Melon Industry Sector Action Plan for Food Waste Reduction 2024

Technical Report

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Disclaimer

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- James Cook University
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- Melons Australia

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Abbreviations

ABARES	Australian Bureau of Agricultural and Resource Economics and Sciences
AFCCC	The Australian Food Cold Chain Council
ARC	Australian Research Council
BMP	Best Management Practice
BOM	Bureau of Meteorology
CLP	Critical Loss Point
CQU	Central Queensland University
CRC	Cooperative Research Centre
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DC	Distribution Centre
DCCEEW	Department of Climate Change, Energy, Environment, and Water
EFWA	End Food Waste Australia
FAO	Food and Agriculture Organisation
FIAL	Food Innovation Australia Ltd
FLA	Food Loss Analysis
FLW	Food Loss and Waste
FLW Standard	Food Loss and Waste Standard
FRO	Food Rescue Organisation
FSC	Food Supply Chain
GHG	Green House Gases
HIA	Horticulture Innovation Australia
IAP2	International Association of Public Participation
IoT	Internet of Things
KPI	Key Performance Indicators
MERI	Monitoring Evaluation Reporting Improvement
MRP	Melon Reference Panel
NQ	North Queensland
PAG	Project Advisory Group
PRP	Project Reference Panel
QDES	Queensland Department of Environment and Science
RC	Root Cause
RDC's	Research Development Corporations
SAP	Sector Action Plan
SDG	Sustainable Development Goals
SFWA	Stop Food Waste Australia
UNEP	United National Environmental Programme
WRAP	Waste and Resources Action Program

EXECUTIVE SUMMARY

This study aims to develop a whole-chain food waste reduction action plan for the Australian melon industry. A mixed methods approach, including a literature review and stakeholder engagement, was employed. The WRAP UK whole chain food waste reduction plan toolkit (WCP) was adapted for this research with the melon industry. A five-stage process was utilized, including the key functions of initiate, plan, solution, actions, and monitoring framework. The review of literature and engagement with key stakeholders across the melon supply chain were designed to:

- Identify hotspots of waste in the melon supply chain from primary production to retailing stage (i.e., before consumption). This project did not deal with consumption /household waste.
- Explore root causes of waste in the melon supply chain.
- Examine and prioritise melon waste management strategies using a food recovery hierarchy.
- Prioritise management options (i.e., proposing actions for managing waste).
- Develop a melon waste prevention and reduction action plan.
- Develop an outline of measuring the impacts of outcomes of the Melon Industry Sector Action Plan for Food Waste Reduction 2024

This report presents findings about the hotspots and root causes of food waste in the Australian melon supply chain along with recommended interventions to reduce food waste, arrived at through the triangulation of the results from a detailed literature review, stakeholder interviews and stakeholder workshops.

The literature review, which was conducted first, explored the key issues of food waste along with the hotspots, root causes, and waste prevention and reduction strategies.

The second stage, stakeholder engagements through one-on-one interviews and group workshops, further identified and validated the hotspots, and root causes of waste in the melon supply chain. Shortlisted interventions/strategies derived from both the literature and engagements (i.e., through stakeholder interviews) were tested in a stakeholder workshop and are presented in this report.

Finally, the report outlines indicators for assessing the impacts and outcomes of the actions using a proposed monitoring and evaluation framework.

Ten strategies were identified, including three for the enabling environment, five that work to prevent the waste from being created, and two that address how the food waste could be repurposed. Multiple actions to implement these strategies are listed in Section 5 Action Plan. These apply to each strategy and include potential outcomes in different time frames. The identified strategies are outlined below.

Enabling Strategies

- **E1.** Data
  Develop and encourage the widespread implementation of improved food waste data collection and analysis tools to inform business decisions.
- **E2.** Education
  Implement an education campaign and supply chain communication/coordination activities to support the reduction of melon food waste.
- **E3**. Policy
  Ensure that policy and regulatory settings support the melon supply chain to reduce food waste.

Prevention Strategies

- **P1.** Supply and demand
  Improve the alignment between the supply of melons and demand.
- **P2.** Stronger supply chain relationships
  Encourage stronger relationships and enhanced communication across the melon supply chain in the interests of reducing food waste.
- **P3.** Industry best management practice (BMP) and extension
  Support best practice production to decrease melon food waste due to agronomic causes and improve consumer trust in the product at market.
- **P4.** Cold Chain and transport
  Improve the transportation of melons, including through the cold food chain to minimise damage and transit times.
- **P5**. Labour
  Support the supply of appropriately skilled labour for the melon industry and the associated supply chain.

Repurposing Strategies

- **R1.** Repurposing
  Increase the quantity of surplus melons being processed and incorporated into value added products for human consumption.
- **R2.** Food Rescue
  Develop a time and cost-effective resource rescue supply chain to increase the number of melons utilised by food rescue organisations.

Each strategy is clarified through the articulation of objectives and key actions. Anticipated short, medium, and long-term outcomes are also specified. A roadmap for the Melon Industry SAP for Food Waste Reduction with a proposed timeline of implementing the strategic actions is also presented.

The Melon Industry SAP for Food Waste Reduction establishes a vision for moving forward on food waste reduction, while recognising challenges in the production, grading and transporting, and distribution stages of the melon supply chain. The plan identifies opportunities and suggests targeted interventions designed to make an impact and bring about multiple benefits.

1. INTRODUCTION

Food loss and waste is one of the major economic and environmental issues in Australia (FIAL, 2021a; FIAL, 2019a). Food Innovation Australia Limited (FIAL) has calculated that the current annual total economic loss impact could be around $36.6 billion from an estimated amount of about 7.6 M tonnes (million tonnes) food wastes within the food supply chain (FIAL, 2021b). An estimated amount of 2600 GL (gigalitre) water and 25 M ha (million hectares) of agricultural land area are required to produce this food, while emitting about 3% of Australian greenhouse gas emissions (GHG) (FIAL, 2021a; SFWA, 2021). The Australian Government (2017) has set targets to reduce 50% of the annually generated total food waste by 2030 in accordance with the UN sustainable development goal (SDG 12.3).

The supply of Australian melons also contributes towards the national inventory of fruit loss and wastage across its supply chain stages. A recent ABARE's survey suggested that on average melon farms have crop wastage of about 20.19% per farm on a national level. The melon industry total production in 2021/22 was 242,465 tonnes with a value of $264.2M (HIA, 2022). Twenty percent less wastage would mean an increase of over 48,953 tonnes and over $53M. Whilst there are a lot of assumptions behind these figures—and we acknowledge possible counter arguments to the feasibility of that increase in crop sale and therefore return—it does serve to illustrate the tangibility of on-farm food waste, without even considering melon food waste at other points in the supply chain. For a comparison, Australia exported 12,870 Tonnes of watermelon in 2021-2022, that is, over a quarter of the wasted crop (HIA, 2023).

This project aims to develop a Sector Action Plan for Food Waste Reduction 2024 for the Australian melon industry to prevent and reduce food waste across the supply chain. The following section describes the project's background and rationale, aims, expected outcomes and impacts. The project is funded by the Queensland Department of Environment and Science (QDES), the End Food Waste Australia Cooperative Research Centre (EFWA CRC) and the Hort Innovation Australia (HIA) Melon Fund. The project formally commenced with the signing of the deed on 26th November 2022 and a start-up meeting on 7th December.

1.1 Project Overview and Scope

The Melon Industry Sector Action Plan for Food Waste Reduction 2024 provides a systems-based approach to reducing food loss and waste, while realising multiple benefits for supply chain partners and collaborators. This commodity specific project is part of a larger project to develop a Horticulture Sector Action Plan for Food Waste Reduction (Hort SAP). This project applied Waste and Resources Action Program's (WRAP) whole chain food waste reduction plan toolkit (WRAP, 2020a; 2020b) to complete an action plan for the melon industry from on-farm production to retail sale. This action plan was co-designed with the key stakeholders most able to directly control or influence the root cause(s) of food waste hotspots and to take action to reduce or eliminate food waste in the value chain.

Initial research focused on identifying waste hotspots, and this was followed by a deep dive into root cause analysis. Using the food recovery hierarchy (Figure 5), the project identified and prioritised a range of practical solutions based on a sequential mixed method, beginning with a literature review on melon waste and waste hotspots, causes, and current and potential intervention to mitigate and reduce food waste. However, the study did not include melon waste at the consumer and/or institutional level and did not quantify the value and volume of waste. Instead, the study reviewed the current melon waste through existing data and literature, discussing the findings with the stakeholders about the reliability and validity of the data. The study also proposed a monitoring, evaluation, reporting, and

improvement (MERI) framework and indicators of the impacts and outcomes; however, this requires further study for the development of a full MERI plan and tracking the progress of the actions that this study developed.

Benefits of the project include **establishing a vision** for increased profitability, increased supply chain efficiency and improved environmental outcomes through reducing food waste, while recognising challenges in the production, processing, and distribution stages of the melon supply chain.

1.2 Definition and Measuring Food Waste

The following definition of food waste, taken from the *National Food Waste Strategy* (2017 p.8), is applied throughout this report. Food Waste includes:

- Solid or liquid food that is intended for human consumption and is generated across the entire supply and consumption chain.
- Food that does not reach the consumer or reaches the consumer but is thrown away. This includes edible food, the parts of food that can be consumed but are disposed of, and inedible food, the parts of food that are not consume because they are either unable to be consumed or are considered undesirable (such as seeds, bones, skins, or peels)
- Food that is imported into and disposed of in Australia.
- Food that is produced or manufactured for export but does not leave Australia.

The term *food loss* is a generic term used in some jurisdictions to differentiate from food waste, either describing where losses occur in the production and processing stages of the supply chain or the reasons why the food is lost, for example, due to disease, weather and over production. The *National Food Waste Strategy* adopts *food waste* as an inclusive term to address both food loss and waste (Arcadis, 2019 p.2). Therefore, this study has chosen food waste as the terminology for this report.

Of note, melon propagators that are grown solely for the purpose of propagating seedless melons and were never intended for human consumption are not considered as food waste. Only wasted crop that was planted with the intention of it making its way for human consumption is considered as food waste.

Due to the great diversity of products as well as their associated supply chains and handling requirements there is not a standard method for evaluating horticultural waste and loss. In using any method for measuring the loss and waste, it is important to consider a clear definition of terms, categorisation of waste or loss, measurement units, as well as data collection and analysis tools (Yahia et al., 2019).

Regarding an appropriate measurement unit, food loss and waste can be reported in terms of weight, volume, quantity, cost, calorific value, greenhouse gas impact, or lost input (e.g., nutrients and water). The melon industry, as illustrated throughout this paper, tends to use weight (tonnes) or value (dollars).

1.3 Project Aims and Expected Outcomes

This project aims to develop a sector action plan (SAP) to be known as the Melon Industry SAP for Food Waste Reduction 2024, to reduce food waste across the melon industry in Australia. The expected outcomes of the project are as follows:

- Growers, packaging, processing and distribution companies, and retailers across the melon supply chain are informed and empowered to undertake effective food waste reduction measures (i.e., actions).
- Increased transparency along the melon supply chain with respect to where and why food waste occurs.
- Businesses can be committed to taking action(s) to reduce food waste in their own operations, and work in partnership with actors across the melon supply chain.
- Greater understandings of the reasons behind melon food waste can inform potential interventions in the melon supply chain.
- Identification of melon food waste valorisation and transformation opportunities, such as utilising food waste from one industry (e.g., low-grade melons) as a raw material for another industry (e.g., melon juice).

1.4 Project Impacts

The main output of this project is the Melon Industry Sector Action Plan for Food Waste Reduction that will assist actors across the melon supply chain to reduce their waste of fresh produce. The impact from this project will be realised through the actions that are recommended in this report. The potential impacts of these actions are described as follows:

- Food waste reduced: A recent report from the Australian Bureau of Agricultural and Resource Economics and Sciences (ABARES) found that the total national average loss and waste of muskmelon and watermelon was approximately 20.19% per farm, which included 14.41% from the pre-harvesting stage and 5.42% from during- and post-harvest stages (Downham, 2022). Discussions with project reference panels members suggested the combined impact of the implementation of all suggested actions would help reduce the current melon waste by 50% by 2030.
- Industry profitability: Reduction in disposal costs and/or increase in efficiency of product to market will lead to higher profitability.
- Rescued food distributed: Increase in rescued fruits and vegetables (as appropriate) will help reduction of food waste and increase the consumption to the people who could not afford to purchase from standard retail shop.
- Greenhouse gas emission savings: Potential to enable GHG reductions due to reduced energy, and organics disposed to landfill.
- Circular economy jobs created: Identification of valorisation opportunities to convert by-products and secondary streams into new products will enable circular economy jobs relating to sorting, processing, stabilisation and transportation, and preparation for market.
- Industry people trained: Industry people aware of food waste issues and sharing knowledge on how to address these through their community of practice.

1.5 Participants

Incorporating the perspectives and experience of a diverse range of stakeholders is fundamental to the development and subsequent implementation of this Melon Industry SAP for Food Waste Reduction (Melon SAP).

WRAP in its *Grower Guidance* (2020 a, b) stresses that collaboration is key and suggests that successfully delivering a 50% reduction in food waste requires collaborative action across the whole supply chain. Customers and supply chain partners have a responsibility to support their suppliers, just as farmers and growers have a responsibility for taking actions in their own businesses.

A melon reference panel (MRP) was established, including Melons Australia; large, medium, and small grower representatives; packaging/distribution, wholesale, processor, and retail actors; End Food Waste Australia; Hort Innovation and CQU researchers (Appendix 2). The panel members engaged in individual interviews with the project engagement officer, participated in online workshops, assisted in data collection, and provided feedback on workshop output.

1.6 Report Structure

The report is structured around three key areas that integrate the deliverables.

1. A description of the project, an overview of the melon industry supply chain and the melon waste issue, and the methodology that has been utilised in this research project.
2. A discussion of the results obtained from the literature review, stakeholder interviews and workshops.
3. Presentation of the action plan and a proposed roadmap to implement the actions.

2. BACKGROUND OF THE STUDY

2.1 Australian Melon Production

The melon production supply chain categorises all the produced melons in Australia into two categories, watermelon and muskmelon. Rockmelon, honeydew, and other varieties are categorised as muskmelon in Australia (Freshlogic Analytics, 2022). Annual production and supply chain destinations of the produced melons in Australia are presented in the Table 1 (for all melons), Table 2 (for muskmelons) and Table 3 (for watermelons) (Freshlogic Analytics, 2022; HIA, 2022). Australia's overall melon production has been decreasing since 2017 along with an increased share of muskmelons in the total supply chain. Australian retailers are the prime gateway to bring this fruit to consumers. To date no melons have been imported into Australia.

Table 1: Australian melon production (combined) supply chain (between 2014 and 2022)

Production & market characteristics	2014	2015	2016	2017	2018	2019	2020	2021	2022*
Production (T)	213455	217207	225727	231146	215503	218324	190024	182572	242465
Production (prod.) ($M)	189	186	166	172	124	145	152	149	248.2
Export as % of production	5.5%	7.5%	8.5%	8.4%	9.4%	9.8%	11.5%	7.1%	11%
Export ($M)	17	24	31	32	32	37	39	27	27.4
Processed as % of prod.	1.3%	1.3%	1.3%	1.3%	1.2%	1.2%	1.3%	1.3%	1.7%
Fresh supply as % of prod.	93.2%	91.3%	90.2%	90.4%	89.4%	89.0%	87.3%	91.6%	93.5%
Fresh supply ($M)	205	194	164	171	114	133	140	149	264
Retail (T)	-	-	-	-	-	160687	148583	139078	184557
Retail ($M)						109	124	122	214.4
Food services (T)	-	-	-	-	-	33676	17378	28140	42,134
Food services ($M)						24	16	26	49.8
Average price ($/kg)	0.88	0.85	0.73	0.75	0.58	0.66	0.80	0.82	-
Household penetration (%)		49.00	50.00	50.00	50.00	50.00	50.00	50.00	-

Source: Freshlogic Analytics. (2022) and HIA (2022)

Table 2: Australian muskmelon production supply chain (between 2014 and 2022)

Production & market characteristics	2014	2015	2016	2017	2018	2019	2020	2021	2022*
Production (T)	65281	65281	66932	67020	45477	50327	58136	67598	57,800
Production ($M)	72	70	71	76	50	63	68	84	81.1
Export as % of production	13.0%	19.0%	20.6%	19.7%	29.8%	28.1%	25.6%	16.0%	17.8%
Export ($M)	14	20	24	23	23	24	26	21	20.6
Processed as % of prod.	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	1.7%
Fresh supply as % of prod.	85.1%	79.1%	77.4%	78.3%	68.3%	70.0%	72.4%	82.1%	46,276
Fresh supply ($M)	71	62	59	66	35	50	54	78	74.7
Retail (T)	-	-	-	-	-	27549	35991	44373	36,509
Retail ($M)						39	46	62	59.0
Food services (T)	-	-	-	-	-	7714	6118	11093	9,766
Food services ($M)						11	8	16	15.8
Average price ($/kg)	1.11	1.06	1.06	1.14	1.09	1.25	1.18	1.24	-
Household penetration (%)		32.60	33.50	34.00	34.00	34.00	34.00	34.00	-

Source: Freshlogic Analytics. (2022) and HIA (2022)

Table 3: Australian watermelon production supply chain (between 2014 and 2022)

Production & market characteristics	2014	2015	2016	2017	2018	2019	2020	2021	2022*
Production (T)	148174	151927	158795	164126	170026	167997	131889	114975	184,664
Production ($M)	117	116	95	96	75	82	84	65	167
Export as % of production	2.2	2.5	3.4	3.7	3.9	4.4	5.2	1.8	1.3
Export ($M)	4	5	7	9	8	13	13	5	6.9
Processed as % of production	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.8
Fresh supply as % of production	96.8	96.5	95.6	95.3	95.1	94.7	93.9	97.2	97.7
Fresh supply ($M)	133	132	105	105	79	84	85	71	189.4
Retail (T)	-	-	-	-	-	133,138	112,593	94,706	148,048
Retail ($M)						70	78	60	155.5
Food services (T)	-	-	-	-	-	25,962	11,259	17,047	32,368
Food services ($M)						14	8	11	34
Average price ($/kg)	0.79	0.77	0.60	0.59	0.44	0.49	0.63	0.56	-
Household penetration (%)	-	46.50	48.00	48.50	48.50	48.50	48.50	48.50	-

Source: Freshlogic Analytics. (2022) and HIA (2022)

Melons are produced across multiple regions in Australia over the entire year, which is advantageous to the implementation of an efficient year-round supply chain model. The overall proportion of production by state of the melons did not change between 2017 and 2021(Melon Australia and Department of Agriculture and Water Resources, 2018; Freshlogic, 2022). Figure 1 shows the production of melons by state in 2017. In terms of production capacity, Queensland (QLD) is the top producer followed by New South Wales (NSW), Northern Territory (NT), Western Australia (WA), Victoria (Vic), and South Australia (SA), respectively (Freshlogic, 2022).

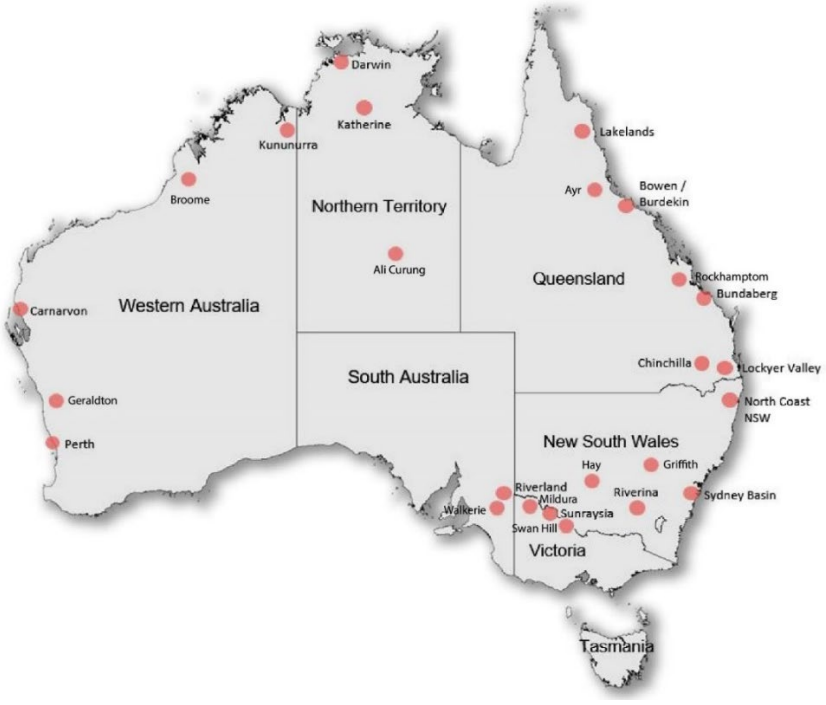

Figure 1: Melon production and harvesting in Australia.
Source: Melons Australia (nd.).

