Hort Innovation

Final Report

The effective control of *Listeria* on whole rockmelons through alternative post-harvest treatment methods

Project leader:

Tom Ross

Delivery partner:

University of Tasmania and Tasmanian Institute of Agriculture

Project code:

VM19000

Project:

The effective control of *Listeria* on whole rockmelons through alternative post-harvest treatment methods
VM19000

Disclaimer:

Funding statement:

This project has been funded by Hort Innovation, using the Melon research and development levy and contributions from the Australian Government. Hort Innovation is the grower-owned, not-for-profit research and development corporation for Australian horticulture.

Publishing details:

ISBN 978 0 7341 4645 8

Published and distributed by: Hort Innovation

Level 7
141 Walker Street
North Sydney NSW 2060

Telephone: (02) 8295 2300

www.horticulture.com.au

Content

Summary

The 2018 Australian rockmelon listeriosis outbreak had devastating consequences for industry and consumers, with large financial losses for producers and seven deaths from listeriosis, and one miscarriage, in Australia directly related to the outbreak. In response, the melon industry made food safety research & development to minimise listeriosis risks through new knowledge, and its adoption, a top priority. In 2019, Hort Innovation initiated a research project, using the melon research and development levy and contributions from the Australian Government, to review relevant literature on sanitisers for whole melons in the packhouse that could contribute to the minimisation of recurrence of similar outbreaks.

The 'desk-top' project sought to:

- review 'best practice' recommendations previously provided to the rockmelon industry, either in Australia or internationally, to reduce the prevalence of *L. monocytogenes* on whole rockmelons (from primary production to packaging and transport)
- review previous outbreaks to identify whether there were similarities across those outbreaks and whether additional risk management practices could be identified
- identify, review and summarise research on the effectiveness of current, or potential, interventions for control of *L. monocytogenes* on whole melons from primary production to the farm gate
- identify other relevant data and knowledge (e.g., growth rates, prevalence, or internalisation of *L. monocytogenes* in/on rockmelons) that can contribute to minimising the risk of listeriosis.

Knowledge of the ecology and eco-physiology of *L. monocytogenes* and of human susceptibility to listeriosis was also reviewed and included in the report.

The full report ("Technical Report") includes detailed reference to, and analysis of, authoritative information relevant to the risk management of listeriosis in Australian rockmelons and from which recommendations for industry 'best practice' have been developed. There is a 'plain english' document that summarises the Technical Report and acts as a guide to the relevant, detailed, information in the Technical Report.

In summary, the research concerning the efficacy of sanitisers currently used in Australian rockmelon packhouses indicates that none achieve greater than $3\log_{10}$ reductions of *L. monocytogenes* on whole melons. The review identified different research areas for the industry, including a range of sanitisers that may warrant further research due to the potential they offer for improved risk reduction. However, all have practical limitations and sanitisers alone cannot guarantee complete risk management of *L. monocytogenes* in rockmelon. Effective risk management will also require an understanding of the ecology of *L. monocytogenes* in the environment and in rockmelon packhouses, attention and response to unusual conditions in the field (e.g. storm events), strict control of fruit and packhouse sanitation, and temperature control in processing and transport.

Keywords

Melon; rockmelon; cantaloupe, listeriosis; *L. monocytogenes*; post-harvest interventions; sanitisers; growth rates; prevalence; whole-of-supply chain risk management

Introduction

Listeria monocytogenes is a foodborne pathogenic bacterium. It does not survive normal cooking, but grows well at refrigeration temperatures and up to 45°C, and is known to contaminate a variety of fresh produce, including melons. It has caused scores of major foodborne outbreaks, resulting in many deaths, miscarriages and severe illness, including a major outbreak from contamination of rockmelons in the USA in 2011 (147 cases, 33 deaths), and two rockmelon outbreaks in Australia.

