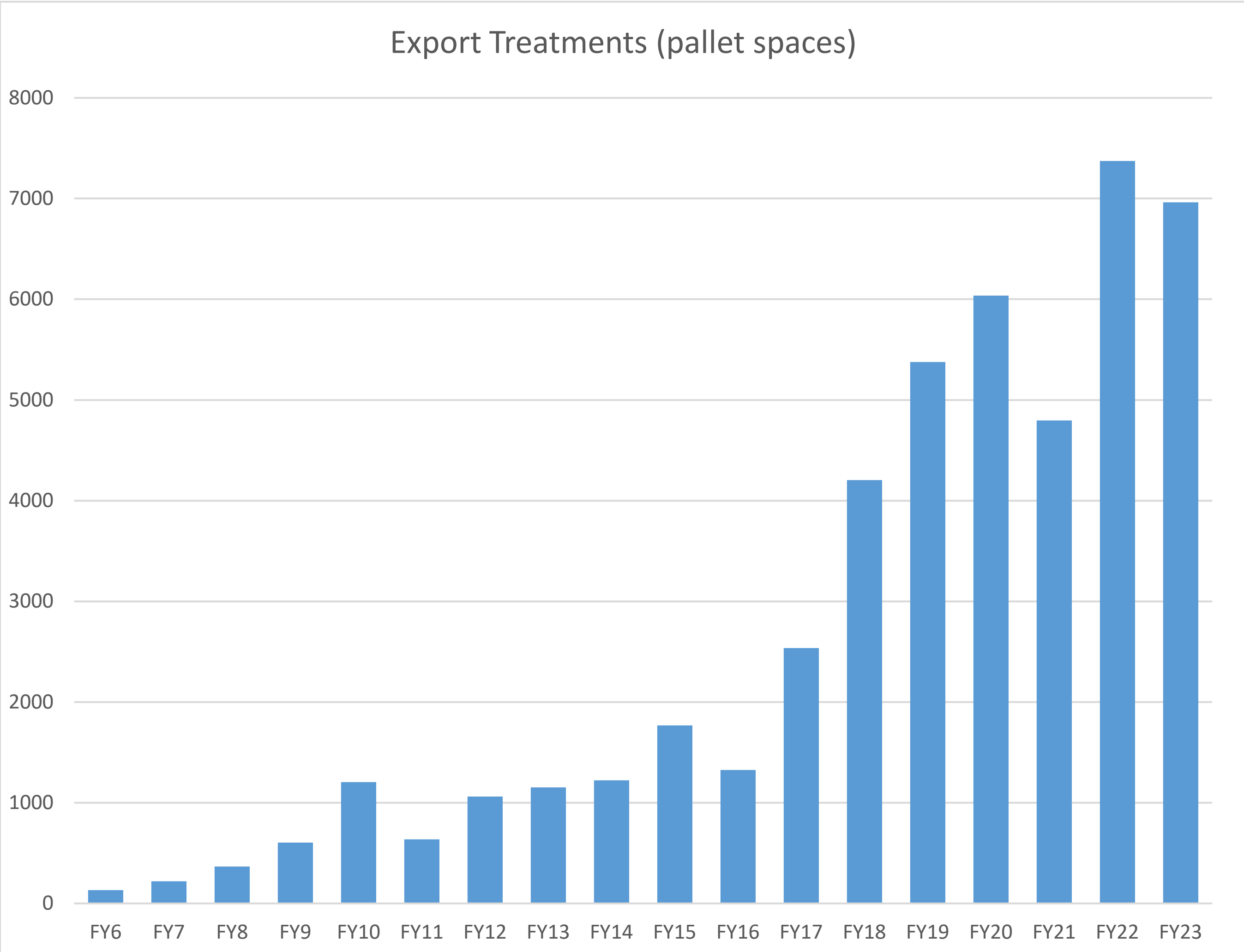