2.2 Australian Watermelon and Muskmelon Supply Chains

The Australian watermelon and muskmelon supply chain stages for domestic supply have been discussed in the reports, *Watermelon Food Safety: A Best Practice Guide and Toolbox* (Singh, 2021) and *Melon Food Safety: A Best Practice Guide for Rockmelons and Specialty Melons* (Singh, 2019), respectively. Figure 2 and Figure 3 show the adapted version of the supply chain stages for watermelon and muskmelon in Australia. A brief pathway of export supply chain stages has been added along with the domestic supply chain stages for both melon categories.

For brevity, the processing tasks of the supply chain stages for watermelon, termed as in-field processing (i.e., in-field cleaning/wiping, in-field sorting and grading, in-field packing into bulk bins), have been presented as a substage in Figure 2. Whereas the key processing activities in the packinghouse (i.e., pre-cooling, dumping, washing, and sanitising, hot water/fungicide treatment, surface drying, packing for domestics or export markets, palletising) have been presented as a substage for the muskmelon processing supply chain activities in Figure 3.

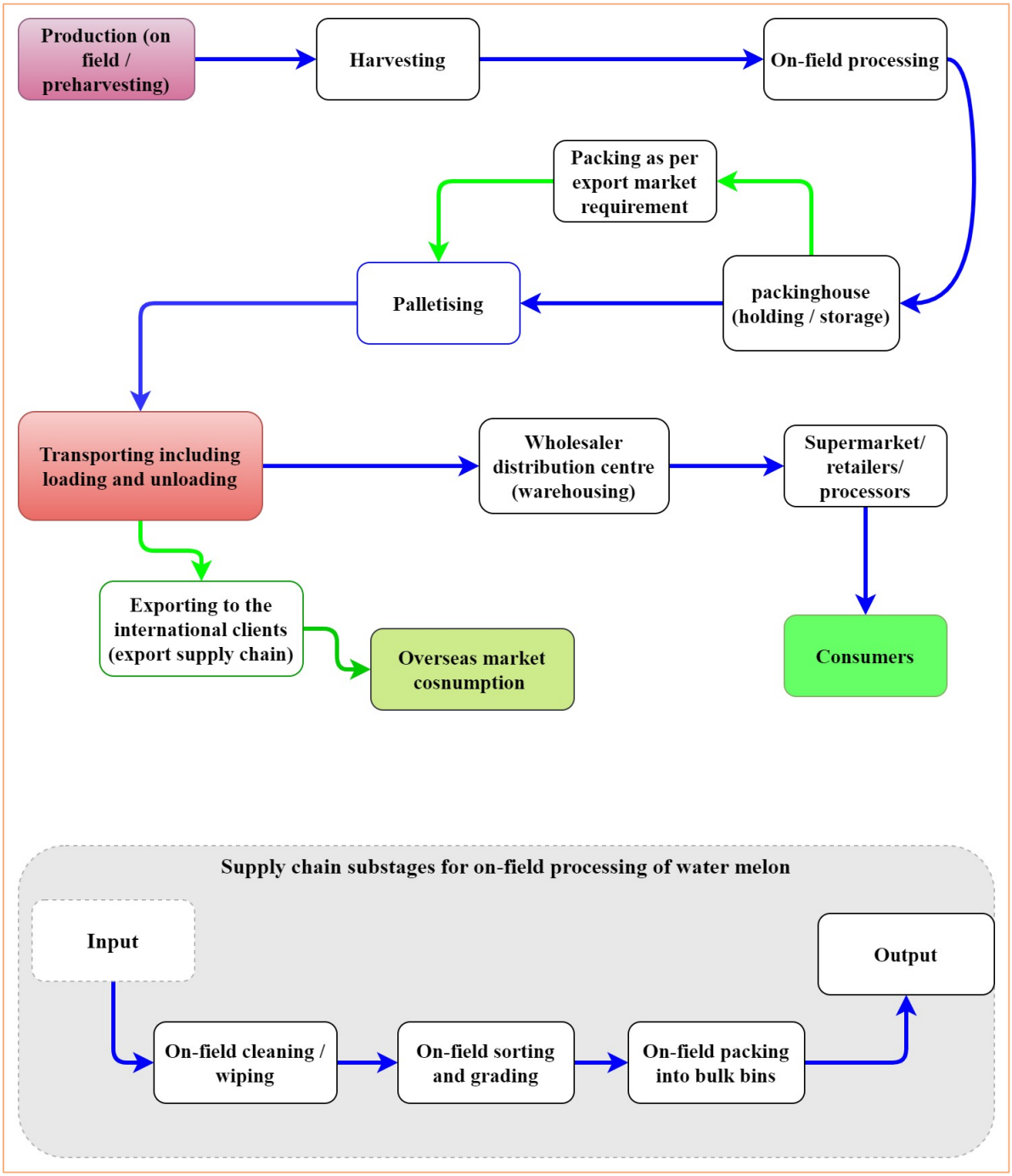

Figure 2: Supply chain stages for watermelon in Australia

Source: Adapted from Singh et al, 2021.

In many cases on-field processing of watermelons includes packing into large cartons, from where it is placed on trucks for transport to the market/agent/export terminal, thereby by-passing the packhouse.

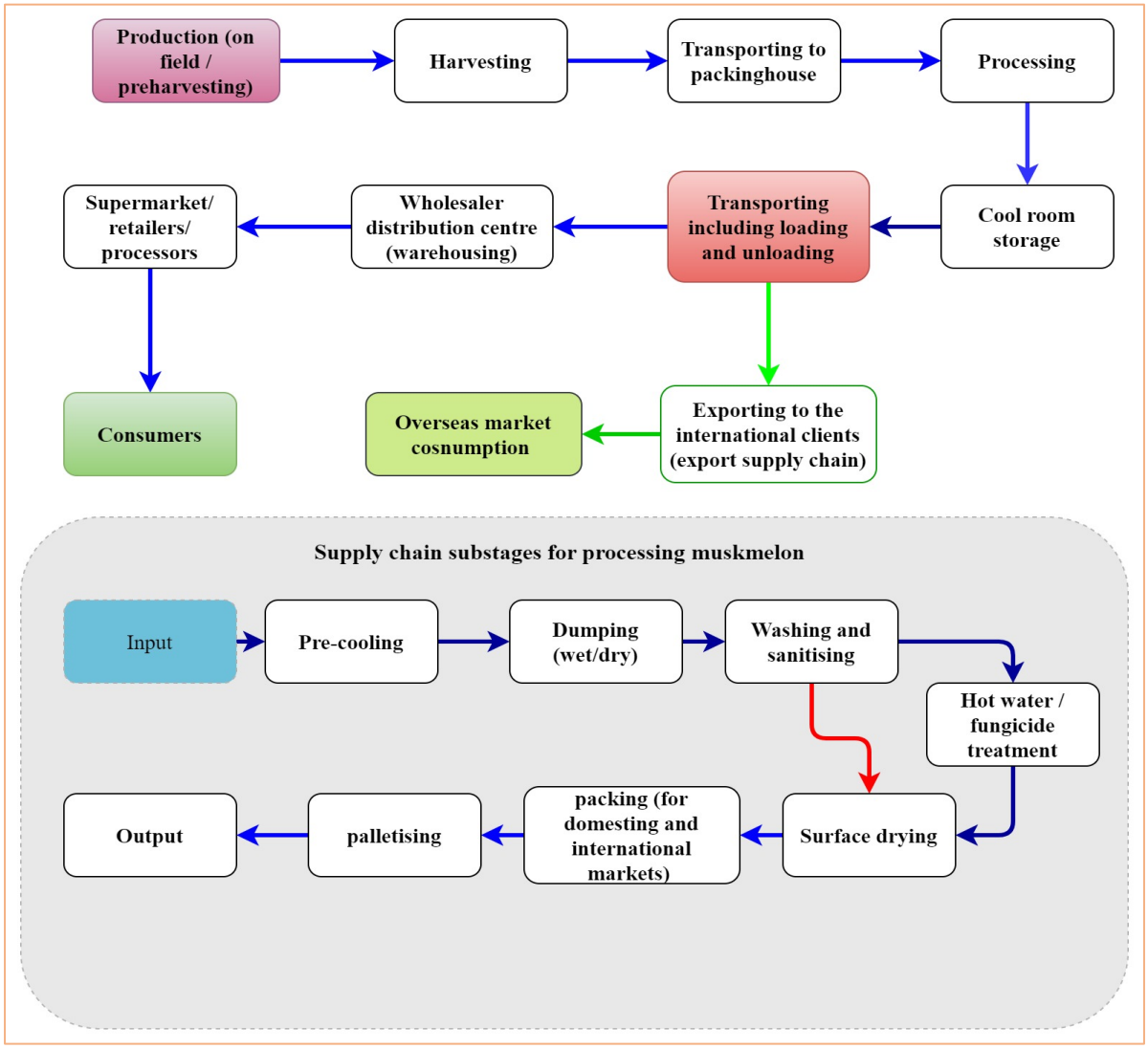

Figure 3: Supply chain stages for muskmelon in Australia

Source: Adapted from Singh, 2019.

3. METHODOLOGY

WRAP UK's whole chain food waste reduction plan toolkit informed the development of the Melon SAP. It is built on the premise that food waste is an end-to-end challenge, requiring a whole chain solution. The five-stage process illustrated below (Figure 4) provides the basic structure of this project, which has brought together stakeholders across the melon supply chain from farm to retail (Table 4). This project has dealt with the first three processes (i.e., where is the waste? why is the waste occurring? and what solutions (i.e., actions) may prevent the waste from occurring?) with a proposed road map to implement the actions. Of note, the project does not deal with household waste nor the implementation and roll out phases.

Figure 4: Whole chain food waste reduction plan: Five stage process

Source: WRAP, 2020 p.3

This study used a sequential mixed methods approach to structure the research and triangulate the key findings. The study then prepared actions based on the key findings. The study team first completed the literature review, then key findings (Appendix 1) from the literature review were discussed individually (i.e., in stakeholders' interviews) with each member of the melon reference panel. The key findings from these interviews (Appendix 2) were then discussed in Workshops 1 and 2 to identify key hotspots, root causes, solutions and to shortlist solutions. The study employed the following four steps for shortlisting proposed solutions for melon food waste reduction:

- Sequential triangulation of findings about root causes, existing interventions, and proposed solutions. Within the above mixed methods, a qualitative 3 x 5 Whys was used to identify and validate the root causes identified.
- Identifying common areas of strategic actions consistent with the framework for the *National Food Waste Strategy* (2017) adopted by the Australian Government and identifying sub-areas of strategic actions.

- Understanding the feasibility of interventions based on four mutually agreed (between the research team and the melon stakeholders panel) criteria, such as volumes of waste, economics (financial feasibility), technological complexity (technical feasibility) and then best and highest use (based on the food waste prevention hierarchy (Figure 5). The study used food waste prevention and management hierarchy (Figure 5) to prioritise all actions proposed in this report. It should be noted that only actions within the green sections, prevention and repurpose, count towards Australia's goal of halving food waste by 2030 (Australian Government, 2017). These actions retain the highest value of the food produced and have the greatest impact in reducing the environmental, social and financial cost of food waste. This approach is consistent with the idea of a circular economy where resources are kept in use for as long as possible, while also minimising negative impacts (DCCEEW, 2017).
- The study then used these criteria, expert judgement and industry consultation to prioritise the short-listed solutions into actions.

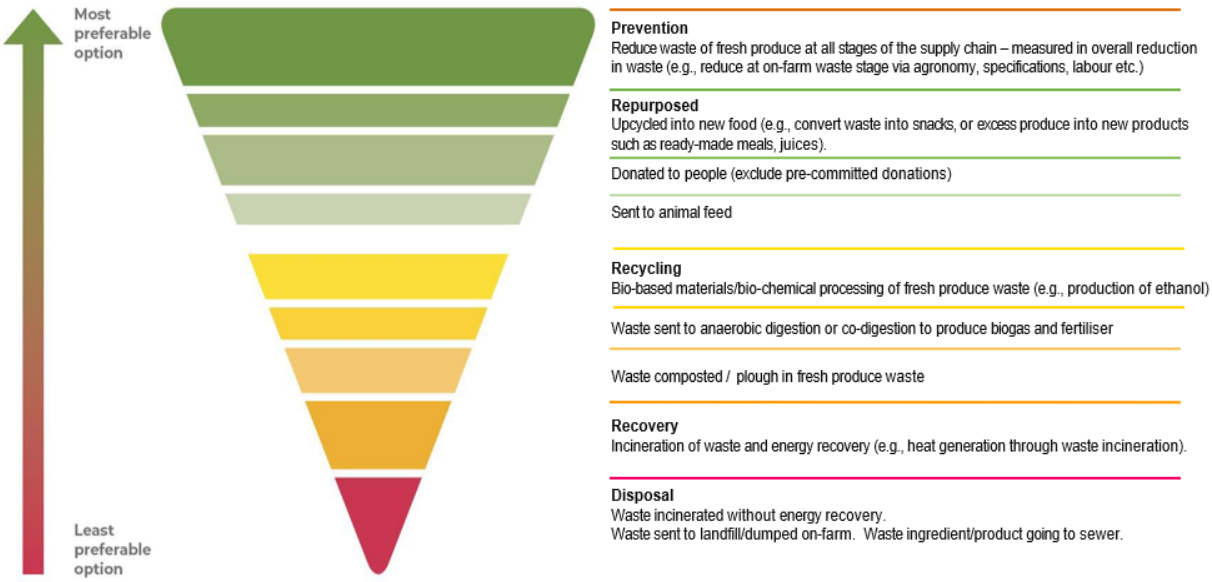

Figure 5: Horticulture specific food recovery hierarchy

Source: SFWA, 2023

The final key actions were articulated from the triangulated key findings based on the above four-step process but not from any individual findings (such as a unique root cause identified in the literature). A detailed description of the methods and activities for the *Melon Industry SAP* are presented in Table 4.

Table 4: Key activities for Melon Industry Sector Action Plan for Food Waste Reduction 2024

WRAP whole chain food waste reduction plan stages	WCP Description for melon	*Melon Industry* SAP: Key activities	*Melon Industry SAP*: Milestones
Initial meeting	• Present the project's objectives & introductions. • Share about operations. • Create a project scope. • Identify data to be gathered.	**Phase 1: Commodity and project partners selection** **Project partners**: • SFWA • QLD DES • Melons Australia • Hort Innovation Australia (HIA) **Industry partners**: • Transport: Cold chain • Retailers • Farmers, wholesalers & distributors **Project scoping** **Develop a stakeholder engagement plan.**	**Phase 1 Milestone**: • *Melon Industry SAP* scoping report and a stakeholder engagement plan. • Application of ethics for three workshops and stakeholder consultation. • Data management plan.
Planning Meeting **Site visit(s)/stakeholder consultation**	• Review next steps. • Finalise/sign off the project scope. • Review data to identify hotspots. • Agree on an agenda for site visit(s). • Walk the chain, end-to-end, identifying melon waste.	**Phase 2a: Defining & identifying waste** • Define the melon supply chain. • Conduct a literature review to document a high-level account of melon waste along the supply chains. Identify past and present interventions to minimise food waste. **Phase 2b**: **Stakeholder consultation** • Undertake stakeholder interview to get a broader picture of hotspots, root causes and existing interventions.	**Phase 2a Milestones** A draft report of methods, the account of current Melon waste, and identifying hotspots, causes and interventions. **Phase 2b Milestones** • A draft summary report on stakeholder interview •
Root causes analysis (Workshop 1)	• Share observations. • Review findings. • Identify root causes. • Generate solutions.	**Phase 3: Root Cause Analysis- Workshop 1** • Share observations. • Review findings.	**Phase 3 Milestone** • A draft report on root cause analysis' methods and tools.

WRAP whole chain food waste reduction plan stages	WCP Description for melon	*Melon Industry* SAP: Key activities	*Melon Industry SAP*: Milestones
		• Identify root causes.	
Solution and action (Workshop 2)	• Hold an idea generation session. • Prioritise solutions to trial.	**Phase 4: Final solutions Workshop 2** • Hold an expanded idea generation session. • Prioritise solutions.	**Phase 4 Milestone** • A draft report on Workshop 1 findings.
Final report with implementation mechanisms & further research	• Propose actions. • Identify KPIs/indicators to monitor outcome and impacts.	**Phase 5a: Draft Action Plan** • Co-create an action plan with timing, responsibility and implementation road map. • Proposed indicators to monitor future outcome and impacts. • Send draft report to melon reference panel for feedback. **Phase 5: Final Action Plan** • Final presentation to stakeholder forum.	**Phase 5a Milestones** • A draft report on Workshop 2 findings and drafted action plan. • **Phase 5 Milestone** Final (technical) report with action plan, proposed implementation roadmap and impact monitoring indicators.

Figure 6: Development stages of *Melon Industry SAP for Food Waste Reduction*

As mentioned earlier, a sequential mixed method has guided all the tasks required for developing the action plan and is described in Table 1. The development stages and tasks (i.e., tasks and time) of the Melon Industry SAP for Food Waste Reduction are presented in Figure 7.

The study utilised seven development stages of the Horticultural Sector Action Plan, as shown in Figure 6. Fifteen stakeholders and researchers attended the initial project inception and scoping meeting. The study team then prepared a stakeholder engagement plan, research design and scope, and formed a melon reference panel consisting of industry, governments, producer, retailers and distributors. A literature review on horticulture food waste, hotspots, root causes and interventions were then undertaken.

Based on the key findings from the literature review, the study team prepared stakeholder interview questions. The interview questions were piloted first before 9 stakeholders from a wide range of relevant fields, including industry, retailer, government, marketer/distributors, transporter and food waste experts were interviewed, with the interviews taking place between January and March 2023 (see Appendix 2). Based on the key findings from the stakeholders' interviews, the team designed two workshops with End Food Waste Australia (SFWA) experts. The same group of stakeholders, 15 and 18 participants (including researchers and facilitators), respectively, attended Workshops 1 and 2. The second workshop generated and prioritised the solutions. The same stakeholders were consulted to further test the validity of the actions and to ascertain who could implement which action(s) (see Figure 6).

This interview and workshop processes and tools were approved by the CQU's Human Research Ethics Committee (Application No. 0000023956). We have removed participants name from the dataset and only reported collective and analysed data to ensure the anonymity of the participants.

4. FINDINGS & ANALYSIS

4.1 Melon Food Waste Hotspots

The average percentage of crop loss/waste for melons in Australia was 20.19% per farm in 2021-22, which includes 14.41% from the pre-harvesting stage and 5.42% during- and post-harvest losses (Downham, 2022). In the state of Queensland, there was a 29.42% per farm total loss, made up of 21.98% from pre-harvest and 7.45% during- and post-harvest losses (Downham, 2022).

Table 5 illustrates the percent of food waste at the various stages of the watermelon and muskmelon supply chains. Other than visible external damages, waste generated by internal damage is seldom observed within the supply chain due to the firm outer layers of the melons and is only realised upon cutting.

The quantity of melon loss and wastages reported in Table 5 indicates that the largest single hotspot is in the field or preharvest. The remaining supply chain stages collectively contribute an equivalent amount to the total pre-retail melon food waste.

Engagement with melon supply chain stakeholders (during interviews and Workshop 1) regarding food waste hotspots confirmed the significant levels of on-farm waste and suggested that the other major hotspot is in the retail sector, especially where the retailer cuts the fruit for sale. Reliable data to support or deny this anecdotal conclusion has not been identified. Wastage in transport and warehousing was considered minimal.