While there have previously been sporadic cases of listeriosis linked to rockmelons in Australia, a large outbreak occurred in Australia in early 2018 that resulted in 22 cases, 7 deaths, and 1 miscarriage (NSW DPI, 2018b). A smaller Australian outbreak that resulted in 9 cases and 2 deaths occurred in 2010. In the 2011 USA outbreak and 2018 Australian outbreak, while the affected rockmelons were in each case linked to a single grower, the consequences were felt by the entire industry and led to rockmelons being perceived as a high risk for food safety. As such, *L. monocytogenes* presents a hazard to the entire rockmelon industry, and identification and collation of the best growing, harvesting and post-harvest practices are required to assist both industry and consumers to minimise the risk from this pathogen. Further research is needed to identify or develop best practices to minimise the risks and promote public confidence in the safety and benefits of eating rockmelons.

Much is known about the ecology of *L. monocytogenes* and its behaviour on foods, the types of consumers at most risk of illness (very young, old, immunocompromised, pregnant), and the levels of *L. monocytogenes* required to cause illness. However, it is clear that the causes of the rockmelon listeriosis outbreaks must be better understood. From that, appropriate strategies to prevent recurrences could be discerned, *e.g.,* more rigorous process controls, more reliable sanitisation of Australian rockmelons, and education of growers/processors about *L. monocytogenes* risk management options.

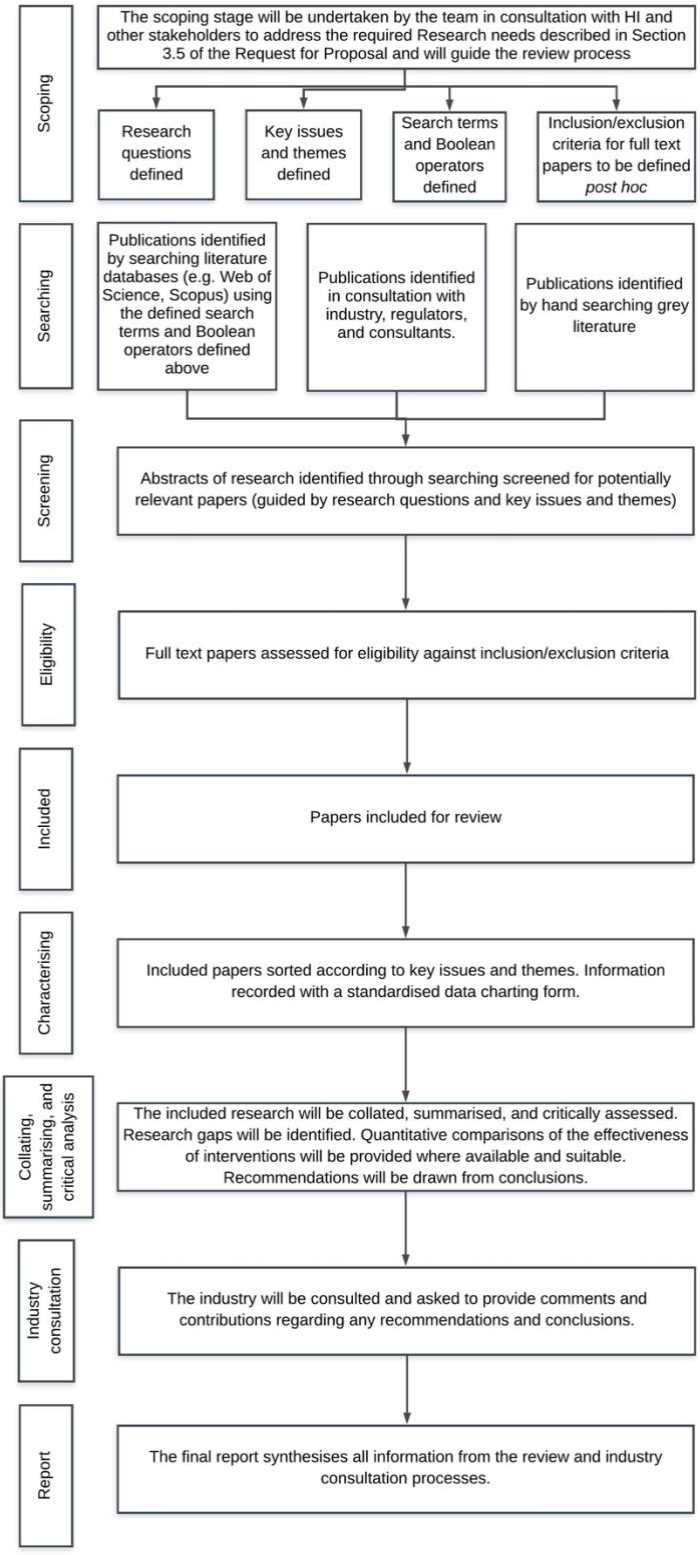
This project undertook a rigorous, quantitative and systematic analysis of current published literature and authoritative websites on the effectiveness of sanitisers against *L. monocytogenes* on rockmelons, on past listeriosis outbreaks associated with rockmelon and their causes, on strategies proposed and employed internationally to reduce the risk of listeriosis from rockmelons, and to relate that knowledge and experience to Australian rockmelon industry conditions. This analysis is underpinned by knowledge of the ecology and pathogenesis of *L. monocytogenes*.