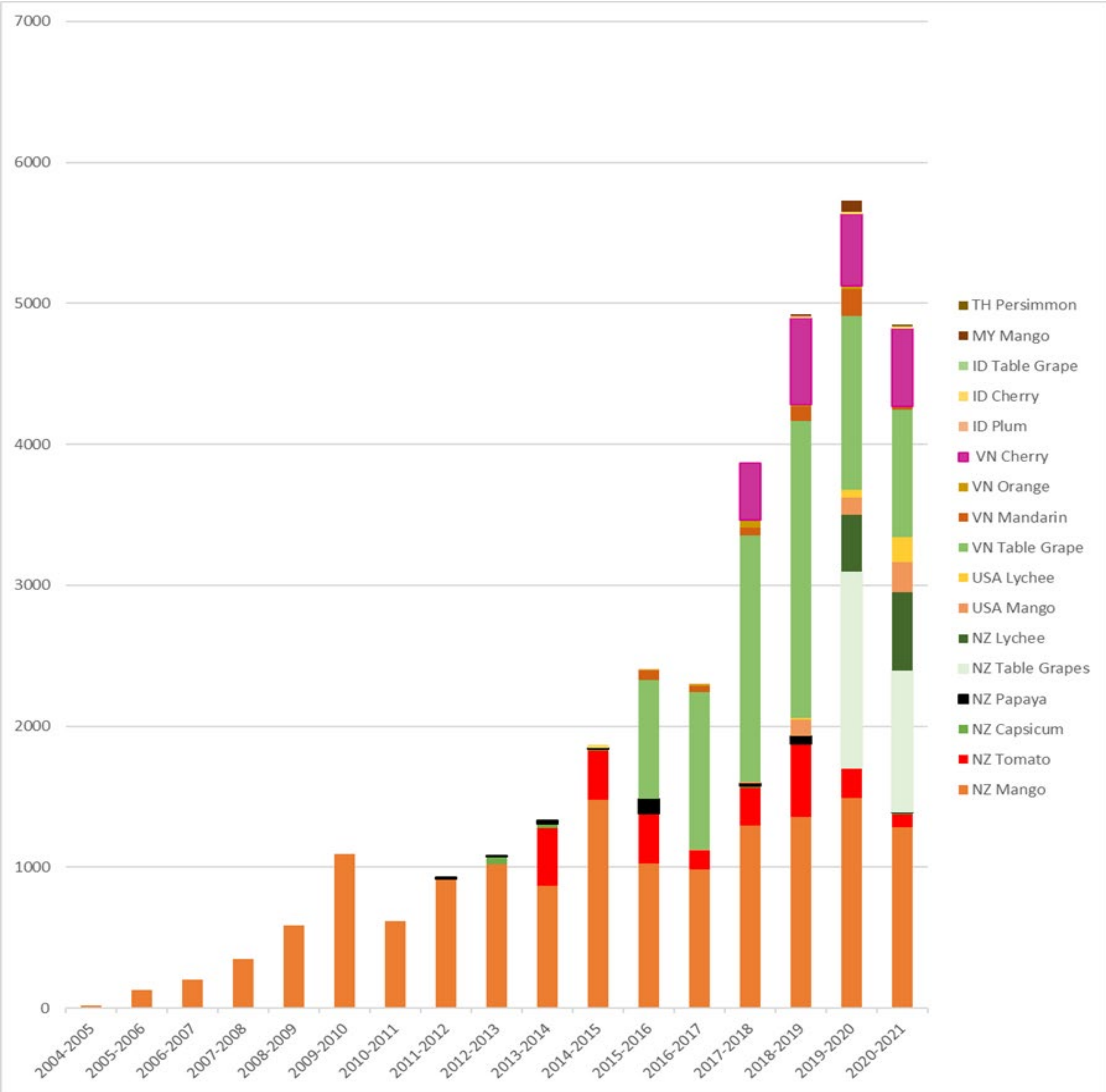