Table 5: Percentage of food waste at various stages of the watermelon and muskmelon supply chains pre retail

Melon supply chain stages	Commodities belong to the supply chain stages (Y = Yes; N = No)		Percentage food waste	
	Watermelon	Muskmelon	Watermelon	Muskmelon
Field production	Y	Y	19 (range: 20-40)	19 (range: 20-40)
Harvest	Y	Y	20	20
In-field cleaning	Y	N		
In-field grading	Y	N		
In-field packing into bulk bins	Y	N		
Packing house	Y	Y		
Pre-Cooling	N	Y		
Dumping	N	Y		
Washing and sanitising	N	Y		
Fungicide treatment	N	Y		
Surface drying	N	Y		
Sorting and grading	N	Y		
Packing	Y (export only)	Y		

Source: Based on Ambiel, Adell et al. 2019

4.2 Root Causes for Melon Food Waste

Root causes are the fundamental reasons for food waste (Møller et al., 2014; Moragues-Faus et al., 2017), and they are often location-specific (Van Berkumet al., 2018). The Canadian Commission for Environmental Cooperation (CEC, 2021), however, distinguishes between apparent causes (reasons) and root causes (i.e., drivers), suggesting that there are two layers to identifying the root causes of food waste: (1) an immediate/proximate reason why food is wasted or lost, namely *cause* and (2) the underlying factor(s) that play a role in creating that reason, namely *driver(s)* or *root cause(s)*. For example, if one of the causes of watermelon or muskmelon food waste is cosmetic or physical damage, the root causes can be poor harvesting technique/inadequate equipment and a range of other contributing factors.

Usually, there are three apparent causes of food waste (Herzberg, Trebbin and Scheider, 2023; CEC, 2021; Feedback & the Rockfeller Foundation, 2017; FAO, 2011):

1. Fruit is physically damaged or does not meet produce specifications.
2. Fruit is unviable and does not warrant progressing further in the supply chain, often the result of an oversupply.
3. Unusable fruits, that is, the fruits are rendered unusable, usually in retail.

These can be traced back to six root causes (Appendix 2, Table 6):

1. Agronomy and weather
2. Farm management practices

3. Labour issues
4. Storage and transport
5. Supply chain issues
6. Retail fruit handling management/operational issues

As mentioned earlier, this project does not address waste at the consumer level, so the associated causes and root causes of food waste at that point in the supply chain have not been included.

Based on reviewing the available relevant literatures (Schmickl & Crailsheim, 2002; Ledger, 2007; Fernández-Trujillo et al., 2013; Tesoriero & Watson, 2016; Pereira et al., 2017; Gardas et al., 2018; Singh, 2019; WRAP, 2020; Adepoju & Ologan, 2021; Singh, 2021; Bartezzaghi et al., 2022; Downham, 2022; Ismael, 2023), data and information obtained from stakeholder interviews and workshops, Table 6 summarises the key root-causes for the identified hotspots that contribute to generation of food waste across watermelon and muskmelon supply chain stages. The apparent causes and root causes were initially drawn from the literature review, and then these were discussed with the melon reference panel members through one-to-one interviews and the workshops (Appendices 1 and 2

Table 6: Apparent causes and root causes of watermelon and muskmelon food waste: Triangulation of key findings from literature review, interviews, and workshops. (Refer to Appendices 1-3)

Apparent causes	Root causes	Supply chain point of waste occurrence			
		Primary Production (at the paddock)	On- farm post-picking*	Transport, Warehousing and Markets	Retail
Fruit is damaged or does not meet product specifications.	RC 1 Agronomy and weather				
	Weather events.	√			
	Lack of quality and appropriate seed stock and planting practices.	√			
	Inconsistent quality of soil health, fertiliser, and supplied water.	√			
	Pest damage from insects or other animals.	√	√	√	
	Insufficient disease control actions.	√			
	Irregular maturity during production stage (i.e., plant growth, flowering, pollination, and fruit development).	√			
	Microbial contamination.	√	√		
	RC 2 Farm management practices				
	Irregular time of picking, for example, night, early morning, daytime/bad weather conditions.	√	√		
	Inadequate farming infrastructure, for example, shed space and equipment.	√	√		
	RC 3 Labour Issues				
	Poor handling of fruit in harvest, packing or transporting that causes damage.		√	√	
	Immature fruit picked due to lack of training for seasonal workers.	√			
	Inadequate labour to harvest and process the crop in a timely manner.	√	√		
	RC 4 Storage and transport practices				
	Inadequate control of storage temperature.			√	√
	Insufficient pre-cooling.			√	
	Prolonged storing of fruits.			√	√

Apparent causes	Root causes	Supply chain point of waste occurrence			
		Primary Production (at the paddock)	On- farm post-picking*	Transport, Warehousing and Markets	Retail
	Mishandling at packing shed (during, e.g., wiping/washing, sanitising, drying, sorting, repacking and/or pallet stacking).		√		
	Carton failure.			√	
	Shortage of pallets or cartons prohibits timely transport.		√		
	Damage of fruits due to unregulated loading, pallet stacking and unloading activities.			√	
	Vibration damage to the fruits (bruising, cracking, loss of quality of the fruit for eating).			√	
	Inefficient or incorrect pallet loading/stacking.			√	
	Temperature of transport containers and exposing fruits to external temperatures.			√	√
	Inappropriate quality assurance processes.			√	√
	Inefficient tracking of fruit pallets to control first-in-first-out activities.				√
Market supply exceeds demand or low price does not justify harvesting and processing.	RC 5 Supply chain issues				
	Lack of communication between supply chain actors to manage quantity and flow of fruit when harvested.	√	√	√	√
	Overproduction.	√			
	Speculative growing.	√			
	Ease of entry into the supplier market.	√			
	Inadequate export market.	√			
Unusable fruits or fruit not sold in store.	RC 6 Retail fruit handling management /operational issues				
	Storage room temperature/varying temperature control.				√
	Cutting and wrapping damages or damages inflicted by consumers.				√
	Mishandling of fruits because of lack of knowledge and training of the store's staff.				√
	Poor demand and order management from the retail stores.				√
	Cut fruit storage time and food safety standards requires removal from shelf after a short time.				√
	Enterprise standards, or interpretations thereof, can result in fruit being discarded ahead of food safety regulation timings.				√

Source: Prepared by the authors

*Musk melons are transferred from the field to the shed (usually on-farm but sometimes off-farm for smaller growers) for further cleaning, grading (sorting) and packaging. Watermelons are usually processed (wiped, graded and put in cartons) in the paddock, so all non-standard watermelons (i.e., either very large or very small) are left in the paddock.

4. ACTION PLAN

5.1 Process to Prepare Waste Prevention and Reduction Actions

The study identified various actions to prevent and reduce food waste in the melon supply chain through reviewing existing practices (see Appendices 1 and 2) and through recommendations from stakeholders in the interviews and in Workshops 1 and 2. As mentioned in Section 3 of this report, the study team short-listed the actions through a four-stage process, and then 11 actions were presented for further discussion between the stakeholders in the final solution workshops (Workshop 3). In Workshop 3, four criteria were used to prioritise the actions (volume, financial feasibility, technical feasibility, and best and highest use principle). Based on the discussion in Workshop 3 the research team developed 10 strategic areas of actions, including three enabling strategies, five prevention strategies and two repurposing strategies, as shown in Figure 7. The 10 strategies and corresponding actions are then outlined individually below.

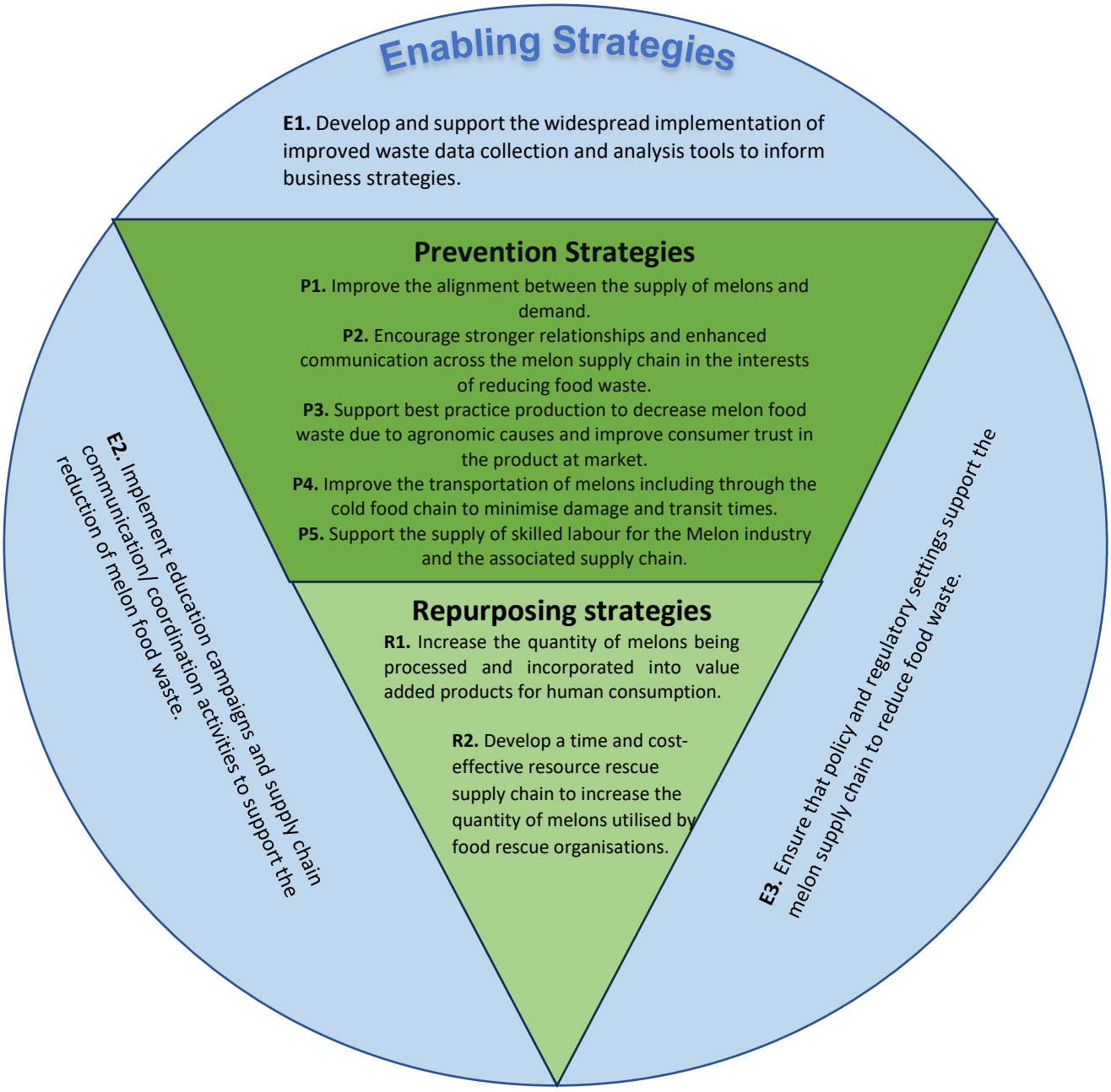

Figure 7: Strategies and actions for *Melon* Industry Food Waste Action Plan

5.2 Melon Industry Waste Prevention and Reduction Actions

STRATEGY E1: Data

Develop and encourage the widespread implementation of improved waste data collection and analysis tools to inform business strategies.

Objective: To acquire comprehensive accurate information on the quantum, nature and causes of melon food waste as a basis for further waste reduction activity and the monitoring of the impact of initiatives.

Actions

- E 1.1 Undertake a review of waste data collection methodologies used nationally and internationally in the melon industry (and other similar commodities) and produce recommendations for the Australian industry and supply chain.
- E 1.2 Develop or adapt melon industry specific data collection tools and processes and encourage consistent utilisation across the supply chain.
- E 1.3 Produce a biannual report on the status of food waste in the Australian melon industry, measuring and evaluating the impact of reduction initiatives.

Expected Outcomes

Short term outcomes	**Medium term outcomes**	**Long term outcomes**
Waste data collection research complete. Melon industry waste data collection tools developed and being trialled.	Regular reporting on melon food waste reduction. Data is being used to inform waste issues/opportunities.	Melon supply chain actors have access to reliable food waste data and apply this in their decision making.

Potential Lead Agencies

- End Food Waste Australia
- End Food Waste CRC
- Melons Australia
- Hort Innovation

In paddock	On-farm/in-shed	Logistics	Market/DC	Retail
√	√	√	√	√

STRATEGY E2: Education

Implement an education campaign and supply chain communication/ coordination activities to support the reduction of melon food waste.

Objective: To empower melon supply chain actors to individually and collaboratively, contribute to food waste reduction, from an informed position.

Actions

- E 2.1 Develop and promote a melon industry educational campaign that highlights the level of melon food waste, the costs to industry and the benefits to be gained by reducing food waste and that encourages industry stakeholders to commit to melon food waste reduction.
- E 2.2 Develop melon food waste reduction information and resources that can be made available to supply chain actors and used to promote waste reduction activities.
- E 2.3 Work with other horticultural industry groups to identify and promote transferrable food waste reduction techniques.
- E 2.4 Support the development of a standard for food waste reduction that can be implemented and is aligned to existing melon industry standards, thus causing minimal additional cost and disruption.
- E 2.5 Identify and showcase food waste champions and innovative waste reduction strategies in the melon supply chain.
- E 2.6 Provide information and training to support retail staff handle and display fruit attractively to increase shelf life and minimise the risk of damage/waste.

Expected Outcomes

Short term outcomes	**Medium term outcomes**	**Long term outcomes**
All melon supply chain actors are cognisant of the level of melon food waste and are actively engaged in initiatives to reduce. Food waste standards are in place.	New food waste reduction strategies are proposed and implemented by melon supply chain actors. Melon food waste at retail stage is minimised.	Significant reduction (>20%) in the amount of melon food waste (as compared to 2023). All supply chain actors have access to food waste reduction strategies.

Potential Lead Agencies

- End Food Waste Australia
- Melons Australia
- Hort Innovation

In paddock	On-farm/in-shed	Logistics	Market/DC	Retail
√	√	√	√	√

STRATEGY E3: Policy

Ensure that policy and regulatory settings support the melon supply chain to reduce food waste.

Objective: To ensure that the regulatory and policy environment facilitates the reduction of melon food waste via a fair and supportive environment that provides incentives for behaviour change and supports industry growth.

Actions

- E 3.1 Maintain biosecurity vigilance to prevent the incursion of new pests and diseases across international and jurisdictional borders.
- E 3.2 Review interjurisdictional biosecurity arrangements to improve harmonisation and minimise interstate transport delays.
- E 3.3 Identify enterprise and government policies that increase melon food waste or prevent value-added opportunity, and advocate for their removal or adjustment.

Expected Outcomes

Short term outcomes	**Medium term outcomes**	**Long term outcomes**
	Strategies are in place to control transferable diseases.	Government policies and procedures are supportive of melon food waste reduction and repurposing activities.

Potential Lead Agencies

- Federal and State governments
- Melons Australia
- End Food Waste Australia.

In paddock	On-farm/in-shed	Logistics	Market/DC	Retail
√	√	√	√	√

STRATEGY P1: Supply and demand

Improve the alignment between the supply of melons and the demand.

Note: This strategy mostly addresses RC 5 (Table 6) (and also other RCs that have element(s) of supply and demand mismatch).

Objectives:

- *Create a better balance between the demand for melons and the available supply to minimise waste and increase profitability.*
- *Improve farm business viability by decreasing the amount of the crop that does not provide a return to the producer.*

Actions

P 1.1 Promote the utility and health benefits of melons and deliver campaigns to drive domestic demand for melons.

P 1.2 Explore the potential for increasing the export of Australian melons, including identifying the current barriers and constraints and developing an internationally attractive value proposition.

P 1.3 Explore new market opportunities for sale of melons in alternative formats and markets.

P 1.4 Support current and potential melon producers to understand the operation of the market, its drivers, and the implications for them.

P 1.5 Explore strategies to improve melon growers' access to market and weather information to improve their ability to make informed decisions re. planting and harvesting.

P 1.6 Explore models that facilitate greater supply and demand balance, such as contract arrangements, whole crop purchase, formation of consortia of small growers and planned production.

Expected Outcomes

Short term outcomes	**Medium term outcomes**	**Long term outcomes**
Increased grower knowledge and understanding of the market and the forces of supply and demand.	Increase planned production to support a decrease in speculative production. New models of supply trialled and implemented. New fresh market channels identified and trialled. Increased national melon consumption.	Additional export markets identified and trialled. Minimal wastage as a result of oversupply.

Potential Lead Agencies

- Australian Melon Growers
- Melons Australia
- Federal and state governments
- Marketers/agents/market information services/retailers
- Hort Innovation

In paddock	On-farm/in-shed	Logistics	Market/DC	Retail
√	√	√	√	√

STRATEGY P2: Stronger supply chain relationships

Encourage stronger relationships and enhanced communication across the Melon Supply Chain in the interests of reducing food waste.

Note: This strategy mostly addresses RCs 4 and 5 (Table 6) (and also other RCs that have element(s) of stakeholder collaboration issues).

Objective: To improve the transparency and clarity of melon food waste reduction by working collaboratively across the supply chain.

Actions

P 2.1 Establish a whole of supply chain steering group to drive the reduction of melon food waste and support the implementation of this action plan.

P 2.2 Identify and quantify in-store melon waste causes and develop strategies to reduce.

P 2.3 Establish a multistakeholder working group to review the current produce specifications and assess the effect produce specifications have on melon food waste levels.

P 2.4 Identify and address communication and understanding differences between supply chain actors on topics, including the impact on grower payment of instore wastage, demand triggers, supply levels, pricing mechanisms, quality standards and rejection criteria.

Expected Outcomes

Short term outcomes	**Medium term outcomes**	**Long term outcomes**
The causes of melon food waste are transparent and commonly understood across the supply chain. Melon produce specifications reviewed, and improvements identified. An enhanced communication system is established between growers and retailers.	The increased sale of melons with diverse aesthetic characteristics is facilitated.	A transparent understanding of melon food waste and opportunities for correction are shared across the supply chain.

Potential Lead Agencies

- Australian Melon Growers
- Marketers/agents/market information services
- Hort Innovation
- Retailers

End Food Waste Australia

In paddock	On-farm/in-shed	Logistics	Market/DC	Retail
√	√	√	√	√

STRATEGY P3: Industry Best Practice Management (BMP) and extension

Support best practice production to decrease melon food waste due to agronomic causes and improve consumer trust in the product at market

Note: This strategy mostly addresses RCs 1 and 2 (Table 6) (and also other RCs that have element(s) of agronomy and farm management issues).

Objective: To decrease the quantity of melons that are wasted and thereby improve the return on the resources (money, time, land, and energy) invested in producing a melon crop.

Actions

P 3.1 Support research on pest and disease management and plant nutrition and encourage the adoption of new and improved ideas through BMP and extension.

P 3.2 Undertake research, including industry-based trials on the use of grading and sorting technologies that determine the ripeness and quality of melons.

P 3.3 Increase support to the melon industry and research facilities to encourage benchmarking, best practice production and innovation including the use of technology.

P 3.4 Support research into melon varieties and breeding to address waste causes and increase crop resilience.

P 3.5 Investigate the expected impacts of climate change on the melon industry, undertake risk assessments and develop recommendations for production.

P 3.6 Develop a relationship with the Bureau of Meteorology (BOM) to provide training and information about climate and weather patterns that will impact melon production in both the short and long term.

Expected Outcomes

Short term outcomes	**Medium term outcomes**	**Long term outcomes.**
Reduction in the rate of melon waste caused by pest/disease.	Technological options available to reduce melon waste during grading and sorting.	Melon varieties available that are disease/damage resilient and have a longer shelf life.

Potential Lead Agencies

- Hort Innovation
- Seed/chemical companies
- Innovation/technology companies
- Agronomists
- State Govt. Dept. of Agriculture
- CSIRO
- BOM
- Universities
- Melons Australia

In paddock	On-farm/in-shed	Logistics	Market/DC	Retail
√	√			

STRATEGY P4: Cold Chain and Transport

Improve the transportation of melons including through the cold food chain to minimise damage and transit times

Note: This strategy mostly addresses RC 4 (Table 6) (and also other RCs that have element(s) of logistics and transport).

Objective: To significantly reduce transport damage that leads to melon rejection across the supply chain.

Actions

- P 4.1 Explore options for improving on-farm transport of melons to reduce damage.
- P 4.2 Utilise real-time monitoring to track loads and to identify temperature, humidity and ride issues and implement strategies to address.
- P 4.3 Increase the development and use of alternative packaging materials and techniques that provide better protection for melons in transit.
- P 4.4 Investigate the potential for rail transport and the impact to be gained by the upgrading of infrastructure on major road transport corridors.
- P 4.5 Enhance the training and supervision of long-distance truck drivers.