The project involved an international team of experts with diverse experience in horticulture, food processing, and microbiological food safety, who consulted with industry stakeholders and were assisted by professional science communicators, who contributed to development of a 25-page ‘plain English’ summary of the Technical Report (~205 pages) to ensure the delivery of robust but comprehensible findings and recommendations. Both reports are appended. The reports also consider and discuss the limitations of reliance on testing for *L. monocytogenes* for product release as a means of food safety management and considers the relevance of a sustained environmental monitoring program for the growing area and processing environment.

Methodology

The review of the literature followed the methodology of Colquhoun et al. (2014). A flowchart of the review process is presented in Figure 2, and is described more fully overleaf.

Figure 2. Flow chart detailing the steps of the review process.



Overview

The project team comprised university-based scientists in Australia and USA, Australian government scientists and industry-experienced consultants who provided a broad range of relevant skills and expertise. The team members met 'virtually' to determine the scope, research questions and key themes of the review process. The following research questions and scope were agreed upon to achieve the objectives initially specified by HI.

The research questions and scope for the review of previous outbreaks were defined as follows:

1. Identify the most recent (2010 – present) confirmed or potential outbreaks that have occurred from contamination of whole rockmelon/melons by *L. monocytogenes* and *Salmonella* in Australia, North America, or Europe.

2. Articulate the key findings regarding the route of *L. monocytogenes* contamination of rockmelons, and whether there are similarities or differences across the rockmelon outbreaks identified.

3. What were the key outcomes or recommendations that arose following the investigations of the identified outbreaks?

The research questions and scope for the review of best practice recommendations, primary production interventions, growth rates, prevalence, and internalisation were defined as follows:

1. What 'best practice recommendations', have previously been provided to the rockmelon industry, both in Australia and internationally, that aim to reduce the prevalence of *L. monocytogenes* (from primary production to when melons leave the farm gate)?

2. What research exists describing the effectiveness of different interventions to minimise/control *L. monocytogenes* in whole melons at all stages from primary production to when melons leave the farm gate? What data gaps exist, what emerging technologies may be applicable, and where is further research required? (*n.b.,* It was also agreed that where reports provided information for other pathogens, in addition to *L. monocytogenes*, they would also be reported.)

3. What research exists regarding growth rates, prevalence, or internalisation of *L. monocytogenes* in/on rockmelons from primary production to consumption. What data gaps exist and where is further research required?

Identification and extensive evaluation of risk-management processes for interventions after whole melons leave the farm gate, or for fresh-cut melons, were agreed to be beyond the scope of this study.

Definitions

The following definitions were defined and agreed upon:

'*Melons*': Cantaloupe, rockmelon, muskmelon, watermelon, honeydew melon.

'*Best practice recommendations*': Suggested methods or techniques for pre- and post-harvest melon production that aim to reduce microbial contamination and that have been issued by government, regulatory, or other authoritative organizations.