Figure 3: Total exports treated by pallet space (approx. 600-1000 kg) for horticulture fresh produce 2006-2023

(Data provided by Steritech Pty. Ltd.)

Since 2013-14, most growth in export volumes can be linked to the establishment of export pathways for new crops (Figure 4). Exported crops now include mango, table grape, lychee, tomato, capsicum, papaya, mandarin, orange, cherry, plum, melon and persimmon. However, it is noticeable that only mango, table grapes, lychee and cherry have access to two or more markets.



ID: Indonesia; NZ: MY: Malaysia; New Zealand; USA: United States; TH: Thailand; VN: Vietnam

Figure 4: Total treated export volumes by pallet space (approx.600-1000kg) for horticultural crops and markets 2004-2021

(Data provided by Steritech Pty. Ltd.)

Imports

In the period 2015-2021, irradiated produce totalling 1100t has been imported to Australia; 1067t from Vietnam and 35t from Thailand. The main commodities include mangoes (500t), lychees (300t) and longan (200t). There have also been low volumes of mango from India, Pakistan, Mexico and etrog from Israel. These low import volumes can be attributed to the unique ability of Australia to meet its own year-round fresh produce demand.

Although imports are low, it is important to recognise the value of two-way trade. Two-way trade results in the establishment of reciprocal trade arrangements that lead to stronger bi-lateral relationships between Australia and its trading partners. These relationships are particularly important when seeking support for regional and global harmonization of regulation, as is the case for phytosanitary irradiation.

Other bilateral activities continue to support two-way trade. Organisations such as the Australian Horticulture Trade (AHT) and Steritech Australia participate in two-way trade development projects to assist countries such as Vietnam to use irradiation pathways that supply Australia with counter seasonal mangoes.

Figure 5: Labelled Vietnamese mangoes

Barriers to the use of phytosanitary irradiation

Identified barriers to phytosanitary irradiation development can be largely divided into two categories: hard and soft barriers. Hard barriers include global regulatory barriers such as food standards and the acceptance of trade protocols but can also include access to accredited irradiation facilities for treatment. Importantly, unless all hard barriers have been addressed, trade in irradiated fresh produce cannot occur.

Soft barriers make up the second category, these can include minor regulatory, cultural or commercial barriers that slow or delay trade where no hard barriers exist. Soft barriers do not prevent trade from occurring, but impact on the commercial viability of irradiation as a phytosanitary treatment.

Australia is a leading example of a country that has successfully addressed all three hard barriers. Australia has a generic food irradiation standard for fresh produce (Standard 1.5.3), a generic domestic trade protocol (ICA-55) and two purpose built treatment facilities.

Australia has been successful in establishing a strong domestic trade pathway using phytosanitary irradiation, however growers and supply chains do not have access to many lucrative export markets as the required hard barriers have not been overcome.

Figure 6: Steritech X-ray facility, Melbourne.

There have been many significant development milestones and many lessons learned in Australia. Many of these lessons can be shared with trading partners that are yet to accept phytosanitary irradiation.

Year	Development milestone
1999	Food Standards Australia New Zealand Standard A.17
2002	Steritech opens world first phytosanitary whole pallet gamma ray facility in Brisbane, Australia
2004	Irradiation trade protocol established for Australian mangoes to New Zealand
2005	First international shipment of irradiated produce: Australian Mangoes to New Zealand
2011	Australia domestic interstate certification assurance procedure ICA-55 established for selected fruit and vegetables allowed under Food Standard 1.5.3
2015	USDA approves pilot pathway for mangoes and lychee from Australia to the US
2015-20	Irradiation trade protocols established with multiple Asia-Pacific trading partners
2020	Steritech opens world first phytosanitary whole pallet x-ray facility in Melbourne, Australia
2021	Food Standards Australia New Zealand approve all fresh produce under Standard 1.5.3 (note numerous revisions were made post Food Standard A17).
2021	ICA-55 becomes Australia's first generic end-point-phytosanitary treatment for all domestic fresh fruit and vegetables
2020-23	Australian retail networks adopt use of ICA-55 following several biosecurity events and suspension of alternate ICA treatment pathways.