Expected Outcomes

Short term outcomes	**Medium term outcomes**	**Long term outcomes**
Reduction in damaged fruit arriving at the markets or DC. Alternative packaging options that increase shelf life and reduce susceptibility to damage are available. Increased information available about fruit condition during transport available to inform improves logistic practices.	Introduction of innovative on-farm transport practices that reduce damage between the paddock and the box.	Full transparency of, if and when damage has occurred and ability to implement targeted mitigation measures for future.

Potential Lead Agencies

- Australian Food Cold Chain Council
- Logistics companies
- Melons Australia
- Supply chain actors, including melon growers, wholesalers, and retailers.
- Agricultural research companies

In paddock	On-farm/in-shed	Logistics	Market/DC	Retail
√	√	√		

STRATEGY P5: Labour

Support the supply of appropriately skilled labour for the melon industry and the associated supply chain

Note: This strategy mostly addresses RC 3 (Table 6) (and also other RCs that have element(s) of labour force management).

Objective: To ensure that the melon industry has a reliable supply of appropriately skilled workers.

Actions

- P 5.1 Develop and distribute resources/tools to support growers to train field and shed staff efficiently and effectively.
- P 5.2 Develop and distribute resources to train and support retail staff regarding melon stock control, handling, and merchandising.
- P 5.3 Support place-based labour initiatives and national strategies and policies that facilitate a reliable supply of seasonal workers.
- P 5.4 Promote the melon industry and the range of available roles as an employment option.
- P 5.5 Encourage investment in emerging technologies that minimises the risk of human error.
- P 5.6 Support industry projects and technologies that address labour issues.
- P 5.7 Review and quantify the impact of the cost of labour on production costs and waste levels.

Expected Outcomes

Short term outcomes	**Medium term outcomes**	**Long term outcomes**
Training resources available for grower and retailer use. Minimal melon food waste caused by lack of staff.	Increased interest in employment and careers in the melon industry.	Minimal melon waste due to labour cost, availability, and skills.

Potential Lead Agencies

- Melons Australia
- Hort Innovation
- Employment providers
- Seed/genetic companies (as maturity ID points continue to develop and become clearer)
- Local businesses, for example, hostels
- State and local governments

In paddock	On-farm/in-shed	Logistics	Market/DC	Retail
√	√	√	√	√

STRATEGY R1: Repurposing

Increase the quantity of melons being processed and incorporated into value added products for human consumption

Objective: To create new value, secondary markets, and new income streams from surplus and waste melons.

Actions

- R 1.1 Produce a collation of existing national and international research into current and past melon value-adding initiatives and communicate these through a range of channels, including forums/conferences, field days and online.
- R 1.2 Assess current melon value-adding activities to identify opportunities for expansion, the barriers to be addressed and the prerequisites for expansion.
- R 1.3 Undertake feasibility studies, including a review of existing appropriate infrastructure and small-scale trials of innovative melon value added food products, nutritional supplements, and pharmaceuticals.
- R 1.4 Facilitate the collaboration of melon supply chain actors, government, private enterprise, innovators, investors, and the financial sector in the development of value-add infrastructure and commercial opportunities.
- R 1.5 Explore regional hubs and/or mobile processing plants to provide access to value adding opportunities for smaller and more remote producers.

Expected Outcomes

Short term outcomes	**Medium term outcomes**	**Long term outcomes**
Existing research on processing options widely available. A minimum of one feasibility in centralised solutions and one in decentralised solutions are underway.	New processing options are being commercialised.	Melon supply chain stakeholders have access to a range of viable melon processing businesses that utilise large quantities of melon waste.

Potential Lead Agencies

- Universities
- Melons Australia
- Federal Government
- Commercial investors
- Hort Innovation

In paddock	On-farm/in-shed	Logistics	Market/DC	Retail
√	√		√	√

STRATEGY R2: Food Rescue

Increase the quantity of melons donated to food rescue organisations.

Objective: To facilitate the use of excess melons to provide food security for Australians through the network of food rescue organisations.

Actions

- R 2.1 Work with the food rescue sector and its supporters to identify, analyse and address the barriers to the increased deployment of edible, out of specification or surplus waste melons to food rescue organisations.
- R 2.2 Advocate for financial incentives, including tax incentives to offset the costs incurred by melon supply chain actors in supporting food rescue organisations.
- R 2.3 Identify a team of high-profile champions to promote the use of food rescue organisations and facilitate connections across the melon supply chain.

Expected Outcomes

Short term outcomes	**Medium term outcomes**	**Long term outcomes**
Industry champions in place. Financial incentives available to offset costs incurred in donating fruit.	Significant increase in tonnes of donated melons received by food rescue organisations.	All growers have a food rescue option for wasted or surplus crop.

Potential Lead Agencies

- End Food Waste Australia
- Food rescue organisations
- State and local governments (through circular economy policy and activity)
- Melons Australia
- Hort Innovation
- Growers and retailers

In paddock	On-farm/in-shed	Logistics	Market/DC	Retail
√	√	√	√	√

5. ROADMAP FOR MELON SECTOR ACTION PLAN

The following roadmap (Figure 8) highlights a potential journey for the melon industry to reach the 2030 target of halving Australia's horticulture food waste. Ongoing communication and support from all melon supply chain organisations, the food rescue sector, not-for-profit organisations (e.g., End Food Waste Australia) and all tiers of government are needed to ensure effective delivery of solutions to meet the 2030 target.

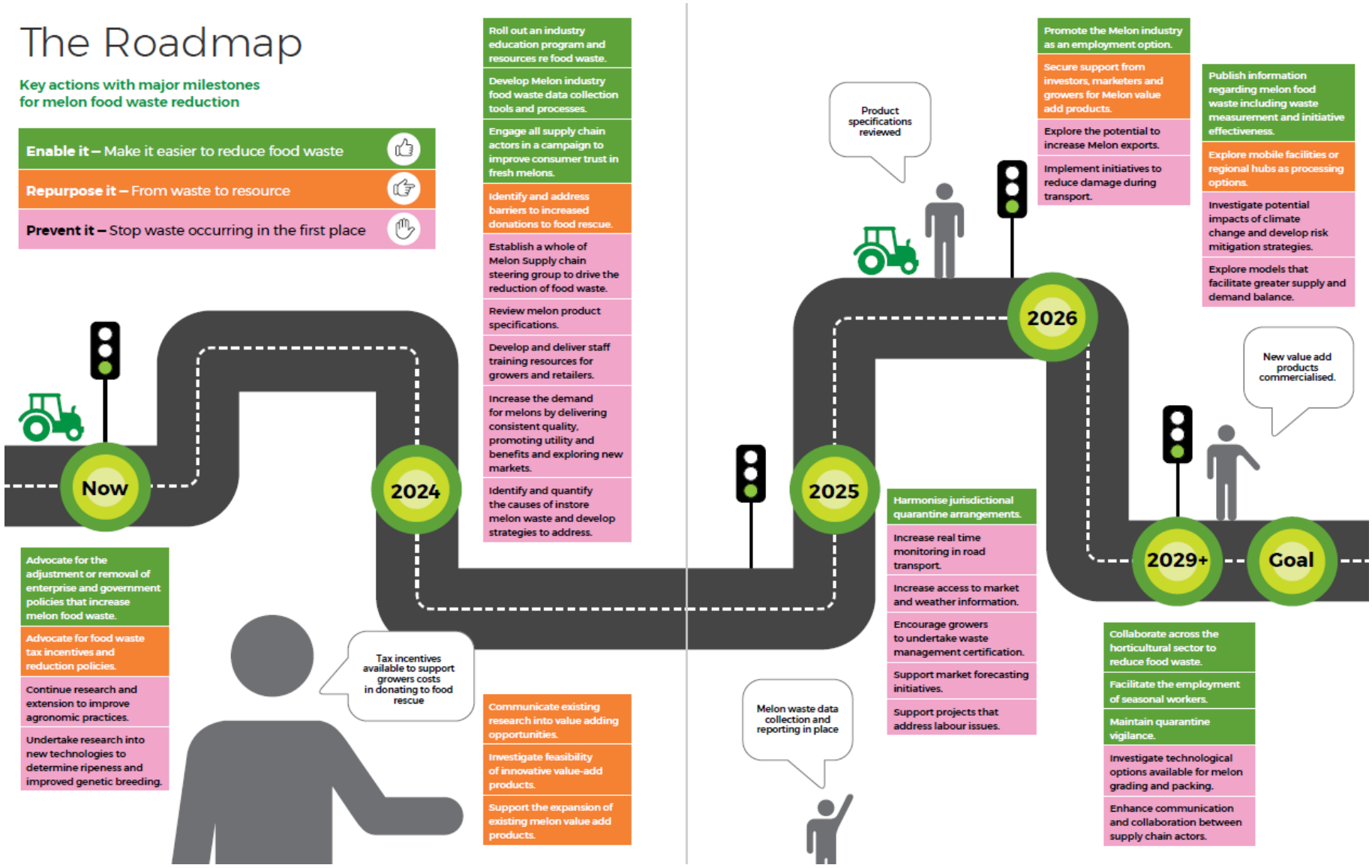

Figure 8: Melon Industry SAP for Food Waste Reduction implementation roadmap

6. MEASURING IMPACTS OF OUTCOMES

7.1 Towards a MERI Plan

Achieving food waste outcomes and impact is a complex process, involving diverse stakeholders and varied production and distribution cycles. It is important to develop a monitoring, evaluation, reporting and improvement (MERI) plan to demonstrate impact, support learning and improvement and meet accountability requirements. While the MERI Plan is not presented in this action plan, a full monitoring and evaluation plan can be developed at the outset of the implementation of this action plan. The MERI plan will incorporate the following:

- Monitoring: Continuous and systematic observation of how the programs is being implemented, the effect of strategies they are intended to address and indicators of outcomes.
- Evaluation: Evidence-based assessment impact of the programs and can include social, economic, environmental, and cultural aspects, often focusing on factors such as effectiveness, efficient, appropriateness and impact.
- Learning: Creation of knowledge and the generation of insights and information program delivery and sharing of knowledge about the lessons learned to inform future practice, policy, and program development.

Any MERI process needs to start with a theory of change.

7.2 Theory of Change

The theory of change starts with the food recovery hierarchy with the pillars of prevention, recycling, recovery and disposal. The theory of change adopted for the Melon Industry Sector Action Plan for Food Waste Reduction 2024 takes into consideration the wider context of food waste. The key elements of the theory of change are as follows:

- There is a need to take into consideration the broader context of food production and distribution systems in developing melon food waste interventions.
- Food waste can occur across the different points of the melon supply chain and will need strategic actions across different dimensions.
- Any change process will require collaboration and information sharing across diverse stakeholders.
- Knowledge and capability development for melon food waste reduction will enable well informed, proactive and innovative approaches to food waste minimisation and transformation.
- If melon food waste can be quantified, via appropriate data across the supply chain, this will enable better management of food waste.
- The scale of interventions will be at different levels, including systemic, policy/regulatory and individual/business behaviour levels. The outcomes will emerge from a combination of industry self-regulation, community behaviour change and complementary policy parameters.
- Melon food waste reduction will require effective planning, coordination and leadership.
- Melon food waste reduction can have economic, social, cultural and environmentally positive outcomes and can potentially provide strong returns on investment.

7.3 Program Logic

The program logic is a tool that sets out to show the link between resources (inputs), activities, and intended outcomes and impact.

In implementing the program logic, a systemic approach to the evaluation will be adopted. This approach encourages a critical and holistic analysis of the opportunities, constraints, and relationships of parts within a system, analysing the system/impacts within wider considerations, and, as a whole. Data collection will use diverse data sources, utilising a mixed methodology for both qualitative and quantitative data. Measuring food waste is complex, and a range of methodologies are available, such as direct measurement and weighing (volumetric assessment), material flow analysis (the way materials are used, re-used and lost), mass balance analysis (input-output assessment) and waste composition analysis (examination of waste details). Different international methodologies may be used and adapted to measure Australian melon waste. There are also analyses relating to economic value and nutritional aspects. These analyses can be applied to a single stage of the supply chain or across the whole of the chain for the melon industry. The methods of how data will be collected and analysed will form part of the MERI plan.

7.4 Indicators of Outcome and Impact

Indicators are measures that show if the outcome and impact is being achieved. They are metrics that provides information to monitor performance and measure achievement against outcomes and impacts of the intended action or activity.

Table 7: Indicators for the actions in the Melon Industry SAP for Food Waste Reduction

Strategy	Actions	Indicators
E1 Data Develop and encourage the widespread implementation of improved waste data collection and analysis tools to inform business decisions.	✓ Undertake a review of waste data collection methodologies used internationally in the melon industry (and other similar commodities) and produce recommendations for the Australian industry and supply chain. ✓ Develop or adapt melon industry specific data collection tools and processes and encourage the consistent utilisation across the supply chain. ✓ Produce a biannual report on the status of food waste in the Australian melon industry measuring and evaluating the impact of reduction initiatives.	✓ Review of data collection methodologies finalised. ✓ Tools and systems in place for data collection. ✓ Baseline data collected. ✓ Participation in data collection across the supply chain. ✓ Incentives in place to support data collection. ✓ Bi-annual reports published. ✓ Mechanisms in place to disseminate, share and utilise data and knowledge across the industry.
E2 Education Implement an education campaign and supply chain communication/ coordination activities to support the reduction of melon food waste.	✓ Develop and promote a melon industry educational campaign that highlights the level of melon food waste, the costs to the industry, the benefits to be gained by reducing food waste and encourages industry stakeholders to commit to melon food waste reduction. ✓ Develop melon food waste reduction information and resources that can be made available to supply chain actors and used to promote waste reduction activities.	✓ Number of educational activities and tools/materials shared. ✓ Standards reviewed through waste reduction lens. ✓ The level of training and information support provided to retailers to minimise food waste.

	✓ Work with other horticultural industry groups to identify and promote transferrable waste reduction techniques. ✓ Support the development of a standard for food waste that can be implemented aligned to existing melon industry standards, thus causing minimal additional cost and disruption. ✓ Identify and showcase food waste champions and innovative waste reduction strategies in the melon supply chain. ✓ Provide information and training to support retailers to display fruit attractively to increase shelf life and minimise the risk of damage/waste.	✓ Level of collaborative activities across the industry regarding food waste. ✓ Good news stories showcased.
E3 Policy Ensure that policy and regulatory settings support the melon supply chain to reduce food waste.	✓ Maintain biosecurity vigilance to prevent the incursion of new pests and diseases across international and jurisdictional borders. ✓ Review interjurisdictional biosecurity arrangements to improve harmonisation and minimise interstate transport delays. ✓ Identify enterprise and government policies that increase melon food waste or prevent value-added opportunities and advocate for their removal or adjustment.	✓ Cross-jurisdictional biosecurity. and quarantine laws reviewed and harmonised. ✓ Policy incentives to reduce food waste developed. ✓ Increasing monitoring and controls in place for disease control.
P1 Supply and demand Improve the alignment between the supply of melons and the demand.	✓ Promote the utility and health benefits of melons and deliver campaigns to drive domestic demand for melons. ✓ Explore the potential for increasing the export of Australian melons, including identifying the barriers and constraints and developing an internationally attractive value proposition. ✓ Explore new market opportunities for sale of melons in alternative formats and markets. ✓ Support current and potential melon producers to understand the operation of the market, its drivers and the implications for them. ✓ Explore strategies to improve melon growers' access to market and weather information to improve their ability to make informed decisions re. planting and harvesting. ✓ Explore models that facilitate greater balance between supply and demand, such as contract arrangements, whole crop purchase, formation of consortia of small growers and planned production.	✓ Forecasting and information tools in place and rates of utilisation. ✓ Improved awareness and understanding about food waste across the melon supply chain. ✓ Improved collaboration across the supply chain about demand and supply. ✓ Improved transparency in the market about prices and sales. ✓ Alternative sales mechanisms in place for oversupply of melons.
P2 Stronger supply chain relationships Encourage stronger relationships and enhanced	✓ Establish a whole of supply chain steering group to drive the reduction of melon food waste and support the implementation of this action plan.	✓ Formation of melon supply chain steering committee. ✓ Increasing monitoring and controls in in-store food waste.

communication across the melon supply chain in the interests of reducing food waste.	✓ Identify and quantify the causes of in-store melon waste to increase shelf life and minimise the risk of damage/waste. ✓ Establish a multistakeholder working group to review the current produce specifications and assess the effect produce specifications have on melon food waste levels. ✓ Identify and address communication and understanding differences between supply chain actors on topics, including the impact on grower payment of instore wastage and, demand triggers, supply levels, pricing mechanisms, quality standards and rejection criteria.	✓ The level of training and information support provided to retailers to minimise food waste. ✓ Formation of multi-stakeholder working group to review produce specification. ✓ Collaborative mechanisms in place to disseminate, share and utilise data, product standards and knowledge across the industry.
P3 Industry best management practice (BMP) and extension Support best practice production to decrease melon food waste due to agronomic causes and improve consumer trust in the product at market.	✓ Support research on pest and disease management and plant nutrition and encourage the adoption of new and improved ideas through BMP and extension. ✓ Undertake research, including industry-based trials on the use of technologies to determine the ripeness and quality of melons. ✓ Increase support to the melon industry and research facilities to encourage benchmarking, best practice production and innovation including the use of technology. ✓ Support research into melon breeding and varieties to address waste causes and increase crop resilience. ✓ Investigate the expected impacts of climate change on the melon industry, undertake risk assessments and develop recommendations for production. ✓ Develop a relationship with the Bureau of Meteorology (BOM) to provide training and information about climate and weather patterns that will impact melon production in both the short and long term.	✓ Improved research and extension support services to growers. ✓ Increased awareness and adoption of new and emerging technologies. ✓ Better knowledge about melon crop resilience. ✓ Evidence base developed for climate adaptation in the melon industry.
P4 Cold chain and transport Improve the transportation of melons, including through the cold food chain to minimise damage and transit times.	✓ Explore options for improving on-farm transport of melons to reduce damage. ✓ Utilise real time monitoring to track loads and to identify temperature, humidity and ride issues and implement strategies to address. ✓ Increase the development and use of alternative packaging techniques that provide better protection for melons in transit. ✓ Investigate the potential for rail transport and the impact to be gained by the upgrading of infrastructure on major road transport corridors.	✓ Efficiencies introduced as best practice into transportation of melons. ✓ Improved use of real-time monitoring to track loads and conditions of transport of melons. ✓ Adoption of innovation in packaging and ripening technologies ✓ Development and uptake of driver and other relevant staff training.

	✓ Enhance the training and supervision of long-distance truck drivers.	
P5 Labour Support the supply of appropriately skilled labour for the melon industry and the associated supply chain.	✓ Develop and distribute resources/tools to support growers to train field and shed staff efficiently and effectively. ✓ Develop and distribute resources to train and support retail staff regarding melon stock control, handling, and merchandising. ✓ Support place-based labour initiatives and national strategies and policies that facilitate a reliable supply of seasonal workers. ✓ Promote the melon industry and the range of available roles as an employment option. ✓ Encourage investment in emerging technologies that minimises the risk of human error. ✓ Support industry projects and technologies that address labour issues. ✓ Review and quantify the impact of the cost of labour on production costs and waste levels.	✓ Assessment of workforce and skill shortages on food waste across commodities and the supply chain completed. ✓ Analysis completed on potential impact of automation on melon workforce and food waste. ✓ Labour market demand and supply options for the melon industry analysed and workforce plans developed. ✓ Trials of innovative workforce supply measures. ✓ Enhanced training for staff across the supply chain to improve food waste reduction.
R1 Repurposing Increase the quantity of melons being processed and incorporated into value added products for human consumption.	✓ Produce a collation of existing national and international research into current and past melon value-adding initiatives and communicate these through a range of channels, including forums/conferences, field days and online. ✓ Assess current melon value-adding activities to identify opportunities for expansion, the barriers to be addressed and the prerequisites for expansion. ✓ Undertake feasibility studies, including a review of existing appropriate infrastructure and small-scale trials of innovative melon value-added food products, nutritional supplements and pharmaceuticals. ✓ Facilitate the collaboration of melon supply chain actors, government, private enterprise, innovators, investors and the financial sector in the development of value-add infrastructure and commercial opportunities. ✓ Explore regional hubs and/or mobile processing plants to provide access to value adding opportunities for smaller and more remote producers.	✓ Feasibility studies of melon value add completed. ✓ Options and trials of melon value added products undertaken. ✓ Secondary markets identified for melon waste value-added products. ✓ Regional and mobile processing hubs options explored and/or established to support the development of secondary products. ✓ Capacity of supply chain actors developed to undertake value added products.
R2 Food Rescue Increase the quantity of melons donated to food rescue organisations.	✓ Work with the food rescue sector and its supporters to identify, analyse and address the barriers to the increased deployment of edible, out of specification or surplus waste melons to food rescue organisations. ✓ Advocate for financial incentives, including tax incentives, to offset the costs incurred by	✓ Increase in the number of food rescue and distribution points and activities. ✓ Challenges and barriers to food rescue identified and interventions in place to address them.

	melon supply chain actors in supporting food resource organisations. ✓ Identify a team of high-profile champions who promote the use of food rescue organisations and facilitate connections across the melon supply chain.	✓ Recognition system established for melon rescue efforts. ✓ Advocacy for activities for tax incentives or rewards, and incentives in place. ✓ Education programs developed and run for food donation. ✓ Good practice showcased and shared. ✓ Number of innovative projects linking with circular economy, value add and other waste stream management initiatives.