'*Interventions*': additional control measures undertaken or applied pre- or post-harvest to melons to reduce levels of *L. monocytogenes* on the surface of whole melons.

Identification of relevant authoritative literature

The key themes to characterise relevant publications were identified as:

- Australian and international outbreaks associated with melons and *L. monocytogenes* from 2010-to-present
- Best practice recommendations proposed to the melon industry in Australia and internationally
- Pre-harvest interventions to reduce *L. monocytogenes* contamination of whole melons
- Existing, already adopted, post-harvest interventions (e.g., exterior melon sanitising) to

reduce *L. monocytogenes* contamination of whole melons

- 'Alternative' post-harvest interventions – other interventions to reduce *L. monocytogenes* contamination of whole melons
- Growth rates, prevalence, or concentration of *L. monocytogenes* in or on rockmelons from primary production to consumption
- Internalization of *L. monocytogene*s in melons

Before undertaking the review, to provide context and to understand the growing and processing conditions in the Australian rockmelon industry, research team members visited rockmelon farms and packhouses in eastern Australia (NSW and Far North Queensland), and Western Australia (Carnarvon and Perth region).

We interviewed growers/producers and other stakeholders to understand their needs and capability to implement anti-listerial programs, and for their experience and learnings on practices that affect food safety outcomes for rockmelons. This allowed us to include valuable industry knowledge in the initial scoping stage of identifying key issues and themes that guided the review process, as well as giving the team members (without that industry knowledge) the necessary background/understanding to be better able to assess the relevance of the published literature to Australian industry conditions. We attempted to invite all farms that were unable to be visited to provide information via email, post, or phone. Other industry stakeholders, including retailers, were also invited to provide information or highlight areas of interest that might be within the scope of the review. Only a few businesses responded but did provide useful insights.

The literature search strategy was designed to provide an exhaustive search that would identify all relevant, authoritative, literature regarding the research questions. Searches (see "Technical Report" for details of search strings and strategies) using two globally recognized electronic bibliographic databases: Web of Science and Scopus, were undertaken. "Grey literature", including industry and regulatory websites, books, and Google Scholar were also searched. Experts and industry stakeholders were also consulted and asked to identify relevant literature. The citations from all searches were collated in a single folder, imported into reference manager software, and then de-duplicated. The reference lists of articles identified as relevant were searched for additional relevant publications.

The abstracts of all papers identified during the search stage were screened to identify the relevant papers: the screening process was developed with reference to the research questions, lessons learned from industry visits, stakeholder discussions, and the key issues and themes identified. Following abstract screening, the utility (relevance) of papers to be included in the review was assessed based on *post hoc* inclusion/exclusion criteria applied after reading the full text versions. Inclusion/exclusion criteria were initially developed during the first team meeting, but were subsequently adapted during the screening/eligibility process as we became more familiar with the subject matter.

The papers selected for inclusion in the review were then categorized and collated according to the identified key research themes. All selected papers were then critically evaluated for relevance and 'usefulness' of information, summary information recorded. Quantitative data for post-harvest interventions were recorded in a standardised format to enable comparison of sanitiser efficacy.

All information included in the review was critically assessed by the research team members who provided further feedback and advice.

As our aim was to represent the full breadth of relevant research, there was no systematic "quality assessment" step to exclude 'unreliable' papers. However, the limitations of particular papers have been commented on in the literature review, and data from some papers were excluded from consideration due to inconsistencies in the information presented.

The conclusions and recommendations of the study were discussed and developed by the research team members. A draft of the final report was released to industry stakeholders for comment before we finalised the 'Technical Report' and the 'Interpretive Summary' based on it.

A professional science communicator was engaged to develop the 'Interpretive Summary' as a companion to the 'Technical Report'.