Table 1: Australian development milestones

Pathways to grow domestic trade

While Australian export markets are responsible for most growth in the volume of produce treated with phytosanitary irradiation, the domestic market has developed rapidly since 2021. The domestic market has seen strong diversification supported with over 60 different crops being treated. The ICA-55 trade pathway has subsequently grown from less than 1% to over 30% of produce treated in 3 years.

Although we are likely to see domestic growth continue, complex and sometimes confusing labelling requirements continue to slow adoption by suppliers and retailers. Likewise, there are refinements that can be made to the ICA-55 trade pathway that could reduce the regulatory burden. If such soft barriers can be addressed, Australia will have developed one, if not the most effective and sustainable domestic biosecurity system in the world.

Addressing soft barriers that impede domestic use of phytosanitary irradiation

Domestic retail purchasing policies

Retail chains continue to play a key role in the adoption of irradiated food. With the introduction of Standard 1.5.3, it is the retailer who decides if irradiated fresh food will be offered to the consumer. While the majority of Australian and New Zealand retail chains allow phytosanitary irradiation (Figure 7), one of Australia's largest retail chains is yet to offer irradiated fresh produce for sale.

Figure 7: Example of Australian and New Zealand retail brands that offer irradiated food to consumers.

In instances where a retail chain has significant market share and dominance, purchasing policies that exclude irradiation may reduce consumer access to fresh produce if a domestic pathway is lost on a temporary or permanent basis. For example, on the 19$^{th\ of}$ September 2023, ICA 1 (Dipping with dimethoate) was suspended from use by the APVMA as a post-harvest fruit fly treatment for mangoes and avocados.

Product quality and shelf life can also be impacted where a domestic treatment pathway is changed. The Western Australian Department of Primary Industry and Regional Development announced that on-arrival treatment under ICA-04 (Fumigation with methyl bromide) would no longer be an option from the 16$^{th\ of}$ November 2023. All ICA-04 treatments must now occur prior to entering the state, thereby impacting established supply chains.

These changes suggest that industry, supply and retail chains will need to be more agile and flexible when using domestic trade pathways. Ideally, industry should conduct risk assessments to prepare for the temporary or permanent loss of domestic trade pathways, thereby avoiding major interruptions to domestic supply.

Retail purchasing policies that do not support the sale of irradiated fresh produce have been attributed to concerns (perceived or not) that consumers will not purchase irradiated fresh produce. However, there is now longer-term evidence to show that when labelled produce is offered for sale, consumers respond with repeat purchasing.

Roberts and Hénon (2015) have shown through international studies, that trust in systems and institutions, rather than perceptions of risk, dictate consumer attitudes. In Australia, FSANZ has confirmed that irradiated fresh produce is safe and nutritious to consume (FSANZ 2014) and have provided the required food standard (Standard 1.5.3) to allow irradiated food to be sold.

Importantly, when consumers were provided with an informed choice, Conroy et.al (2022) found that when choosing between irradiation (X-ray) or methyl bromide treatment, 84% of respondents chose irradiation once they became aware of the benefits and limitations of each treatment.

Irradiated fresh produce is now being marketed profitably and without risk to reputation by many of Australia's larger and independent retail chains, however it is important in the short term that the awareness of growers, suppliers and retail chains is improved.

From July 2021 to June 2023, over 5000 pallets of Australian grown produce have been treated with irradiation prior to domestic sale. With the average net weight of each pallet estimated at 600-1000 kg, this equates to the sale of over 21 million, 150 g servings consumed in the states of Tasmania, South Australia and Western Australia.