7. CONCLUSION AND RECOMMENDATIONS

This report has presented findings about hotspots and the root causes of food waste in the Australian melon industry through a triangulation of the results gathered from the literature review, stakeholder interviews and stakeholder workshops. Ten strategies were identified, including three for the enabling environment, five supporting preventions, and two for repurposing melon food waste. Multiple actions were also listed under each of the strategies with potential outcomes in different time frames. In addition, a roadmap for the implementation of the Melon Industry SAP for Food Waste Reduction was given, outlining key actions with major milestones for melon food waste reduction through a combination of enabling, prevention and repurposing strategies.

In conclusion, by aligning production with demand, improving transportation, repurposing surplus melons and implementing supporting measures, the melon industry can contribute significantly towards reducing food waste and achieving the target of halving melon food waste by 2030. In addition to the 10 strategic action areas identified: economic, environmental and social impacts could be quantified; cost-effective and durable logistics could be explored; transportation policy and network development could be undertaken; production and market risk could be assessed; and the role of uncertainty management could be investigated.

References

Adepoju, A. O., & Ologan, O. (2021). Post-harvest loss along the watermelon value chain in the tropics. *International Journal of Vegetable Science*, *27*(5), 461-471. https://doi.org/10.1080/19315260.2020.1848961

AFCCC. (2022). *Australian cold food code Part 2a: Guiding principles of fresh produce transport in the Australian cold chain – Product specifications*. https://afccc.org.au/cold-food-codes.html

AFGC. (2017). *Australian cold chain guidelines 2017*. https://www.afgc.org.au/wp-content/uploads/2019/07/Australian-Cold-Chain-Guidelines-2017.pdf, accessed on February 2024.

Agrifutures. (2016). *Transformative technologies internet of things - A fact sheet series on new and emerging transformative technologies in Australian agriculture*. The Rural Industries Research & Development Corporation (RIRDC). https://agrifutures.com.au/wp-content/uploads/publications/16-039.pdf

Allu, R., & Belavina, E. (2020). *Contractual terms for reducing food waste - Possibilities and potentials within fresh grocery supply chains*. https://www.theconsumergoodsforum.com/wp-content/uploads/ECR-Report-2020-v4.pdf

Ambiel, C., Adell, A., Sanguansri, P., Krause, D., Gamage, T., & Juliano, R. G.-F. a. P. (2019). *Mapping of Australian fruit and vegetable losses preretail*. CSIRO, Australia.https://www.csiro.au/en/research/production/food/mapping-horticultural-food-loss, accessed on February 2024.

Arcadis. (2019) *National food waste baseline – Final assessment report*. AGNESP, Canberra. https://www.dcceew.gov.au/sites/default/files/env/pages/25e36a8c-3a9c-487c-a9cb-

Australian Bureau of Statistics (ABS). (2020-2021). *Agricultural commodities*. https://www.abs.gov.au/statistics/industry/agriculture/agricultural-commodities-australia/latest-release

Australian Bureau of Statistics (ABS). (2022). *Price index theory*. https://www.abs.gov.au/statistics/detailed-methodology-information/concepts-sources-methods/producer-and-international-trade-price-indexes-concepts-sources-and-methods/2022/chapter-3-technical-methodology/price-index-theory., accessed on February 2024.

Australian Government. (2017). *National food waste strategy: Halving Australia's food waste by 2030*. Commonwealth of Australia. https://www.fial.com.au/sharing-knowledge/food-waste

Bartezzaghi, G., Cattani, A., Garrone, P., Melacini, M., & Perego, A. (2022). Food waste causes in fruit and vegetables supply chains. *Transportation Research Procedia*, *67*, 118-130. https://doi.org/https://doi.org/10.1016/j.trpro.2022.12.042

Barthel, M., Fava, J., James, K., Hardwick, A., & Khan, S. (2017). *Hotspots analysis: An overarching methodological framework and guidance for product and sector level application*. Economy Division of UNEP & WRAP. https://www.lifecycleinitiative.org/new-hotspots-analysis-methodological-framework-and-guidance/

Beausang C., Hall C., & Toma L. (2017), Food waste and losses in primary production: Qualitative insights from horticulture. *Resources, Conservation and Recycling Volume, 126*, 127-185 https://doi.org/https://doi.org/10.1016/j.resconrec.2017.07.042

Benyam, A., Soma, T., & Fraser, E. (2021). Digital agricultural technologies for food loss and waste prevention and reduction: Global trends, adoption opportunities and barriers. *Journal of Cleaner Production*, *323*, 129099. https://doi.org/https://doi.org/10.1016/j.jclepro.2021.129099

Brodribb, P., & McCann, M. (2020). *A study of waste in the cold food chain and opportunities for improvement*. https://www.agriculture.gov.au/sites/default/files/documents/study-of-waste-in-cold-food-chain-and-opportunities-improvement.pdf, accessed on February 2024.

CFA. (2013). *The cool farm tool (CFT) - Greenhouse gas emissions calculator*. Cool Farm Alliance. https://coolfarmtool.org/coolfarmtool/greenhouse-gases/

CFA. (2016). *The cool farm tool (CFT) - Biodiversity tool*. Cool Farm Alliance (CFA). https://coolfarmtool.org/coolfarmtool/biodiversity/

CFA. (2017). *The cool farm tool (CFT) - Water metrics*. Cool Farm Alliance (CFA). https://coolfarmtool.org/coolfarmtool/water/

Chomicki, G., Schaefer, H., & Renner, S. S. (2020). Origin and domestication of Cucurbitaceae crops: insights from phylogenies, genomics and archaeology. *New Phytologist*, *226*(5), 1240-1255. https://doi.org/https://doi.org/10.1111/nph.16015

Commission of Environmental Cooperation (CEC). (2021). *Why and how to measure food loss and waste: A practical guide - Version 2.0.* Montreal, Canada: Commission for Environmental Cooperation. http://www.cec.org/media/media-releases/why-and-how-to-measure-food-loss-and-waste-a-practical-guide-2-0/, accessed on February 2024.

de Hooge, I. E., van Dulm, E., & van Trijp, H. C. M. (2018). Cosmetic specifications in the food waste issue: Supply chain considerations and practices concerning suboptimal food products. *Journal of Cleaner Production, 183*, 698-709. https://doi.org/https://doi.org/10.1016/j.jclepro.2018.02.132

Dongmei, W., Huxiang, G., & Ziyou, B. (2013). Effect investigation of relative humidity and temperature on multi-layer corrugated sandwich structures. *Journal of Sandwich Structures & Materials*, *15*(2), 156-167. https://doi.org/10.1177/1099636212463834

Downham, R. (2022), *Crop loss/waste on Australian horticulture farms 2021–22,* ABARES, Research Report. DAFF, Canberra. https://www.agriculture.gov.au/abares/research-topics/surveys/horticulture-crop-loss#daff-page-main, accessed on February 2024.

Dunning, R. D., Johnson, L. K., & Boys, K. A. (2019 - Quarter 1). Putting dollars to waste: Estimating the value of on-farm food loss. *Choices*, *34*(1). https://www.choicesmagazine.org/choices-magazine/theme-articles/examining-food-loss-and-food-waste-in-the-united-states/putting-dollars-to-waste-estimating-the-value-of-on-farm-food-loss

Ekman, J., Goldwater, A., & Winley, E. (2016). *Postharvest management of vegetables: Australian supply chain handbook*. Horticulture Innovation Australia Limited (Hort Innovation). https://www.melonsaustralia.org.au/wp-content/uploads/2018/12/Postharvest_Vegetable_Book.pdf, accessed on February 2024.

European Commission. (2007). Council Regulation (EC) No 1234/2007 of 22 October 2007 establishing a common organisation of agricultural markets and on specific provisions for certain agricultural products (Single CMO Regulation). *Official Journal of the European Union*, *L 299*, 1-149.

Fabi, C., & English, A. (2018). *SDG 12.3.1: Global food loss index*. Food and Agricultural Organisation of the United Nations. https://sdg12hub.org/sites/default/files/2021-06/ca2640en.pdf, accessed on February 2024.

FAO. (2014). Food loss and assessments causes and solutions - Case studies in small-scale agriculture and fisheries subsectors: Kenya - Banana, maize, milk, fish. https://www.fao.org/fishery/en/publications/82655, accessed on February 2024.

FAO. (2018). *Food loss analysis case study methodology*. https://elearning.fao.org/course/view.php?id=374, accessed on February 2024.

Feedback & the Rockfeller Foundation, (2017). Causes of food waste in international supply chains. London: Feedback and the Rockfeller Foundation. England. https://feedbackglobal.org/wp-content/uploads/2017/02/Causes-of-food-waste-in-international-supply-chains.pdf, accessed on February 2024.

Fernández-Trujillo, J. P., Lester, G. E., Dos-Santos, N., Martínez, J. A., Esteva, J., Jifon, J. L., & Varó, P. (2013). Pre- and postharvest muskmelon fruit cracking: Causes and potential remedies. *HortTechnology hortte*, *23*(3), 266-275. https://doi.org/10.21273/HORTTECH.23.3.266.

FIAL. (2020a). *Resources for implementing the National Food Waste Strategy*. Department of Climate Change Energy the Environment and Water (DCCEEW). https://www.dcceew.gov.au/environment/protection/waste/publications/resources-implementing-national-food-waste-strategy

FIAL. (2020b). *A roadmap for reducing Australia's food waste by half by 2030*. Department of Climate Change Energy the Environment and Water (DCCEEW). https://www.dcceew.gov.au/environment/protection/waste/publications/roadmap-reducing-food-waste

FIAL. (2021a). *National food waste strategy feasibility study - Appendices*. https://www.fial.com.au/sharing-knowledge/food-waste#Dashboard

FIAL. (2021b). *The national food waste strategy feasibility study - final report*. https://www.fial.com.au/sharing-knowledge/food-waste#Dashboard

Filimonau, V., & Ermolaev, V. A. (2021). Mitigation of food loss and waste in primary production of a transition economy via stakeholder collaboration: A perspective of independent farmers in Russia. *Sustainable Production and Consumption*, *28*, 359-370. https://doi.org/https://doi.org/10.1016/j.spc.2021.06.002

FLW Protocol Steering Committee and Authors. (2016). *Food loss and waste accounting and reporting standard - Version 1.0*. The Food Loss & Waste Protocol (FLW Protocol). https://flwprotocol.org/

Food Innovation Australia Ltd (FIAL). (2019a*). A roadmap for reducing Australia's food waste by half by 2030*.

Food Innovation Australia Ltd (FIAL). (2019b), *Resources for Implementing the national food waste strategy.*

Food Innovation Australia Ltd (FIAL). (2021). *The national food waste strategy feasibility study, can we halve Australia's food waste by 2030?*

Frese, M., Krauss, S. I., Keith, N., Escher, S., Grabarkiewicz, R., Luneng, S. T., Heers, C., Unger, J., & Friedrich, C. (2007). Business owners' action planning and its relationship to business success in three African countries. *Journal of Applied Psycho*logy, *92*(6), 1481-1498. https://doi.org/10.1037/0021-9010.92.6.1481

Freshlogic Analytics. (2022). Australian horticultural statistics handbook (database, 2013-2021)- The nation's most comprehensive source of Australian horticulture data. https://public.tableau.com/views/AustralianHorticultureStatisticsHandbookFY21/Fruit?:language=eUS&:embed=y&:embed_code_version=3&:loadOrderID=0&:display_count=y&publish=yes&:origin=viz_share_link

Gardas, B. B., Raut, R. D., & Narkhede, B. (2018). Evaluating critical causal factors for post-harvest losses (PHL) in the fruit and vegetables supply chain in India using the DEMATEL approach. *Journal of Cleaner Production*, *199*, 47-61. https://doi.org/https://doi.org/10.1016/j.jclepro.2018.07.153

Grinberga-Zalite, G., & Zvirbule, A. (2022). Analysis of waste minimization challenges to European food production enterprises. *Emerging Science Journal*, *6*(3), 530-543. https://doi.org/http://dx.doi.org/10.28991/ESJ-2022-06-03-08

Hanson, C., Lipinski, B., Robertson, K., Dias, D., Gavilan, I., Gréverath, P., Ritter, S., Fonseca, J., VanOtterdijk, R., Timmermans, T., Lomax, J., O'Connor, C., Dawe, A., Swannell, R., Berger, V., Reddy, M., Somogyi, D., Tran, B., Leach, B., & Quested, T. (2016). *Food loss and waste accounting and reporting standard, Version 1.0*. https://www.wri.org/research/food-loss-and-waste-accounting-and-reporting-standard

Hassoun, A., Kamiloglu, S., Garcia-Garcia, G., Parra-López, C., Trollman, H., Jagtap, S., Aadil, R. M., & Esatbeyoglu, T. (2023). Implementation of relevant fourth industrial revolution innovations across the supply chain of fruits and vegetables: A short update on Traceability 4.0. *Food Chemistry*, *409*, 135303. https://doi.org/https://doi.org/10.1016/j.foodchem.2022.135303

Herzberg, R., Schmidt, T., & Keck, M. (2022). Market power and food loss at the producer-retailer interface of fruit and vegetable supply chains in Germany. *Sustainability Science*, *17*(6), 2253-2267. https://doi.org/10.1007/s11625-021-01083-x

Hoehn, D., Vázquez-Rowe, I., Kahhat, R., Margallo, M., Laso, J., Fernández-Ríos, A., Ruiz-Salmón, I., & Aldaco, R. (2023). A critical review on food loss and waste quantification approaches: Is there a need to develop alternatives beyond the currently widespread pathways? *Resources, Conservation and Recycling*, *188*, 106671. https://doi.org/https://doi.org/10.1016/j.resconrec.2022.106671

Hort Innovation Australia (HIA). (2023). *Australian horticulture statistics handbook 2021/22*. Hort Innovation, Sydney.

Ishangulyyev, R., Kim, S., & Lee, S. H. (2019). Understanding food loss and waste—Why are we losing and wasting food? *Foods*, *8*(8). https://doi.org/10.3390/foods8080297

Ismael, R. K. (2023). Quantification of food waste in retail operations: A fruit and vegetable wastage case in Paraguay. *Environmental Challenges*, *10*, 100665. https://doi.org/https://doi.org/10.1016/j.envc.2022.100665

Jagdish. (2022). Top 20 steps to boost watermelon yield: How to increase fruit size, quality, and production. Agri Farming. https://www.agrifarming.in/top-20-steps-to-boost-watermelon-yield-how-to-increase-fruit-size-quality-and-production

Johnson, L. K., Dunning, R. D., Bloom, J. D., Gunter, C. C., Boyette, M. D., & Creamer, N. G. (2018). Estimating on-farm food loss at the field level: A methodology and applied case study on a North Carolina farm. *Resources, Conservation and Recycling*, *137*, 243-250. https://doi.org/https://doi.org/10.1016/j.resconrec.2018.05.017

Johnson, L., & Dunnin, R. (2019). *Turn field losses into profits*. Lisa K Johnson Consulting. https://cefs.ncsu.edu/wp-content/uploads/Vegetable-and-Specialty-Crop-News-April-2019.pdf?x47549, accessed on February 2023.

Kerzberg, R., Trebbin, A., and Schneider, F., 2023, Product specifications and business practices as food loss drivers – A case study of a retailer's upstream fruit and vegetable supply chains , Journal of Cleaner Production, 471 (2023) 137940 https://doi.org/10.1016/j.jclepro.2023.137940

KPMG. (2020). A national food waste tax incentive: Boosting food relief through Australia's tax system. https://kpmg.com/au/en/home/insights/2020/09/food-relief-australia-tax-system.html

KPMG. (2022). Australian National Food Donation Tax Incentive (NFDTI) Implementation Analysis. https://kpmg.com/au/en/home/insights/2022/11/food-donation-tax-incentive-australia-reduce-food-waste.html

Ledger, S. (2007). *Improving melon supply chain handling systems*. Horticultural Australia Ltd (HAL). https://www.horticulture.com.au/globalassets/hort-innovation/historic-reports/improving-melon-supply-chain-handling-systems-vx04001.pdf

Lewis, H., Downes, J., Verghese, K., Young, G., Florin, N., & McKenna, K. (2017). *Food waste opportunities within the food wholesale and retail sectors*. https://www.uts.edu.au/isf/news/finding-ways-reduce-food-waste-within-supply-chain

Lipinski, B., Hanson, C., Waite, R., Searchinger, T., & Lomax, J. (2013). *Reducing food loss and waste - Creating a sustainable food future, installment two - Working paper*. World Resources Institute (WRI). https://www.wri.org/research/reducing-food-loss-and-waste

Loebnitz, N., Schuitema, G., & Grunert, K. G. (2015). Who buys oddly shaped food and why? Impacts of food shape abnormality and organic labeling on purchase intentions. *Psychology & Marketing*, *32*(4), 408-421. https://doi.org/https://doi.org/10.1002/mar.20788

Magalhães, V. S. M., Ferreira, L. M. D. F., & Silva, C. (2022). Prioritising food loss and waste mitigation strategies in the fruit and vegetable supply chain: A multi-criteria approach. *Sustainable Production and Consumption, 31*, 569-581. https://doi.org/https://doi.org/10.1016/j.spc.2022.03.022

McKenzie, T.J., Singh-Peterson, L., & Underhill, S.J.R. (2017). Quantifying postharvest loss and the implication of market-based decisions: A case study of two commercial domestic tomato supply chains in Queensland, Australia. *Horticulturae*, *3*(44), 1-15.

Melons Australia. (nd.). *Australian melons – Growing regions*. https://www.melonsaustralia.org.au/consumer/growing-regions.

Messner, R., Johnson, H., & Richards, C. (2021). From surplus-to-waste: A study of systemic overproduction, surplus and food waste in horticultural supply chains. *Journal of Cleaner Production*, *278*, 123952. https://doi.org/https://doi.org/10.1016/j.jclepro.2020.123952

Mohammadi, H., Ghazanfari, M., Pishvaee, M. S., & Teimoury, E. (2019). Fresh-product supply chain coordination and waste reduction using a revenue-and-preservation-technology-investment-sharing contract: A real-life case study. *Journal of Cleaner Production*, *213*, 262-282. https://doi.org/https://doi.org/10.1016/j.jclepro.2018.12.120

Møller, H., Hansen, O. J., Svanes, E., Hartikainen, H., Silvennoinen, K., Gustavsson, J., et al. (2014), *Standard approach on quantitative techniques to be used to estimate food waste levels*. Project report FUSIONS.

Moragues-Faus, A., Sonnino, R., & Marsden, T. (2017). Exploring European food system vulnerabilities: Towards integrated food security governance. *Environmental Science & Policy*, *75*, 184-215.

NationMaster. (2022). *Top countries in melons production*. https://www.nationmaster.com/nmx/ranking/melons-production

Pereira, A. S., Santos, G. R. d., Sarmento, R. A., Galdino, T. V. d. S., Lima, C. H. d. O., & Picanço, M. C. (2017). Key factors affecting watermelon yield loss in different growing seasons. *Scientia Horticulturae*, *218*, 205-212. https://doi.org/10.1016/j.scienta.2017.02.030

Sadrnia, H., Rajabipour, A., Jafari, A., Javadi, A., Mostofi, Y., Kafashan, J., Dintwa, E., & De Baerdemaeker, J. (2008). Internal bruising prediction in watermelon compression using nonlinear models. *Journal of Food Engineering*, *86*(2), 272-280. https://doi.org/https://doi.org/10.1016/j.jfoodeng.2007.10.007

Schmickl, T., & Crailsheim, K. (2002). How honeybees (*Apis mellifera L*.) change their broodcare behaviour in response to non-foraging conditions and poor pollen conditions. *Behavioral Ecology and Sociobiology*, *51*(5), 415-425. https://doi.org/10.1007/s00265-002-0457-3

SFWA. (2021). *Our vision for halving food waste: Our 2021-2025 strategic plan.* Stop Food Waste Australia (SFWA). https://www.stopfoodwaste.com.au/wp-content/uploads/2021/09/SFWA-strategic-plan-final.pdf

Shahbazi, F., Rajabipour, A., Mohtasebi, S., & Rafie, S. (2010). Simulated in-transit vibration damage to watermelons. *Journal of Agricultural Science and Technology*, *12*(1), 23-34.