Outputs

The following outputs have been delivered:

1. A comprehensive 'Technical Report' detailing the scope of available research into the following: *L. monocytogenes* outbreaks attributed to melons; post-harvest sanitisation options for whole rockmelons to reduce the risk of listeriosis from rockmelons; pre-harvest and other post-harvest interventions specifically to remove *L. monocytogenes* from the surface of whole rockmelons; growth rate data for *L. monocytogenes* on the rind and flesh of rockmelons; prevalence of *L. monocytogenes* in/on whole rockmelons from preharvest to retail; rockmelon specific guidelines for primary production and processing; and research into internalization of *L. monocytogenes* into rockmelons. The report also includes conclusions and recommendations for future research needs in the industry regarding sanitisers and other measures to reduce the risk of listeriosis from Australian rockmelons.


PROJECT VM19000

Technical Report: The effective control of *Listeria* on whole rockmelons through alternative post-harvest treatment methods

Zoe Bartlett, Michelle Danyluk, Elizabeth Frankish, Roger Stanley, John Bowman, SP Singh, and Tom Ross.

Tasmanian Institute of Agriculture
University of Tasmania
April 2020

2. An 'easy-to-read', Interpretive Summary of the Technical Report developed by professional science communicators.

Additionally, a short article (June 2020) on the project and reports was published, upon request, in "*Food Australia*", which is the journal of the Australian Institute of Food Science of Technology

A short article was also presented in *Melon News* (June, 2020), that also directed readers to the two project reports.

Outcomes

The major outcomes of the project are yet to be realised, partly due to the consequences of the Covid-19 outbreak in Australia and internationally and also because the project findings are yet to be widely distributed to the industry. However, the results of the project were presented to the relevant SIAP who considered that further research on the efficacy of sanitisers, against *L. monocytogenes* on rockmelons, was potentially warranted.

While the reports have not yet been released to the industry it would be expected that participants in the industry will also be interested in the results of the project and that they may contact members of the research team, or HI, for further information.

Monitoring and evaluation

The Tasmanian Institute of Agriculture (TIA) at the University of Tasmania has adopted a monitoring, evaluation and reporting (MER) framework for the whole organisation which will provide the capability and experience to assess expected outcomes from this project. In assessing project performance, we will consider impact, sustainability, effectiveness, appropriateness and efficiency. An M&E plan was to be developed for the project.

Given the SARS2-CoV pandemic these systems were not able to use effectively. However, we provide the following qualitative evaluation of the performance of the project and project team against the assessment criteria.

Effectiveness

The project to review and collate the relevant available literature/reports concerning processes that can reduce levels of *L. monocytogenes* potentially present on rockmelons was undertaken conscientiously and systematically, as evident in the Technical Report. While the review identified that there was a dearth or data applicable to the conditions of use of sanitisers in the Australian rockmelon industry, the study was effective in identifying, reporting and evaluating the current 'state of play' relevant to the Australian rockmelon industry. The reporting of project outputs involved direct communication with the relevant SIAP, industry reports and trade journals. The project identified the relevant research that is available to guide decisions regarding effective anti-listerial treatments for rockmelons but also explaining the limitations of those treatments and the relevant literature as they relate to consumer safety and risk management of *L. monocytogenes* on rockmelons.

Relevance

The project was initiated by the industry to meet current needs for advice about management of the risk of listeriosis from Australian rockmelons. The comprehensive identification and analysis of the relevant and reliable literature has provided an excellent resource for the industry. The analysis also links closely to other Australian studies funded by HI.

Process appropriateness

The process, described above, involved thorough scientific investigations, review and summary as well as engagement and discussion with representative industry stakeholders, including visits to many rockmelon farms in western New South Wales, far north Queensland, and the Carnarvon and Perth regions in Western Australia.

Efficiency

The project involved an international team with experts in Florida (USA), Western Australia, New South Wales and Tasmania. The project was characterised by a high level of consultation and direct interaction with Australian industry stakeholders and development of 'plain English' documents to communicate project outcomes.

Recommendations

L. monocytogenes is common in natural environments, particularly if decaying vegetation is present, and may occasionally be present in the faeces of humans and domestic animals. It can become established in food processing plants, where there are food residues, and is well-known to present risks to businesses processing foods that support the growth of *L. monocytogenes* and that are eaten without further cooking.