Industry case studies that demonstrate the success of domestic sales and compare the strengths and weaknesses of phytosanitary treatment pathways can help build industry capability. Informed supply and retail chains are most likely to deliver the highest quality fresh produce to consumers and generate the widest range of biosecurity and environmental benefits.

Recommendations		Responsibility	Timeframe
1	Australian case studies should be developed by the horticulture sector to provide domestic evidence of successful, long-term marketing and retailing of irradiated fresh produce to consumers.	Industry, Steritech Australia	Short term
2	Industry should conduct risk assessments and prepare for the temporary or permanent loss of domestic trade pathways.	Industry	Short-medium term

Labelling

Whole foods or foods made of ingredients that have been irradiated are required to be labelled under FSANZ Standard 1.5.3. The labelling requirements allow flexibility to suit different products, supply chains and retail formats. The wording is not prescribed but must be scientifically accurate and not misleading. For example, using a specific term such as X-ray while clarifying that it is a chemical-free treatment used to prevent fruit fly has demonstrated a neutral or positive influence on consumer purchasing.

To date, supply chains and retailers have demonstrated several lower-cost, practical methods to meet labelling requirements other than piece level labelling. Examples include signage and labelling on the master case in produce displays, and on-shelf or larger produce section signage that use scannable QR codes.

Figure 8. Alternative labelling approaches in South Australia.

While domestic labelling requirements were designed to be flexible and meet the needs of various products and scenarios, they have cost and operational implications that may encourage some supply chain participants to use alternate end point treatments or not supply the market at all. The requirement to label fresh produce as "irradiated", "treated by X-ray" or similar wording can therefore be considered a disadvantage, since fresh produce treated by other phytosanitary treatments (chemical pesticides and fumigants, vapor heat treatment, cold disinfestation) do not require such labelling.

These labelling requirements were created with good intent: to empower consumer choice. Nevertheless, after 20 years with no notable consumer concern, there is a strong case to consider amending or removing the requirement for domestic labelling. There is also new evidence that the intended purpose of labelling has worked counter intuitively, creating a soft trade barrier that has increased the cost of supply and reduced consumer choice in some domestic markets.

Recommendations		Responsibility	Timeframe
3	Investigate the case for amending or removal of domestic labelling under FSANZ Standard 1.5.3. and State and Territory biosecurity legislation for prescribed goods.	Industry, Commonwealth and State Regulators	Short term

Domestic audit and accreditation

There is scope to remove some of the regulatory burden on irradiation service providers, supply chains and biosecurity agencies. This could be achieved by amending domestic entry conditions to allow the use of modern technology in the issuing, transfer and review of treatment records and documents such as Plant Health Assurance Certificates. For example, geotagged, time stamped photographic records could be used as an alternate method of verification for low-risk products and pathways, freeing up inspection resources for high-risk biosecurity priorities.

As an existing generic treatment that is accepted by all state and Commonwealth authorities, there may be potential for irradiation to be moved to a parallel system alongside the complex and aging ICA system. Exploring this potential could foreseeably open the door for other complimentary innovation in technologies, processes and traceability that enhance domestic biosecurity and trade outcomes.

Recommendations		Responsibility	Timeframe
4	Develop a concept paper that explores the potential to streamline ICA-55, with scope to consider both wider ICA system improvements or alternate parallel systems.	State Regulators	Medium term

Domestic post-harvest research

A review conducted by Golding et.al (2022) examined the literature concerning fresh produce tolerance to phytosanitary irradiation for 20 fresh commodities, these included:

- Tropical fruit: mango, citrus, pineapple, longan, dragon fruit
- Temperate fruit: apple, pear, peach, nectarine, plum, citrus, persimmon, kiwifruit, table grapes, melon, Berries: blueberry, strawberry, raspberry
- Vegetables: tomato, capsicum, asparagus.

The review confirmed that phytosanitary irradiation treatment (<1,000 Gy) maintained final product quality for nearly all fruits, berries and vegetables. However, some examples were found where attributes such as fruit softening, skin blemishes (citrus, avocado) and disruption to ripening (mango) can impact quality, market and consumer acceptability.