Singh, S. P. (2019). *Melon food safety: A best practice guide for rockmelons and specialty melons*. NSW Department of Primary Industries (NSW DPI). https://www.dpi.nsw.gov.au/__data/assets/pdf_file/0020/1179011/Melon-food-safety-best-practice-guide.pdf

Singh, S. P. (2021a). *Food safety training, extension and capacity for the melon industry – Phase 2 (VM18003).* Hort Innovation. https://www.horticulture.com.au/growers/help-your-business-grow/research-reports-publications-fact-sheets-and-more/vm18003/

Singh, S. P. (2021b). *Watermelon food safety: A best practice guide and toolbox*. The NSW Department of Primary Industries. https://www.horticulture.com.au/growers/help-your-business-grow/research-reports-publications-fact-sheets-and-more/Watermelon-food-safety-A-best-practice-guide-and-toolbox/

Singh, S. P. S., Khan, Z., Warren-Smith, A., & Strojny, K. (2021). *Watermelon food safety - A best practice guide and toolbox.* https://www.horticulture.com.au/globalassets/hort-innovation/resource-assets/vm18003-watermelon-food-safety-guide.pdf

SISC. (2013). *Working Metrics 1.0*. The Stewardship Index for Specialty Crops (SISC). https://www.stewardshipindex.org/working-metrics

Stop Food Waste Australia (SFWA). (2023). *Sector action plans: Working together to reduce food loss and waste* (unpublished manuscript).

Tesoriero, L., & Watson, A. (2016). *Major diseases of melons in Australia*, Australian Melon Association (AMA). file:///C:/Users/akbard/Downloads/Major-melon_diseases_in_Australia.pdf

The Australian Melon Association (AMA). (n.d.) *Melons Australia: Main melon varieties in Australia*. https://www.melonsaustralia.org.au/about/

The Parliament of the Commonwealth of Australia. (2022). Treasury Laws Amendment (More Competition, Better Prices) Bill 2022, Canberra, Australian Government. https://www.legislation.gov.au/Details/C2022A00054

WRAP. (2015). Food Futures. https://wrap.org.uk/resources/report/food-futures

WRAP. (2020). Whole chain food waste reduction plan toolkit. The Waste and Resources Action Programme (WRAP). Retrieved 27/12/2022 from https://wrap.org.uk/resources/tool/whole-chain-food-waste-reduction-plan-toolkit.

WRAP. (2022). The Courtauld Commitment 2030: Progress and Insights Report 2022. https://wrap.org.uk/resources/report/courtauld-commitment-2030-progress-and-insights-report-2022

WRAP, & IGD. (2022). The Food Waste Reduction Roadmap Progress Report 2022. (Prepared by Darren Smillie, Rachel Devine, Elaine Charlesworth and Sue Riley). https://wrap.org.uk/resources/report/food-waste-reduction-roadmap-progress-report-2022

WWF & SISC. (2022). *Food loss metric guide*. https://www.stewardshipindex.org/working-metrics

WWF. (2018). *Summary report: No food left behind: Underutilized produce ripe for alternative markets*. https://www.worldwildlife.org/pages/no-food-left-behind

WWF. (2020). 5 holistic approaches to tackling on-farm food loss - No food left behind. https://files.worldwildlife.org/wwfcmsprod/files/Publication/file/5yhb2r0l34_NFLB_Virtual_Convening_2020_Synthesis_FINAL.pdf

Yahia, E. M. (2019), Introduction. In E. M. Yahia (Ed.), *Postharvest technology of perishable horticultural commodities* (pp. 1-41). Woodhead Publishing.

Appendices

Appendix 1. Literature review for melon industry SAP for food waste reduction: Key findings

1. Defining food loss/waste

1.1 Key attributes of food loss analysis

When a food loss (waste) analysis (FLA) is performed it looks for the hot spots, the prioritised problems to seek solutions and the key intervening factors that contributes to the food loss and waste (FLW) issues in the food supply chain (FSC). It is imperative to understand the stages of the FSC for selected F&V commodity to categorise their causes of food loss which would help to identify the hot spots (also known as critical loss points (CLP)). The hotspots are termed as the level of greatest accumulated loss in both quantitative and qualitative losses along with the economic impact to the relevant stakeholders (FAO, 2018). A food loss analysis (FLA) is the methodological framework to gather and understand the information on food losses for a selected FSC of a certain geographical area (i.e., global, regional, country specific, any designated area within a country) (FAO, 2014, 2018).

The primary output of a food loss analysis is a food loss reduction strategy, which is a specific plan for reducing and preventing losses. It also contributes to policy recommendations. The key attributes of a FLA are as follows (FAO, 2018):

- Focuses on a single food commodity at a time to produce detailed list of outputs along the FSC of that food.
- Collects both quantitative and qualitative data from the FSC of the selected food.
- Considers the whole system (i.e., the FSC, social, cultural, environmental, economic, and demographical issues) as input to produce the impact on the FLA outputs in each of the sectors.
- FLA can identify the indicative quantity and intensity of the loss, the causes which make the loss, and exactly direct towards the required activities where efforts should be made to improve the situation and reduce the food loss along the FSC.

The FLA leads to the development of goal-oriented food loss reduction strategy based on the given inputs from whole systems and provide the output based on the methodological analysis approach. Figure A1.1 shows the schematic presentation of input data collection from various sources, purpose-driven analysis, and the directive uses of the primary output of the FLA.

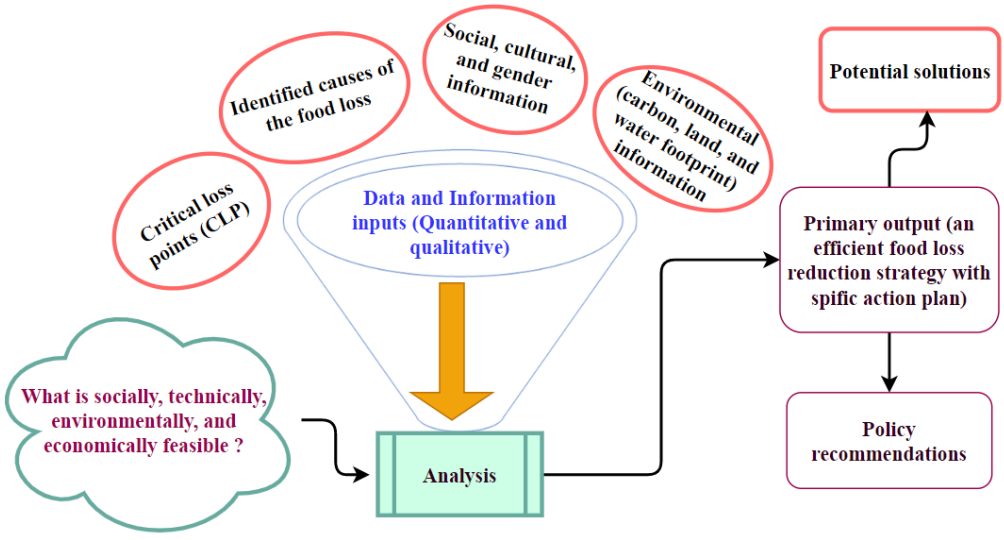

Figure A1.1 Generalised food loss analysis procedure (FAO, 2018)

1.2 Reasons and benefits of conducting food loss analysis

There are three main reasons for conducting food loss analyses (FAO, 2018):

1. To identify the causes of food losses, hotspots, and to determine feasibility of solutions to reduce them.
2. To provide inputs for monitoring and evaluation (programme accountability)
3. To provide inputs for impact assessment

The benefit of conducting a food loss analysis:

- To identify the causes of food losses, the critical loss points, and to determine feasibility of solutions to reduce them.
- A single food loss analysis is valuable in that it reveals the priority intervention areas for the food supply chain being studied.
- The data and information, it generates, can be used to decide on context specific multi stakeholder interventions.
- Additionally, the knowledge generated can be shared with other stakeholders either within the same food supply chain or elsewhere (in similar contexts or adjusted as needed).

2. Overview of melon production and safe handling

2.1 Australian melon production

Melons are one of the species which belong to the Cucurbitaceae family and are botanically a pepo type berry fruit (Chomicki et al., 2020). As per Australian Melon Association (AMA), there are three main types of melon fruits, namely - Rockmelon (Cantaloupe), Honeydew, and Watermelon produced in Australia (The Australian Melon Association (AMA)). The melon production supply chain categorises all the produced melons in Australia into two categories, Watermelon and Muskmelon (Rockmelon, Honeydew, and other varieties are categorised as muskmelon in Australia) to present statistical data of melon industries (Freshlogic, 2022). Global total melon production has reported to be more than 27.5 M tonnes in the year 2019 of which about 50% was produced in China and 0.75% in Australia (about 0.202 M tonnes) (NationMaster, 2022). Australian melon production capacity was ranked 18th in the world. About 10% reduction in the production volume was observed in that year than that of the previous year in Australia.

2.2 Safe handling of melons

The Australian melon industry supplies watermelons, and muskmelons (i.e., varieties of rockmelons, honeydew melons and other specialty melons) for the domestic market. Consumers may experience safety hazards (food-borne pathogen contamination) if the melons are unsafe due to mishandling. The supply chain stages for the watermelons and muskmelons are almost similar regarding food safety risk control measurements. But the postharvest handling can be different based on either washing and sanitising the fruits in the packinghouse or packing in the field after cleaning (washing/wiping) (Singh, 2019, 2021a, 2021b). Currently, the Australian general industry practice is to clean the muskmelons by washing and sanitising. In case of watermelons, a few of the growers undertake postharvest washing, brushing, and sanitising, but most of the growers just clean/wipe them after harvesting, then grade them to pack in the field for next stage activities of the supply chain system. When the fruit is not cleaned/sanitised a risk of, microbial contamination exists which could impact other fruit and result in increased food wastage. Pre-harvesting stages: Mishandling in any substages of the production or pre-harvesting activities may result in the melons becoming inedible, thus bringing loss to the growers and suppliers.

- Harvesting and Post-harvest stages: Personal hygiene could be one of primary factors to contaminate the melon fruits as there are more of the manual activities during the harvesting period. Harvesting mature melon fruits, handling, cleaning, and packing activities need to be according to the best practice guides (Singh, 2019, 2021a, 2021b) to avoid microbial contamination and damages to the fruit to avoid fruit loss and wastage.
- Transport and Distribution: Melons are transported several times throughout their supply chain stages. Effective loading, unloading, transportation stacking, temperature controlling, and packing

guidelines are required for the melons in each step of the transportation and distribution chain (Singh, 2019, 2021a, 2021b).

- Retail Market: The retailers and wholesalers need to follow standard handling and storing activities of the melons. The shelf life for melons (watermelons and muskmelons) improves when stored below 5°C (Singh, 2019, 2021b). When the cut fruit is sold, proper hygiene and measures of cross-contamination are required to avoid quality loss and food-borne illness to the customers.

3. Overview of food loss and waste quantification across the food supply chain

3.1 Types and causes

While physical volume of food loss is part of the problem, loss of nutritional and market value is of equal importance. Food loss occurs in all global regions - although food loss levels are higher in developed regions, losses in developing countries are significant (FAO, 2018; Malhotra, 2019). When food is lost or wasted the energy and resource inputs which went into its production are also wasted. Therefore, the loss of food can be classified as quantitative, qualitative, and economic as presented in Figure A1.2 (FAO, 2018).

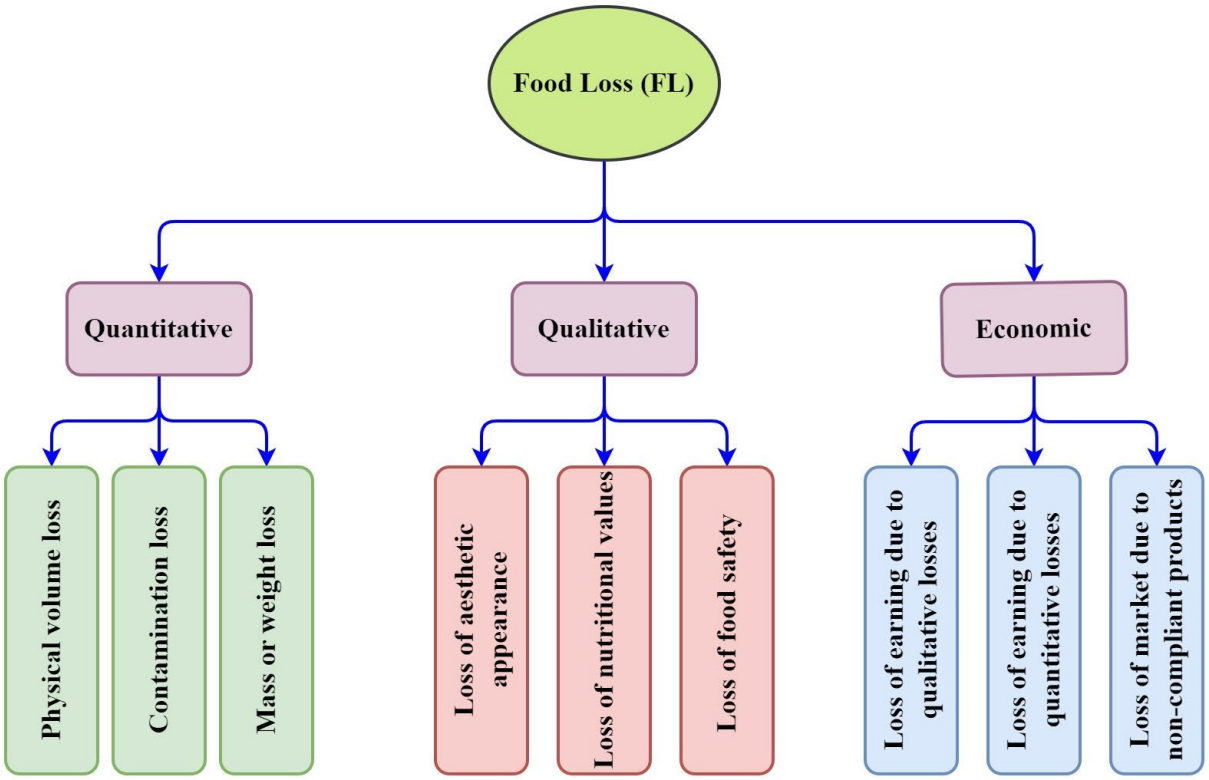

Figure A1.2 Types of food losses (FAO, 2018)

Table A1.1 (Ishangulyyev et al., 2019) briefly presents the common causes of FLW in various stages of the FSC. It looks like that the causes are almost similar and require high level remedial activities to resolve the issues. These causes are also enhanced if there is poor accessibility to the high quality (i.e., drought and pest resistant) seeds, insufficient public sector support, inefficient managerial action plan, and unavailability of the consumers' approach towards the quality of the food.

Table A1.1 Possible causes of FLW (extracted from review work of Ishangulyyev et al. (2019))

Stage	Possible Causes of FLW
Production Stage	- Infrastructural limitation - Over Production - Harvesting timing - Harvesting method (mechanical versus manual) - Pesticides and fertilizers - Economic problems - Quality Standards - Choice of variety
Handling and Storage Stage	- Degradation and spillage according to product characteristics - Transportation from farm to distribution - Storage infrastructure
Processing and Packaging Stage	- Unavoidable losses - Technical inefficiencies and malfunctions - Methods and changes in processing lines - Contamination in processing lines - Legislation restrictions - Packaging system - Overproduction
Distribution and Marketing Stage	- Inappropriate conveyance conditions (temperature-controlled aircrafts and ships) - Contamination of transportation - Transportation and market facilities - Road and distribution vehicles - Business Rule - Packaging management - Commercial conditions - Consumer Reference

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Regardless of the methodologies adopted for analysing the FLW there requires framework to progress towards the analysis by following a set of working steps (Table A1.2). The FLW protocol and approaches can help to develop the framework for the desired fruit commodities. Ambiel et al. (2019) adopted the FLW framework provided by Hanson et al. (Hanson et al., 2016) in the “Food loss and waste accounting and reporting standard” (FLW Protocol Steering Committee and Authors, 2016) (Table A1.2).

Table A1.2 FLW assessment framework Approach adopted by Ambiel et al. (2019)

FLW Steps	Approach adopted by Ambiel et al. (2019)
Define goals	To quantify and map the extent of fruits and vegetable losses in the Australia horticulture supply chains, including losses undergone on farm, in packing houses and during processing for the purposes to aid in the implementation strategies for enhancing horticultural supply chain sustainability by reducing and adding value to FLW.
Review accounting and reporting principles	To the extent feasible, our research adheres to the accounting and reporting principles: relevance, completeness, consistency, transparency, and accuracy. Limitations are considered in the discussion section and results are checked against other reports for consistency.
Establish scope	Timeframe: Survey from 2017 growing season plus supplemental references. Material type: Edible fresh fruits, vegetables and unharvested parts as defined by farmers.

	Data obtained from other reports, references and ABS information were used to estimate, validate survey data, and fill any missing data gap. Destination: Survey data to identify type and final usage of lost F&V including percent reported where available. Boundaries: • Food category: The Codex General Standard for Food Additives (GSFA 2018) online covering fresh fruits (04.1.1) and fresh vegetables (04.1.1) • Life cycle stage: Primary production, packaging, processing, transport, and distribution up to retail only. • Geography: Growing regions in Australia according to ABS information. • Organization: Several farms were surveyed, and extrapolated results based on average loss and ABS production statistics and other published literature.
Decide how to quantify FLW	Loss data was reported on a national and state basis, where sufficient coverage was reached the regions of food losses were also identified and reported.
Gather and analyse data	The information has been compiled by means of a survey and complemented with pre-existing literature sources.
Calculate inventory results	Results were based on weighted average of survey data or estimate based on existing references.
Assess uncertainty	We compare our data with available information reported in literature both domestically and internationally.
Report FLW inventory	Report of FLW by commodity, commodity type and region are detailed in main report and appendices.
Exclusions	Further loss characterisation and quantification, including out-of-spec 'ugly' produce or actual parts left in field, as well as by-products obtained in packing houses or during processing, must be carried out regionally following this work.

4. Hotspot analysis

4.1 Hotspot categorisation

A sustainable food future is only possible when there will be least amount of food loss and food waste across the food value chain. About 42% and 25% of the total share of food available are lost or wastes in North America and Oceania respectively (Lipinski et al., 2013). Reducing FLW quantity by 50% will ensure huge social, economic, and environmental benefits along with serving more food to the hungry people from the same food production capacities. Therefore, the hotspot analysis (Figure A1.3) along with the FLA is essential to identify prioritised action plans and solutions across the desired FSC stages. the hotspot analysis comprises both qualitative and quantitative data categories from various sources to offer potential solutions on the identified actors of the FSC and thus allocate resources to effectively accomplish the action plans (Barthel et al., 2017). The UNEP has developed a methodological framework to conduct hotspot analysis though which the outputs are expected to be usable, transparent on purposes, supported by robust analysis for decisions, inclusive, and comprehensive (Barthel et al., 2017).