Listeriosis outbreaks from whole rockmelons are rare: there are only three listeriosis outbreaks from whole rockmelons reported in the international literature in over 40 years, but all resulted in fatalities. Two of those outbreaks occurred in Australia, and one in North America.

Investigations after the two largest outbreaks suggested that high frequency contamination of rockmelons with *L. monocytogenes* contributed to those outbreaks. In the scientific reviews of those outbreaks it was suggested that the contamination of the melons probably occurred in the packhouse after colonisation of the packhouse by *L. monocytogenes*, potentially by:

- *L. monocytogenes* on fruit after adverse weather events (heavy rainfall in December prior to harvest, followed by dust storms) (Australia 2018 outbreak); or
- introduction to the plant of contaminated 're-purposed' food processing equipment from another produce processing business (USA 2011 outbreak); or
- contamination from trucks that were transporting un-saleable melons as feed to a cattle farm (USA 2011 outbreak); or
- failure to use sanitiser spray on melons (USA 2011 outbreak); or
- that high prevalence, but low level, contamination occurred in the field after adverse weather events and was not eliminated during processing in the packhouse (Australia 2018 outbreak).

Listeriosis is a rare disease but, as discussed earlier, specifically affects people with compromised immune systems. Even in those susceptible people the doses of *L. monocytogenes* required to cause infection are usually relatively high (more than a million cells), suggesting that *growth* of *L. monocytogenes* on, or in, foods contributes significantly to the likelihood of infection. *L. monocytogenes* can grow at refrigeration temperatures and can grow on the surface and in the flesh of rockmelons: while the rind is not eaten, transfer of *L. monocytogenes* onto the fruit pulp from the surfaces of the rockmelon during cutting represents a food safety risk. These characteristics mean that risk management of rockmelons from *L. monocytogenes* will require a "whole of supply-chain" approach, e.g., involving adoption of GAP, GMP and food safety plans/HACCP, potentially including environmental monitoring, and actions both to minimise contamination of the fruit and to minimise the potential for growth on the fruit.

Whole Melon Sanitisation

In response to industry requests for information on sanitiser efficacy, while it is clear that sanitisers make an important contribution to product safety, our literature review and analysis revealed limited consistent evidence to determine the efficacy of sanitisers currently used in Australia specifically to kill or remove *L. monocytogenes* on the surface of whole rockmelons. In response to specific industry queries, *there is no evidence that sanitisation treatments currently used by the Australian rockmelon industry will reliably achieve > 3 log_{10}CFU reductions of L. monocytogenes on the surface of whole rockmelons.*

The 'bacterial kill' achieved by a sanitiser depends on factors such as the type of sanitiser itself, pH, temperature, organic matter, the commodity, the contact time and the target organism. In routine operation, concentration and contact time with the fruit are fundamental to sanitiser efficacy. We concluded that there is insufficient rigorous research regarding both product quality and safety to specify recommendations for optimal contact times, specifically to inactivate *L. monocytogenes* on the surface of melons, for sanitisers currently used in the Australian rockmelon industry. Nonetheless, in the absence of new evidence our analysis supports the recommendations of NSW DPI (2019b) for chlorine (100ppm), peroxyacetic acid (80ppm), and chlorine dioxide (aqueous) (5ppm) contact times of 2 minutes. However, due to the potential limited efficacy of those sanitisers, as demonstrated in this scoping study (see Technical Report), rockmelon food safety management will also require the consistent implementation of a whole-of-chain approach.

We also identified and summarised research publications concerning a number of potential alternative sanitisation

methods that might produce > 3 log_{10}CFU reductions in *L. monocytogenes* on the surface of whole rockmelons. Several promising technologies (including, but not limited to, X-rays, octenidine dihydrochloride, hot water, superheated steam, and dry steam) have been investigated and reported to produce > 3 log10CFU reductions in *L. monocytogenes* on the surface of whole melons or rind sections. However, due to limited research, cost, practicality, and other considerations, not all of these will be relevant for the Australian industry. Determination of cost/benefit for these proposed treatments was beyond the scope of this review. However, we have provided general indications of the potential benefits and limitations for all sanitisers/treatments in the Technical Report.