It is not clearly understood how irradiation interacts with fruit and vegetable physiological processes, nor how maturity or pre- and post-harvest handling may affect product tolerance to irradiation. As trade volumes increase and diversify, improved understanding of product tolerance and quality outcomes will continue to develop and can guide future research. Where known challenges exist with fruits such as citrus and avocado, the quality of commercial shipments have been inconsistent, suggesting there are variables that once identified, could be controlled to optimise product quality.

There may be unexpected benefits arising from research if irradiation is found to prevent post-harvest storage disorders or can be used to manipulate fruit ripening.

Recommendation		Responsibility	Timeframe
5	Conduct further research to identify and control variables that impact the tolerance of fresh produce to irradiation	Hort Innovation, Industry, Research Providers	Medium-long-term

Pathways to grow international trade

International trade in irradiated fresh produce continues to grow where the required food standards exist, and trade protocols have been negotiated. While market access for irradiated fresh produce has taken several years to establish, negotiations to include additional commodities can often be expedited.

Prior to 2016, Australia's irradiated trade was almost entirely built off mango exports to New Zealand, then new export markets were added including the USA, Vietnam, Indonesia, Malaysia and Thailand. Further efforts have resulted in additional commodities being traded in the above markets, expanding the volume of trade.

High value Asian markets are a key focus for Australian exports, however many of our most important trading partners such as Japan and Korea do not have a trade pathway that includes phytosanitary irradiation.

In most instances, the absence of food standards represents the greatest hurdle when negotiating market access for fresh produce via an irradiation pathway. With few established mechanisms for engagement, new platforms must be found that encourage collaboration, sharing of information and the refinement of food standards.

Assessing future market access opportunities

Kingham and Roberts (2022 unpublished) have suggested that export markets can be broken into four groups, based on the likelihood of negotiating market access for phytosanitary irradiation. This is very much based on the presence or absence of food standards and the acceptance of phytosanitary irradiation as an end point treatment.

Group 1: Markets with established trade in irradiated fresh produce

Australia has already negotiated market access with New Zealand, the USA, Vietnam, Indonesia, Malaysia and Thailand. For these markets, Australia can expect to increase the volume of exported fresh produce by adding new commodities in the short-term.

Group 2: Establishing market access in countries that already export irradiated fruit.

These countries already have experience in the development of appropriate trade protocols and the necessary food standards. Included in this group are several countries that have expressed interest in exporting fruit to Australia and should be amenable to reciprocal trade arrangements. Potential targets in this group would include India, Pakistan, Mexico and Peru.

Group 3: Establishing market access in countries that have appropriate food standards

There are several countries with food regulations that permit the sale irradiated fresh produce, but barriers to trade remain such as the absence of appropriate legislation, trade protocols or limited regulatory capacity. The most important target in this group would be China, with several other potential markets in Bangladesh, Philippines, Singapore and Sri Lanka.

The United Kingdom (UK) is also in this group, but until Brexit, the UK was essentially bound by a European Union (EU) regulation that only permits the irradiation of herbs and spices for decontamination. Interest and support for food irradiation in the EU has been extremely limited for over 20 years. Strong public resistance to any changes to the present, restrictive regulation is expected and there appears little political will to examine the issues involved.

Group 4: Countries with food standards that do not allow phytosanitary irradiation of fresh produce

Over 30 countries permit one or more uses of food irradiation but do not permit the treatment or sale of fresh produce irradiated for phytosanitary purposes. Before any trade can be contemplated, these markets would need to modify their food regulations, only then could meaningful discussions regarding trade opportunities be held. These countries include important trading partners such as Japan and Korea.

Targeting the 'low hanging fruit'

In the short term, an increase in the volume and/or the diversity of commodities should be achievable in some, but not all Group 1 markets.