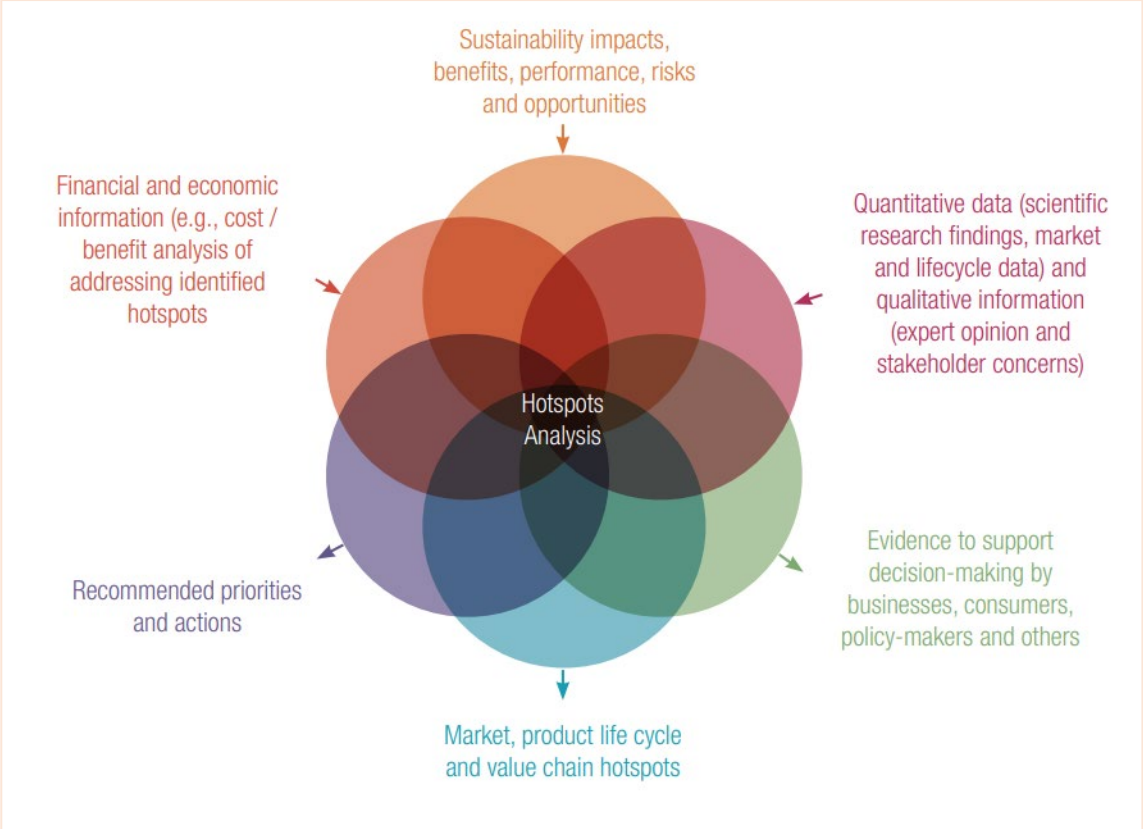

Figure A1.3 Applications of the hotspot analysis (Barthel et al., 2017)

The generalised process steps (Barthel et al., 2017) of the methodological frameworks containing 8 steps along with provisions for iterations to quickly fix any issue and produce reliable outputs. These steps are, (i) Defile goal & scope, (ii) Gather data and seek expert advice, (iii) Identify and validate the hotspots, (iv) Respond to data and stakeholder gaps (during any meeting with working group), (v) Identify and prioritise actions, (vi) Review and validate initial findings with key stakeholders and experts, (vii) Disseminate findings, (viii) Review, revisit the hotspots analysis, and update accordingly.

A recent study (FIAL, 2021) on Australian national food waste strategy has used the UNEP hotspot identification approaches (Barthel et al., 2017) for waste generated in the year 2018-2019 from 18 food commodities in Australia. The categorisations of waste are shown in the Figure A1.4.

Hotspot A life cycle stage whose contribution to the impact category is greater than even distribution of that impact across the life cycle stages.	**Warmspot** A life cycle stage whose contribution is approximately equivalent to an even distribution of the impact across the life cycle stages.	**Cold Spot** A life cycle stage whose contribution to any impact category is less than even distribution of that impact across the life cycle stages
Hotspot All life cycle stages collectively contributing more than 50% to any impact category.	**Cold Spot** All life cycle stages collectively contributing less than 50% to any impact category.	

Figure A1.4 Categories of hotspot identification zones for F&V commodities (Barthel et al., 2017)

4.2 Hotspots and causes of FLW generated for melons across the supply chain stages

A recent publication, Crop loss/waste on Australian horticulture farms 2021–22 by the Australian Bureau of Agricultural and Resource Economics and Sciences (ABARES) (Downham, 2022) has reported that total national average loss and waste of melon and watermelon fruits accounts about 20.19% per farm which includes 14.41% from the pre-harvesting stage and 5.42% from during-and- post-harvest losses. In terms of state level data, this publication only reported about Queensland state that there was about 29.42% per farm total loss contributed by 21.98% and 7.45% from pre-harvest, and during-and-post-harvest losses, respectively.

Based on reviewing the definition of hotspots for FLW generation from the section 5.1 and available relevant literatures (Adepoju & Ologan, 2021; Bartezzaghi et al., 2022; Downham, 2022; Fernández-Trujillo et al., 2013; Gardas et al., 2018; Ismael, 2023; Ledger, 2007; Pereira et al., 2017; Schmickl & Crailsheim, 2002; Singh, 2019, 2021b; Tesoriero & Watson, 2016; WRAP, 2020), Table A1.3 is presenting the key identified hotspots which contribute to generation of FLW across the supply chain stages of the melon fruits.

Table A1.3 Identified hotspots and root causes of FLW generation in the respective supply chain stages for watermelon and muskmelon fruits

Supply chain stages	Hotspots
Production/ Pre-harvest stage	Cultivation outputs
Harvesting	Fruit collection / picking
Processing	On-field processing
	Packing house processing
Transportation	Transferring from packing house to the distribution centres
	Transportation from warehouses to the retailers
Warehousing	Storing/holding, and stacking
Retail	Fruit handling
	Management / operational issues
Consumers	Consumer activities

5. Root-cause analysis

5.1 Defining root causes and categorisation for FLW generation.

Root causes are the fundamental or structural reasons behind food waste and loss (Møller et al., 2014), In general, there are six major categories of common root causes of horticultural waste/loss generation, namely: Bio-chemical causes, environmental causes, behavioural & managerial causes, technological causes, operational & organisational causes, and commercial & legal causes (Australian Government, 2017; Beausang et al., 2017; Brodribb & McCann, 2020; CEC, 2021; Hoehn et al., 2023; Messner et al., 2021, McKenzie et al., 2017). Each of these categories includes different specific root causes of waste or loss associated with one or more than one stage of the product's supply chain.

5.2 Root causes for losses and wastes across melon supply chain stages

Based on reviewing the available relevant literatures (Adepoju & Ologan, 2021; Bartezzaghi et al., 2022; Downham, 2022; Fernández-Trujillo et al., 2013; Gardas et al., 2018; Ismael, 2023; Ledger, 2007; Pereira et al., 2017; Schmickl & Crailsheim, 2002; Singh, 2019, 2021b; Tesoriero & Watson, 2016; WRAP, 2020), Table A1.4 is presenting the key root-causes for the identified hotspots that contribute to generation of FLW across the supply chain stages of the watermelon and muskmelon.

Table A1.4 Identified hotspots and root causes of FLW generation in the respective supply chain stages for watermelon and muskmelon.

Supply chain stages	Hotspots	Root causes
Production/ Pre-harvest stage	Cultivation outputs	Cultivation season
		Quality of seeds, and plant spacing
		Quality of soil health, fertiliser, and supplied water
		Insect invasion and destruction by animals
		Insufficient knowledge use of disease control actions
		Insufficient working capital, inadequate access to credit and government supports
		Irregular maturity during production stage (i.e., plant growth, flowering, pollination, and fruit development)
		Lack of technological support and skilled labour for good farming practices
		Inadequate arrangement to protect the growing-up fruits
		Inadequate farming infrastructure
Harvesting	Fruit collection / picking	Time of picking: e.g., night, early morning, daytime
		Temperature exposure for long time
		Unskilled labour
		Damaging fruits while handling
		Weather conditions for fruit damage
		Immature fruit collection
		Unharvested products left on field.
		Insufficient infrastructure to deal with overproduction
		Lack of communication with supply chain actors to avoid fruit losses, risk of under-pricing, and secondary market entry with the unsold filtered edible fruits
Processing	On-field processing	Inadequate capacity to process for more than one supply chain actors
		On-field cleaning, sorting, and packing into bins
		Improper stacking of fruits into bins, and pallets
		On-field transportation
		Transportation from field to processing centres
		Not labelling to track the product
		Prolonged holding or storing fruits on-field with exposed higher ambient temperature
		Microbial contamination
	Packing house processing	Inadequate control of storage temperature
		Insufficient pre-cooling
		Mishandling for packinghouse activities (wiping/washing, sanitising, drying, sorting, repacking, pallet stacking)
		Not packing into standardised boxes that damages fruits
		Lack of appropriate storage facilities and cold chain facilities
Transportation	Transferring from packing house to the distribution centres	Damage of fruits due to unregulated loading, pallet stacking, and unloading activities
		Temperature control (refrigerated/non-refrigerated) during the transportation system
		Vibration damage to the fruits (bruising, cracking, loss of quality of the fruit for eating)
		Inefficient pallet loading.

	Transportation from warehouses to the retailers	Temperature of transport containers and exposing fruits to external temperatures. Insufficient cold chain capacity.
		Vibration damage to the fruits (bruising, cracking, loss of quality of the fruit for eating)
Warehousing	Storing/holding, and stacking	Inadequate temperature, humidity, and air flow for the warehouse stay period
		Prolonged storing of fruits / Long lead time
		Unregulated pallet stacking
		Unskilled labour
		Inefficient tracking of fruit pallets to control first-in-first-out activities
Retail	Fruit handling	Storage room temperature
		Microbial contamination
		Cutting and wrapping damages
	Management / operational issues	Poor shelf life of the fruits
		Poor demand and order management from the retail stores
		No standard official training and procedures to avoid microbial contamination, and loss of food from displays
Consumers	Consumer activities	Over-buying than the quantity to be consumed
		Improper storage at home
		Not interested to buy due to financial issues
		Lack of consumer awareness on fruit wastes (quantitative and qualitative)

5.3 Case studies of good practices

There is no complete study on FLW quantification and utilisation for watermelon and muskmelons to be used as best-case studies for whole chain practices. But the following examples can help to develop an integrated action plan to reduce wastes from the melon supply chains.

5.3.1 Production stage (plant, flower, and fruit stages), (Pereira et al., 2017)

Pereira et al. (2017) conducted a study to identify the critical components and quantify the key factors affecting yield loss during watermelon production using a crop life table as a tool in 5 different growing seasons between 2011 and 2012 in Brazil. The production stage of the of the watermelon supply chain has three components, i.e., plant (vegetative phase, reproductive phase), female flower production, and total fruit development. The yield losses are shown in the Table A1.5.

Table A1.5 Yield losses reported in various production component stages of watermelon in various seasons (Pereira et al., 2017)

Production component		Yield losses (%)				
		April/June 2011	June/September 2011	September/December 2011	February/April 2012	May/August 2012
Plants		27.90 ± 6.65	10.61 ± 5.24	18.95 ± 6.69	15.42 ± 4.81	66.51 ± 4.33
Loss factors	Bacterium	0.88 ± 0.59	0.00 ± 0.00	0.57 ± 0.57	3.13 ± 3.13	0.00 ± 0.00
	D. bryoniae	20.37 ± 5.40	2.59 ± 1.67	12.97 ± 7.00	0.00 ± 0.00	0.00 ± 0.00
	Fusarium sp.	2.04 ± 0.93	0.00 ± 0.00	0.00 ± 0.00	8.77 ± 3.95	0.00 ± 0.00
	P. cubensis	0.00 ± 0.00	5.19 ± 3.34	0.00 ± 0.00	0.00 ± 0.00	66.51 ± 4.33
	Pythium sp.	3.05 ± 1.60	0.61 ± 0.50	5.41 ± 2.69	0.00 ± 0.00	0.00 ± 0.00
	Rhizoctonia sp.	0.72 ± 0.49	0.00 ± 0.00	0.00 ± 0.00	3.52 ± 2.42	0.00 ± 0.00
	Chrysomelidae	0.85 ± 0.59	2.22 ± 1.26	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00
Flowers		52.27 ± 2.32	51.10 ± 3.42	59.01 ± 3.50	54.65 ± 4.99	46.93 ± 4.98
Fruits		16.53 ± 3.55	25.20 ± 3.91	89.03 ± 4.06	93.36 ± 3.71	13.82 ± 4.02
Loss factors	Abnormal fruits	14.33 ± 3.57	13.97 ± 2.83	54.32 ± 5.31	83.04 ± 7.09	13.82 ± 4.02
	Blossom-end rot	1.64 ± 1.77	2.98 ± 1.65	11.94 ± 2.87	5.46 ± 3.29	0.00 ± 0.00
	Cracked fruits	0.00 ± 0.00	0.00 ± 0.00	3.33 ± 1.56	3.82 ± 2.88	0.00 ± 0.00
	Diaphania spp.	0.56 ± 0.56	8.25 ± 2.00	19.43 ± 4.36	1.04 ± 1.04	0.00 ± 0.00

Key findings of the experimental investigation are:

- Watermelon yield losses result from plant physiological disturbance and from attacks by fungi, insects, and bacteria. Watermelon yield losses are highest during rainy and humid seasons. These loss factors should be managed during the entire cultivation period.
- Preventive measures are required for diseases caused by the insects during vegetative and reproductive stages.
- Flower abortion and the formation of abnormal fruits were also among the sources of the losses that determined watermelon yield. Watermelon flower pollination and the fertilisation of ovules activate the production of plant hormones that enable fruit set and development.

5.3.2 Pre and post harvest, and marketers risk factors

Adepoju and Ologan (2021) evaluated the key factors which affect the pre-and-post-harvest losses and marketers across watermelon value chain based on tropical Nigerian region before 2020. The study reported that, key constraints identified by producers were insect infestation, insufficient working capital, poor handling of produce, lack of access to market, and lack of technology while inadequate access to funds, lack of storage facilities, and poor packaging of produce were identified by marketers. The majority of producers and marketers experienced loss of up to 40%, some >60% (Adepoju & Ologan, 2021).

5.3.3 Poor handling and quality losses of melon

Poor handling at each of the supply chain stages lead to a significant portion of food loss and waste. Cutting immature melons from field, bruising, cracking, and microbial contamination are the major pre-and-post-harvest poor handling consequences (Pereira et al., 2017). Ledger (2007) conducted a study (in a supermarket) to determine the impact of the melon (rockmelons, seedless watermelons) handling practices across the supply chain to assure higher eating acceptability to the consumers. Based on the experimental inspections on handling practices and quality losses of the melons that would impact on saleability of melons the observations are presented in the Table A1.6.

Table A1.6 Impact on saleability of the melons due to handling issues across supply chain (Ledger, 2007)

Rockmelon	Seedless watermelon
Mandatory pre-cooling with forced air cooling prior to transportation.	Risk of exposure to temperature above 25 °C due to transportation without refrigeration facility and holding period at the market.
Variation of fruit temperature within a pallet was observed, higher at the top of and little low at the inside of the packing container on pallet.	Slow cooling for watermelon was observed in the fibreboard bins.
In terms of fruit quality, the external portion starts deteriorating before the internal quality losses.	In terms of fruit quality, internal quality of the fruit starts deteriorating prior to the rind.
Skin quality deterioration and rotting begins after 2-5 days when stored at 20 °C. Little change occurs in brix, colour of the flesh, flavour, texture, and seed cavity condition after 7 days when stored at 20 °C.	Saleable life significantly reduces if the watermelon is stored at 30 °C for more than 3 days. The loss of texture and crystallinity appearance, and increase in orange flesh colour during that
Cut fruit quantity in the retailer displays should not exceed sales target to avoid excessive wastage.	Cut fruit quantity in the retailer displays should not exceed sales target to avoid excessive wastage.
Traceability reduces due to absence of packing dates and other relevant information in the rockmelon boxes.	Traceability reduces due to absence of packing dates and other relevant information in the bins.

5.3.4 Packing, stacking, and palletising

Bruising in the watermelon fruits can happen due to poor packing, staking, and palletising practices. Internal fruit damages can be seen when the fruit is cut in the retailer places or at consumers' places. Bruising can be one of the key fruit loss and waste generation causes. Sadrnia et al. (2008) conducted nonlinear finite element analysis (FEA) to investigate internal bruising in watermelon compressed in longitudinal and transverse directions by parallel plates. This study indicated that the bruise of the red flesh is the primary form of mechanical damage of watermelons under compression in both directions.

In Australia, watermelons are packed using the bulk bin/carton system (double and triple wall octagonal bins) in fields straight after harvesting. Over filling the bottom bin can result in damaged watermelons (Singh et al., 2021). Using pallets in good condition and the correct size to match the bins is required to prevent the damage to lower bins. Being paper based, fibreboard strength is reduced by cold temperatures and high humidity and that drastically reduce the stacking strength of the packaging (Dongmei et al., 2013).

5.3.5 Transportation: Vibration damage to fruit during transportation (Shahbazi et al., 2010)

Fruit bruising can also occur during handling, transport, and storage. Due to the thickness of watermelon rind, flesh bruising is difficult to detect. Shahbazi et al. (2010) evaluated in-transit vibrational damage (frequency, acceleration and duration) and fruit position in the bin on watermelon. Fruits located at the top of the bin showed more damage than those in middle and bottom positions ($P< 0.05$). The tests also showed greater damage to watermelon flesh than watermelon hull. This study shows that packaging, especially for fruit that has extended transport times such as when going interstate or to foreign countries, should be evaluated and improved.

5.3.6 Retail: retail food safety survey for cut melon (Singh et al., 2021)

NSW DPI conducted a survey in the year 2019-2020 (October 2019-April 2020) on cut melon food safety in 41 selected retailers of which 28 were supermarkets and 13 were greengrocers. Out of total 448 samples (252 watermelons, 123 rockmelons, 65 honeydews and 8 specialty melons) picked from these stores, 56% (251) of samples were collected from ambient fruit displays and 44% (197) were collected from cold or refrigerated displays. Some key observations from the survey included:

- The cut melon pulp temperatures recorded at the retail outlets revealed that the fruit were either not properly cooled before cutting or retail shelves were not maintained at 5 °C.
- Most (94%) retailers did not wash or sanitise fruit before cutting.
- Most (88%) retailers claim to clean and sanitise cutting equipment and surfaces, however, do not have a regular sanitisation schedule.

- 17% of retailers used some form of labelling on cut melons.
- 56% of retailers displayed cut melons at ambient conditions.
- 95% of retailers cut fruit in small batches to sell on the same day.

The data suggested that prolonged display of potentially contaminated cut melons can lead to growth of bacterial pathogens faster at ambient conditions compared to cold or refrigerated conditions.

5.3.7 Case study: Mapping of Australian fruit and vegetables losses pre-retail: melon and watermelon (Ambiel et al., 2019)

For the melon and watermelon crop, the Australian loss estimates ranged between 20-40% (46- 92 kilo tonnes) of primary production (Figure A1.5). These values are consistent with a USA study (Fish et al., 2009) with 20% (521 kilo tonnes) of melons and watermelons left on field.

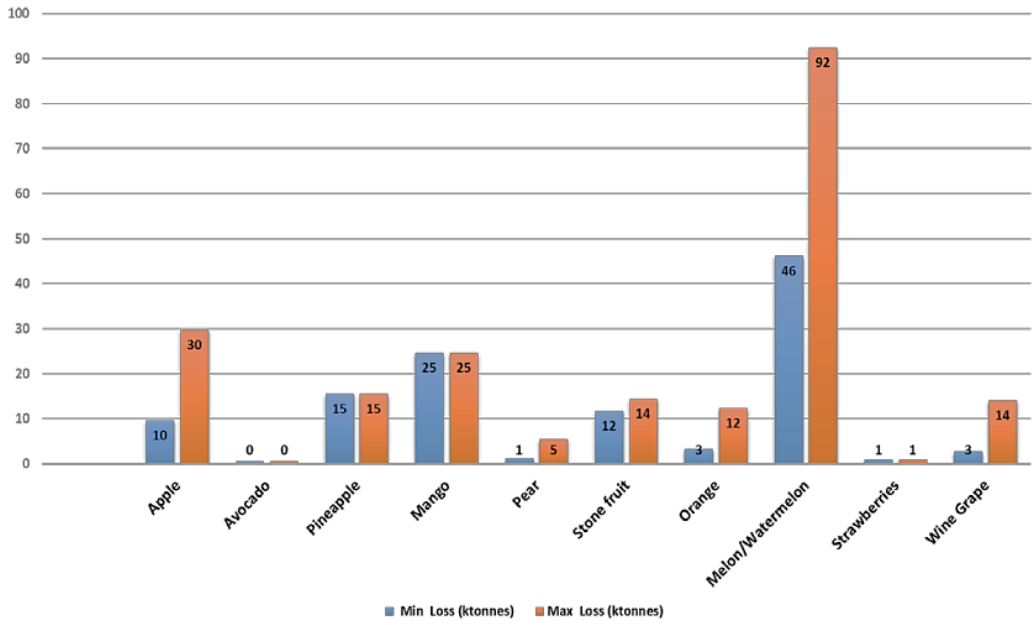

Figure A1.5 Australian annual loss estimation from fruit crops during primary production stages (Ambiel et al., 2019)

Australian melon and watermelon losses were estimated to have the highest losses among the other fruits. However, other international literature in the countries India and the USA suggests a much higher loss estimate of 33 and 48%, respectively, during melon and watermelon processing. Moreover, Table A1.7 is showing the Fruit grower loss, and Fruit packers / processor loss, respectively for national and state coverage in the current Australian Food Loss Survey for this case study.