Recommendations

Whole-of-supply-chain Risk Management

The previous publications "Melon Food Safety: A Best Practice Guide for Rockmelons and Specialty Melons" (NSW DPI, 2019b) and "Melon food safety toolbox: Practical resources for implementing best practice"(NSW DPI, 2019a), prepared by Dr Sukhvinder Pal (SP) Singh from NSW Department of Primary Industries, represent the most relevant and recent comprehensive advice provided to the Australian melon industry and should be reviewed by all stakeholders.

For minimisation of the risk of *L. monocytogenes* from Australian rockmelons we recommend further research should:

- assess the prevalence of *Listeria* spp. or *L. monocytogenes* on whole rockmelons and in environmental samples at different points in Australian rockmelon supply chains and from different geographic regions. While this is being undertaken in some parts of the industry, it would be beneficial for a database to be established where results can be collated by state, and nationally, to be able to demonstrate with confidence to risk assessors and consumers the apparently low prevalence of *L. monocytogene*s on rockmelons and in rockmelon growing sites in Australia
- investigate the potential for internalisation of *L. monocytogenes* into whole rockmelons at different points in the rockmelon supply chain (e.g., field, packhouse, consumer handling)
- assess the potential influence of weather events on the prevalence of *Listeria* spp. on/in fruit in the field and the growing environment and the potential persistence of *Listeria* spp. both in the soil and on whole melons in the field under different weather conditions. This assessment should include collaboration with farmers/producers regarding current practices to help frame science-based risk management decisions regarding harvest after 'adverse' weather events
- further investigate the ability of *L. monocytogenes* to colonise rockmelon packhouses from environmental sources or contaminated fruit
- improve quantitative knowledge of factors, such as temperature, surface moisture, relative humidity, extent of netting, or others, that influence the potential for growth of *L. monocytogenes* on rockmelons and how those factors vary throughout the supply chain
- investigate whether regular "in-house" environmental monitoring (both factory and growing environment) is feasible and will reduce listeriosis risk from rockmelons, and if so, develop specific guidance on environmental testing programs including methods, sites, and frequencies
- develop and communicate a holistic risk management strategy that includes growers assessing and responding to adverse weather events, or other unusual circumstances, and more effective and reliable hygienic handling of fruit from the field and during processing and transport

Whole Melon Sanitisation

To optimise the application of sanitisers on whole rockmelons as part of a whole-of-supply-chain approach to minimise the risk of listeriosis from Australian rockmelons we recommend:

- research to determine minimum contact times at relevant (i.e., commercially realistic) concentrations for currently used sanitisers specifically to inactivate *L. monocytogenes* on the surface of whole melons, with consideration of the level of risk reduction both to consumers *and the industr*y against practicality, economic, legal, and fruit quality considerations of the anti-listerial methods.

- validation of commercial sanitisation processes using industry-relevant conditions of sanitiser concentrations, contact times and other variables (such as organic load) on inoculated whole melons
- *not* pursuing research into low penetration surface treatments such as UV and other light treatments, alone. However, in hurdle applications (using combinations of methods) there may be an application for these methods and, in general, research into the application of multiple hurdle/sanitisation technologies is recommended
- re-evaluating and initiating further research into methods that have demonstrated relatively high effectiveness against *L. monocytogenes* such as ozone, X-ray, octenidine dihydrochloride, hot water, superheated steam, and dry steam including determination of their costs versus benefits
- determining the efficacy of high penetration technologies, such as X-rays, to eliminate potential internal contamination of melons by *L. monocytogenes*
- and that future intervention studies should:
    - o include detail of the variety of melon used
    - o assess sanitiser efficacy against multiple pathogens (e.g. *L*. monocytogenes, *Salmonella,* and *Escherichia coli*) in parallel because, they have been shown to have different resistance
    - o assess efficacy at both the rind and the stem scar following inoculation and treatment because the efficacy of sanitisers has been shown to differ at those sites
    - o assess the effectiveness of treatments at multiple times after inoculation to determine the effect of biofilm formation on their efficacy
    - o assess melon quality in parallel with pathogen inactivation tests to ensure that treatments are commercially viable
    - o perform re-inoculation and growth studies on whole melons after treatment to explore the capacity of *L. monocytogenes* to re-contaminate fruit from environmental sources, including packhouses
    - o use industry-relevant contact times, determine the effect of increasing levels of organic matter on efficacy, and apply inoculation and treatments to whole melons (rather than rockmelon portions)