For example, mango exports to New Zealand have benefited from the transition from sea to air freight, providing New Zealand consumers with a premium product. Other commodities are now following suit, with Australian table grapes and summerfruit now seeking similar outcomes in Vietnam.

Playing the long game

Food standards

Before irradiation can be included in a market access negotiation, the receiving country must recognise the Codex Standard for irradiated foods and maintain a domestic food standard allowing phytosanitary irradiation to be used with imported fresh produce.

While there are established processes between national plant protection organisations to negotiate trade protocols and market access, the same cannot be said for the development of food standards. Food standards are based on sound science, with food irradiation approved many times over by well recognised scientific organisations from around the world, such as the United States Department of Agriculture (USDA), United States Food and Drug Administration (FDA), FSANZ and World Health Organisation (WHO). It is therefore possible for our trading partners to recognise the Codex Alimentarius and use pre-existing risk assessments from recognised organisations to expedite the development of food standards.

It is unlikely that Australian trade negotiations will drive necessary changes to food standards with trading partners such as Japan, Korea and China. Importantly, bilateral and multilateral activities such as IMRP and PSiP (Figure 9) are highlighting the benefits of phytosanitary irradiation, the need to amend global and regional food standards, and identify strategies to overcome soft barriers with our trading partners.

For this to occur, organisations with the responsibility for food standards (such as FSANZ and National Health Departments) must come together, build strong relationships and the commitment to amend food standards.

Figure 9: International platforms for collaboration

Recommendation		Responsibility	Timeframe
6	Identify bi-lateral and multilateral opportunities to build partnerships that target the establishment of global or regionally accepted food standards	FSANZ, Commonwealth Regulators, Industry	Short Medium-term

Improving the technical application of irradiation

For the majority of insect groups, sufficient research has been undertaken to confirm the minimum effective irradiation dose whereby the insect will die, no longer develop or become sterile. Few gaps in our knowledge have been identified in Australia.

Nevertheless, Australian researchers and regulators should collaborate with international researchers and projects to improve and expand efficacy data for emerging pests and diseases. While Australia may not always play a significant role in generating this data, the sharing of this knowledge remains important for ongoing biosecurity and trade.

Efforts should also be targeted toward expanding ISPM 28 to include the 400 Gy generic dose, development of common treatment bands within the 400 Gy generic dose, and assessment of priority non-insect pests.

Recommendation		Responsibility	Timeframe
7	Participate in international and regional efforts to expand ISPM 28.	Commonwealth Regulators, Research Providers	Short Medium-term

Conclusion

The Australian experience has shown that many challenges to the use of phytosanitary irradiation have been overcome in both our domestic and international markets. In both instances, the cumulative experience gained in Australia over the past 20 years has been important when addressing and overcoming barriers to adoption.

With substantial growth in both domestic and international trade of irradiated fresh produce, Australia should seek to maintain this momentum. To do so, government and the horticulture sector are urged to focus short-term efforts toward removing the remaining hurdles that restrict domestic trade.

Having learned so much, Australia is also well placed to share our knowledge with international trading partners, helping to establish regionally and globally accepted trade protocols and food standards that will deliver access to new markets for irradiated fresh produce.

It is important that Australia achieve market access to Japan, Korea and China. To achieve market access in the medium to long-term, strong bilateral and multilateral partnerships will be needed to effect changes to food standards and trade protocols.

In summary, the following recommendations are presented to inform government and horticulture sector efforts to overcome barriers to domestic and international trade of irradiated fresh produce.

Recommendations for domestic trade

Recommendations		Responsibility	Timeframe
1	Australian case studies should be developed by the horticulture sector to provide domestic evidence of successful, long-term marketing and retailing of irradiated fresh produce to consumers.	Industry, Steritech Australia	Short term
2	Industry should conduct risk assessments and prepare for the temporary or permanent loss of domestic trade pathways.	Industry	Short-medium term
3	Investigate the case for amending or removal of domestic labelling under FSANZ Standard 1.5.3. and state and territory biosecurity legislation for prescribed goods.	Industry, Commonwealth and State Regulators	Short term
4	Develop a concept paper that explores the potential to streamline ICA-55, with scope to consider both wider ICA system improvements or alternate parallel systems.	State Regulators	Medium term
5	Conduct further research to identify and control variables that impact the tolerance of fresh produce to irradiation	Industry, Hort Innovation, Research providers	Medium-long-term

Recommendations for international trade

Recommendations		Responsibility	Timeframe
6	Identify bi-lateral and multilateral opportunities to build relationships and partnerships that target the establishment of global or regionally accepted food standards	FSANZ, Commonwealth Regulators, Industry	Short Medium-term
7	Participate in international and regional efforts to expand ISPM 28.	Commonwealth Regulators, Research Providers	Short Medium-term

(Short term 1-3 years, medium term 3-5 years, long-term 5-10 years)

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Appendices

Appendix A: AM19002 Building capacity in irradiation - Pathways to adoption

A research consortium comprising Australian, New Zealand and international research partners have conducted extensive review to identify and evaluate the impact of regulatory, cultural and commercial barriers to the acceptance and adoption of phytosanitary irradiation by domestic and international supply and retail chains through project AM19002 Building capacity in irradiation-Pathways to adoption. The project was funded by the Hort Frontiers Asian Markets Fund, part of the Hort Frontiers strategic partnership initiative developed by Hort Innovation, with co-investment from Agriculture Victoria, Steritech, New South Wales Department of Primary Industries, South Australian Research and Development Institute, New Zealand Plant and Food Research, Aerial (France) and the Australian Government.

The objectives of project AM19002 were to:

- Build a body of knowledge concerning phytosanitary irradiation for the Australian horticulture sector, government, and our international trading partners
- Fill gaps in our knowledge regarding the effective use of phytosanitary irradiation to treat pests and diseases
- Identify future research and development activities that will increase the use and acceptance of phytosanitary irradiation domestically and internationally.

Completed Reviews

Acter et.al (2023) examined the published irradiation efficacy data for plant pests and diseases of quarantine concern to Australia and its major trading partners, identifying where gaps in the literature exist for specific plant pests and diseases.

Kingham and Roberts (2022) investigated the regulatory challenges for phytosanitary irradiation as a trade pathway for Australian exports and reported on the present status and potential for domestic and international trade in irradiated fresh produce. Potential pathways to facilitate the expansion of irradiated Australian exports are discussed and recommendations provided to address domestic and international regulatory challenges.

Golding et.al (2022) conducted a review of phytosanitary irradiation pathways and impacts on product quality. This review examined the published literature on the effect of low dose irradiation (<1,000 Gy) on fruit and vegetable quality for 7 varieties of tropical fruit, 14 varieties of temperate fruit and 3 vegetables, suggesting in all but a few instances, that quality is not impacted by irradiation.

Reilly (2023) documented the commercial barriers that influence the adoption of phytosanitary irradiation, describing the role of hard and soft barriers in restricting domestic and international trade. Reilly identifies six key focus areas where government and industry efforts can be harmonized and coordinated to overcome these barriers to trade.

Aoude-Werner (2022) reviewed the availability of state-of- the-art detection methods for their ability to detect and to validate irradiation treatment of fruits and vegetables at doses used for phytosanitary purposes. The information gathered has revealed that none of the considered methods, whether standardized, developed or under development, fulfills the requirements to either confirm the exposure to ionizing radiation or to validate that the correct phytosanitary dose has been used.

In addition, a previous review conducted by Roberts and Henon (2015) captured consumer attitudes toward to irradiated food. The review examined cases of successful retailing of irradiated food and challenges the belief that consumers will not purchase irradiated food. The review suggests a range of strategies whereby proponents of phytosanitary irradiation can improve commercial uptake by the retail sector.