Final comments

The rare outbreaks of listeriosis from rockmelons seem to be associated with a change in conditions in the field or the packhouse that introduces and/or concentrates the pathogen. If contaminated melons from the field then pass through or overwhelm the sanitising systems and no environmental monitoring or sufficient cleaning regimes are implemented, *L. monocytogenes* can colonise the packhouse unchecked and contaminate even 'clean' melons.

As this scoping study suggests, the efficacy of most of the current sanitising systems for whole rockmelons may be limited: even if those sanitising systems are optimised, *L. monocytogenes* may not be completely removed and may persist at low levels. Therefore, it is important for all procedures prior to sanitising to reduce the likelihood of the pathogen entering the sanitising system. Moreover, following sanitising, hygiene procedures must strive to prevent recontamination of the fruit, and to reduce the potential for growth of the pathogen, and to prevent colonisation of the processing facilities by pathogens from the field or via other routes.

We have identified a range of potentially more effective sanitisers that warrant further investigation due to the potential they offer for improved risk reduction for both consumers and the industry. However, all will have limitations and, from our review of available literature and expert opinion, their overall effectiveness on rockmelon food safety will depend on the implementation of a vigilant and whole-of-supply-chain approach to food safety throughout the industry.

Refereed scientific publications

Journal article

Ross, T. and Bartlett, Z. (2020). Managing *Listeria monocytogenes* in the Australian rockmelon industry. *Food Australia,* June 2020: 38 – 40.

References

Colquhoun HL, Levac D, O'Brien KK, Straus S, Tricco AC, Perrier L, et al. (2014). Scoping reviews: time for clarity in definition, methods, and reporting. *Journal of Clinical Epidemiology*, 67: 1291-1294. DOI: http://dx.doi.org/10.1016/j.jclinepi.2014.03.013

Intellectual property, commercialisation and confidentiality

At this time there are no project IP, project outputs, commercialisation or confidentiality issues to report. The outputs of this project are all based on published literature in the public domain. The analysis of the relevant data may lead to a publication.

Acknowledgements

This project has been funded by Hort Innovation, using the melon research and development levy and contributions from the Australian Government. Hort Innovation is the grower-owned, not-for- profit research and development corporation for Australian horticulture.

The University of Tasmania and the Tasmanian Institute of Agriculture would like to thank all the contributors who provided their time, and expertise, during the project. Special thanks must go to the many farm owners and employees who most generously provided team members access to their farms and time to collaborate with us and share their knowledge. Appreciation also goes to those stakeholders who responded to the call for information. We particularly extend our thanks to Jemma O'Hanlon, R&D Manager Hort Innovation, and Dianne Fullelove, Melon Industry Development Manager. We would like to particularly acknowledge the assistance and support of Dr. SP Singh, New South Wales Department of Primary Industries who shared his knowledge of the industry with us and made introductions for us to key industry stakeholders, and to Dr. Craig Shadbolt, New South Wales Food Authority, who provided additional insights and technical detail about the 2018 Australian outbreak investigation. We also extend our thanks to all the stakeholders who made time to review and comment on this report.

Appendices

Bartlett, Z., Bowman, J.P., Danyluk, M., Frankish, E., Singh, S.P., Stanley, R. and Ross, T. (2020). *VM19000 Technical Report: The effective control of Listeria on whole rockmelons through alternative post-harvest treatment methods.* 205 pp.

Helman, M., Bartlett, Z. and Ross, T. (2020). *VM19000 Interpretive Summary.* 25 pp.