Table A1.7 Fruit grower loss and fruit packers/processor loss for melon / watermelons (extracted from Appendix E, Table 24, 25 of (Ambiel et al., 2019))

Fruit	National production (ktonnes)*	Production covered by current survey (ktonnes)	% production covered nationally	Loss (%) (average or individual value)	% Loss range	Packers/Processor production (ktonnes) (state / covered state)	% Production covered by state
Fruit grower loss	231.15	62.03**	27 %	20%	20/20%	QLD -76.89/62.03	QLD - 80%
Fruit packers/ processor loss	231.15	62.03**	27 %	19%	20/40%	QLD - 76.89/62.03	QLD - 80%

6. Potential Interventions to Reduce FLW

6.1 Best management practice (BMP)

Best management practice (BMP) is essential for each of the supply chain stages of the watermelon and muskmelons. The BMP guidelines for food safety enhancement for watermelon (Singh et al., 2021) and muskmelons (Singh, 2019) provide effective instruction from farmers to the retailers that may efficiently reduce food losses significantly along with increased food safety. These guidelines proposed checking of practices to be exercised for the respective stage of the supply chain before starting the activities for the next stage. Another best management practice is to utilise the tools for greater ecosystem management e.g., “Working Metric 1.0” by the SISC (SISC, 2013). Growing different varieties disease-resistant seeds, provide adequate nutrients to help faster and healthy growth of melon (Jagdish, 2022).

6.2 Whole crop purchase (WCP)

WRAP has proposed a strategy to reduce food waste across the value chain by developing collaborative problem-solving approach among the actors, namely, the whole chain food waste reduction plan (WRAP, 2022; WRAP & IGD, 2022) to reduce food loss from the farm FLW stream. One of such collaborative approaches is the whole crop purchase (WCP) through whole crop contracts (Allu & Belavina, 2020; Grinberga-Zalite & Zvirbule, 2022; WWF, 2020). In this approach contracts between the farmers and the retailers are relaxed to buy all the grown crops including the cosmetically flawed and stock pilled surplus productions rather than buying only visually perfected and forecasted amount for a season (Allu & Belavina, 2020; Grinberga-Zalite & Zvirbule, 2022; WWF, 2020). To an extent, whole crop purchasing is standard practice for pack houses, where a grower’s entire crop is graded selectively for different retail, wholesale, and other markets to maximise crop utilisation. Retailers own a greater market bargaining and driving power for both growers and the consumers, which they can use extensively to maximise the profit from investing on whole crop purchasing by rebranding the new standards for the cosmetically imperfect as well as overproduced commodities (WWF, 2020).

6.3 On-farm measurement techniques

Accurate measurement of in-field grown produce help to develop a better insight to the farmers on surplus after selling the commodities to the primary buyers, what portion of the left-over is marketable in the secondary marketing destinations, and what portion could be finally destined as wastes. This activity is the first step to preventing excess field loss as the growers can divide their produces into marketable, edible (but not saleable to the primary buyers), and unfit categories (Johnson & Dunnin, 2019; WWF, 2018). Growers can also revise their action plans accordingly, i.e., if higher volume of edible surplus is observed then seeking secondary marketing, value products, or reduced plantation can be planned, and the higher quantity of unfit produce may help the growers to revise their preharvest action plans, and implement best management practices, thus can reduce the carbon footprint as well (Dunning et al., 2019 - Quarter 1; WWF, 2018). Therefore, the food loss and waste generation can be reduced from on-farm measuring activities.

The Food Loss Metric tool (WWF & SISC, 2022) proposed by the WWF/SISC can track and report the overall quantity of food grown that are ready to be harvested but still did not enter into the FSC for consumption. The Food Loss Metric Tool can also link to other tools like Cool Farm Tool that can quantify the on-farm GHG emissions (CFA, 2013), how well the farm management supports biodiversity (CFA, 2016), and irrigation water (blue and green water footprint) requirement (CFA, 2017) to manage the farm efficiently and economically.

6.4 Specifications Review

Retailers always aim to achieve high quality acceptance from the customers for their purchasing goals and they do not offer any abnormal looking fruits and vegetables to the customers until the customer willingly pick those. The very first quality factors for sorting the fruits and vegetables are their cosmetic appearance - based on which the products are categorised for pricing (de Hooge et al., 2018; European Commission, 2007; Herzberg et al., 2022). Other supply chain actors between growers and the retailers also set their own quality specification parameters to ensure 100% acceptance and minimum wastage

when transferring the goods to the next supply chain stages. Retailer quality specifications for fresh fruit and vegetables are commonly cited by growers and the supply chain as a driver of waste across all sub-sectors. (Kerzberg, R., Trebbin, A., and Schneider, F., 2023). A critical decision point for applying retailer specifications is the packhouse. Quality is also sensitive as it is a highly competitive area between retailers. Though the European Union does not allow the rejection of physically imperfect fruits and vegetables by supply chain actors, the self-managed quality guidance by the sellers can certainly filter out the imperfect commodities (de Hooge et al., 2018; Loebnitz et al., 2015). There is a necessity of developing customer willingness and capacity development by the retailers to overcome the barriers like less capacity to accommodate more goods, higher operational costs, and lower pricing issues by keeping the edible food loss and food insecurity issues (de Hooge et al., 2018).

6.5 Forecasting and AgriTech

Strong and reliable stakeholder collaboration is required to reduce the FLW from primary production sector and establishing smart farming practices (Filimonau & Ermolaev, 2021; Magalhães et al., 2022; Mohammadi et al., 2019). Building an aggregated database for growers and retailers can help exchanging assessments, orders, and production forecasting (WWF, 2020). Developing confidence and trust values between the supply chain actors is pivotal for reducing food waste. Transparent food supply chain and mature regulations for adoption of technologies are the key factors to gain success in preventing food loss and wastes and achieve environmental sustainability through digitising the agricultural sector (Benyam et al., 2021). Industry 4.0 revolution can be adopted to utilise in the fruit and vegetable supply chain, which are collectively termed as Traceability 4.0 due to their capability to solve complex agricultural supply chain issues (Figure A1.6) (Hassoun et al., 2023).

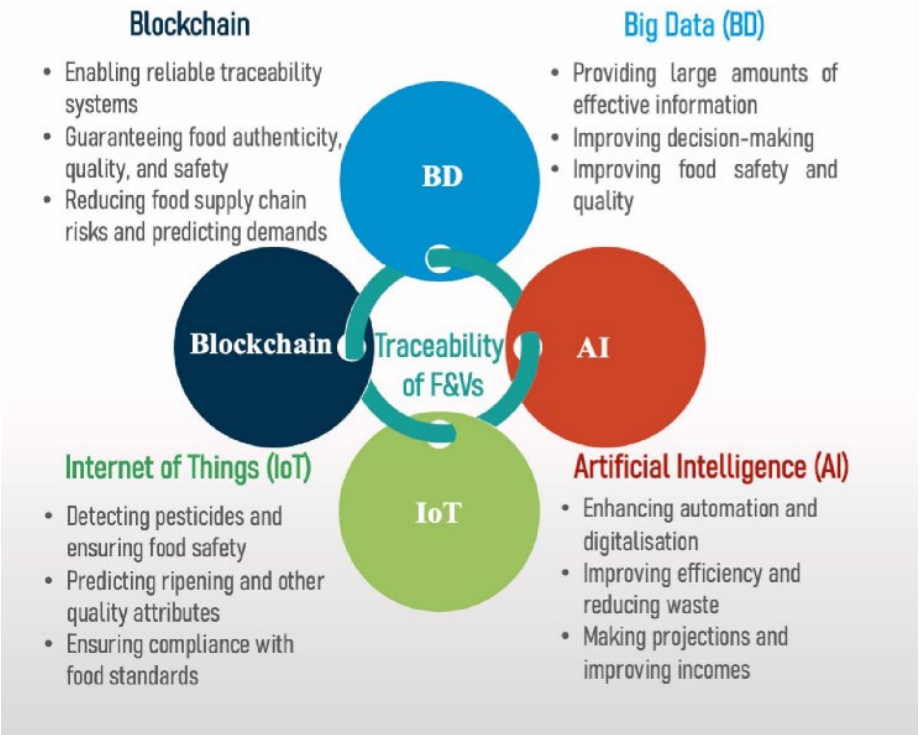

Figure A1.6 Traceability 4.0 enablers to be used in the F&V supply chain (Hassoun et al., 2023)

Real time efficient utilisation of IoT systems in the agricultural industries could be traced back in 1990s through GPS tracked machinery operations to modern drones in various purposes, and about 70% of the crop producers in the USA are using the IoT applications (Agrifutures, 2016). Australian horticultural industries can benefit from the adoption of IoT applications for high-level information management requirements to obtain higher percentages of crop production.

6.6 Policy Interventions to foster fair trading practices.

Policy shifts that empower farmers in contractual negotiations will assist in reducing on-farm food waste. For instance, a recent amendment to Treasury Laws – the “More Competition, Better Prices Bill 2022” (The Parliament of the Commonwealth of Australia, 2022) has been passed in both houses of the Australian Parliament on October 27, 2022. Previously, whilst courts could declare a standard form contract or it’s terms unfair and void them, it was not prohibited and came with no penalties. This amendment substantially increases penalties. Other policy changes, such as those in Retail Sale and Returns, would have significant implications in reducing fresh produce waste also.

6.7 Tax Incentive Reform

With the key focus to help diverting more of the excess food to the food relief sectors, the National Food Donation Tax Incentive (NFDTI) proposal developed by KPMG with the support of the End Food Waste Cooperative Research Centre recommends a tax incentive based on the ability to offset a percentage of costs related to food donations from taxable income (KPMG, 2022). The food relief sector in Australia has a great potential to supply food to the hungry people due to more than sufficient food production for its population, hence it is highly recommended that the Federal Government will be supporting the tax incentive benefits to the supply chain actors who actively spend their time and money to divert their food waste for better causes (KPMG, 2020, 2022). In addition to contributing to sustainability goals, the proposed incentives would provide support to small - medium enterprises, particularly farmers and small businesses in transport and logistics, stimulating regional economies and mitigating some of the economic impacts of labour shortages, natural disasters, and the cost-of-living crisis.

6.8 Post-Harvest Guides for packing and processing

Preventing moisture loss, retaining flavour and quality of the harvested fruits need effective thermal control measures in the packing, processing, and storage places. Best management practices described in the “Postharvest management of vegetables: Australian supply chain handbook” presents how the processing and storage places’ environmental parameters could be designed and controlled to optimise the quality life span of the commodity (Ekman et al., 2016). Besides these, the packaging materials, waxing, and fruit coatings, controlled atmosphere (CA) can help retaining the fruit quality efficiently. The ethylene exposure to the fruit and vegetables damages the colour and shelf life of the fruit commodity and it only reduces when the storage temperature is lower than 25°C (Ekman et al., 2016). Chilling injuries will take place when storage temperature is below 5°C.

6.9 Upcycle lower grade produce.

Upcycling of the leftovers, and the waste portion of the fruits (i.e., seeds, rind) can help developing circular economic trends for the selected commodity. Use of appropriate technologies to process surplus/waste produce into higher-value products can help to reduce remaining horticulture waste by at least 70%. This will not only mitigate the crop wastage but also saves resources utilised in the production and will reduce carbon footprint.

In order to realise these opportunities, it will be important to understand the scale and locational attributes, the available (Tchonkouang et al., 2023, Moshtaghian et al., 2021) technologies and possible markets.

6.10 Develop and implement the Fresh Produce Chapter of the Cold Food Code

The Australian Cold Chain Guidelines for Food 2017 (AFGC, 2017) provides best practice recommendations for transport, logistic and safety requirements to ensure the safety and quality of chilled and frozen foods. These guidelines work alongside respective country or state legislation to handle commodities that require controlled atmosphere. The Australian Food Cold Chain Council (AFCCC) has developed a Cold chain benchmarking tool through which Australian businesses can find out for what activities the businesses require cold chain transportation services (AFCCC, webpage). This program uses analysis of information collected in seven steps to generate useful feedback on those areas where effective cold chain and quality management activities will be required. AFCCC has taken responsibility to develop a new series of codes as a practical initiative to reduce the country’s

FLW problem, that cost an estimated amount of $20 billion yearly (AFCCC, 2022).). Recently published content, “Australian Cold Food Code Part 2a: Guiding principles of fresh produce transport in the Australian cold chain – Product specifications”, is one of the detailed best practice guides to handle fruit and vegetable immediate post-harvest (AFCCC, 2022). These codes, cold chain assessment, and the waste reduction goals will help efficiently adopting cold chain technologies to reduce food loss from the supply chain activities.

6.11 Improve instore/product/packaging

Businesses in the wholesale and retail stages of the supply chain have three opportunities to help in reducing waste of fresh produce: across their own businesses; upstream with growers, transporters, and processors; and downstream – by influencing how household consumers and foodservice companies manage, cook, and serve horticulture products.

Using sustainable technological innovation for the instore product displaying, temperature management, labelling, and packaging reinforced with product management such as reviewing pack sizes, providing loose products and storage guidance can significantly reduce the loss quantity of the perishable commodities, especially, cut watermelon and muskmelons.

6.12 Work with Australian Food Pact signatories to reduce food waste

The Australian Food Pact (SFWA, 2021), a voluntary multi-year agreement, requires the commitment of member food businesses to develop and implement a Food Waste Action Plan. Success of this program may demonstrate an overall reduction of food waste by 28% (FIAL, 2019), that will benefit the actors within FSC and reduce significant amount of unwanted GHG emissions that would be emitted if directed to landfilling. Currently there are 26 signed members including the two largest retailers, Coles and Woolworths, with conversations underway with Aldi and Metcash (IGA) about joining.

6.13 Minimise loss during production and processing

Retailers and wholesalers can increase collaboration with producers to maximise crop utilisation (e.g., Whole Crop Purchase, Specifications review and forecasting. –A good collaboration approach between retailers and producers can effectively prevent generation of more food loss and wastes throughout the supply chain stages.

6.14 Minimize loss during transit

When retailers support the establishment of cold chain transportation of the fruits and vegetables according to the best practice management code provided by the AFCCC (AFCCC, 2022), they can drive the system to be more efficient.

6.15 Use more of what is produced

Retailers can initiate introducing products from the lower graded produce; thus, the whole crop purchase system can work well along with supporting the food redistribution program and diverting the food wastes into upcycling activities rather than directing towards animal feed or land filling (Messner et al 2021). However, such initiative requires consumers, industry and government support.

Note: Reference of the intext citation can be found in the reference list of the technical report.

Appendix 2. Melon Industry Stakeholder engagement action plan: Key findings

1. Introduction

The present study aims to develop a sector action plan to address food loss and waste in this melon industry. This document summarises findings from stakeholder engagement through interviews and workshops. (Data Collection Phase I) about horticultural loss and waste in general.

1.1 Stakeholder interviews and workshops

The purpose of stakeholder interviews and workshops was to collect information about food waste across the melon supply chain by having in-depth conversations with stakeholders. All the interviews were conducted in March 2023. The data collected from the interview was utilized to design poll questions and discussion topics in Workshop 1. Discussion topics of workshop 2 and proposed action plan was developed from the data collected through interviews and workshop 1. The list of participants for the stakeholder engagement is listed in the Table A2.1. During the workshops the research team and funding agencies participated along with the other stakeholders.

Table A2.1: List of participants

Sl. No.	**Participants**	Participation in stakeholder engagements		
		Interview	**Workshop 1**	**Workshop 2**
1	Primary producer 1	✓	✓	✓
2	Primary producer 2	✓	✓	✓
3	Primary producer 3	✓	✓	
4	Post-Harvest Expert	✓	✓	✓
5	Wholesale/distribution	✓		✓
6	Major retail representative	✓		✓
7	Biosecurity expert from industry	✓	✓	✓
8	Melon industry representative	✓	✓	✓
9	Horticulture Industry representative	✓	✓	

Prior to each of the interviews, the interviewer introduced themselves and discussed the purpose of the project and requested permission to record the conversation. Interview questions/ discussions focused on multiple themes related to food waste in melon industry. Similar approach was taken for both workshops.

1.2 Tools for stakeholder engagement

The following tools (Table A2.2 - A2.5) were used for collecting data during the stakeholder engagement. The data collection process was approved by the CQUniversity Human Research Ethics Committee. The workshops were facilitated by the research team and the stakeholders were engaged in open floor discussion and group tasks in the breakout rooms. All the workshops were organised in online platform using Zoom.

Table A2.2: Stakeholder engagement tool for interviews

Interview questions (finding solutions)
1. In your opinion, at what stage of the horticulture supply chain the most food waste occurs? (e.g., production and harvesting, processing, and packaging, wholesale and distribution, retail) 2. How could we minimize overproduction in the horticulture industry? Is there any mechanism to signal the accurate (near accurate) demand for horticulture products? 3. What strategy is required to divert the oversupplied horticulture products to new markets (including export)? 4. Do you think inefficient cold supply chain management is the key reason for food waste in the horticulture sector? How could we increase the efficiency of the cold supply chain? 5. What strategy is required to ensure that maximum edible discarded food can be sent to food rescue and/or food banks? 6. Do we need more energy recovery plants in Australia to process waste food from the horticulture sector? 7. What new technology could be used in the horticulture supply chain to reduce food waste? 8. What types of training is required to educate the supply chain actors and consumer about food waste in horticulture? 9. In your opinion, is there any legislative framework that leads to increased food waste? What types of change are required to minimize food waste without compromising the purpose of such a framework? 10. What else could be done to reduce the horticulture food waste to half by the year 2030?
General question to identify the hotspots and root cause
Production and harvesting stage 11. What is your primary produce? What is the size of the land of production? What is the average yield (kg/ha)? 12. What are the main reasons for product loss on the field? 13. During the harvest, what percentage of horticulture products are damaged? 14. What is the main reason for the waste during harvesting? (e.g., mechanical operation, storage, handling etc.) 15. How do you treat these wastages (e.g., compost, energy recovery, stockfeed etc.)? 16. Is there any option/opportunity to produce value-added products from these wastages? 17. Do we have appropriate logistics and infrastructure for producing value-added products? 18. What types of support are required for the value-added products industry?
Processing 19. During the processing stage, what percentage of waste occurs for horticultural commodities? What is the nature of such loss (expiration dates, trims, Final product rejection)? 20. Do you have any agreement in place with the wholesaler and retailer to minimize food waste?
Wholesale and distribution: 21. How much (percentage) of food waste take place during transportation and distribution? What are the main reasons behind such waste (Excess stock, storage facilities, labour shortage, temperature management)? 22. What support could government provide you to minimize food waste during distribution?
Retail 23. What percentage of horticulture products are rejected at the retail stage because of cosmetic specifications? Is there any opportunity to market such out-of-specification products at the retail stage? 24. What are the destinations of discarded horticulture products at the retail stage? Is there any restriction to send the discarded products to the food bank?

Table A2.3: Workshop 1 Runsheet and activities

Workshop 1: Melon Hotspots and Root Causes Analysis
Time, day and date: 10am to 12pm, Tuesday April 4th. **Venue: Online (Zoom)** **Facilitators**: Prof. Delwar Akbar (DA), Ms. Margaret Marty (MM), Carolyn Cameron (CC), and Melissa Smith (MS) **Technical Support**: Dr. Azad Rahman (AR) **Focus of the workshop**: • Identify the food waste hotspots in the Melon supply chain? • Articulate the causes of Melon food waste – both first level reasons and root causes

- Identify the initiatives that organisations have in place to stop/minimise Melon food waste?
- Seek the participants input into a prioritisation of the criteria for the selection of action plan strategies.
- Triangulation of findings from the participant interviews

CONTEXT NOTES:

The Melon Reference Panel is a small group that represents growers, industry bodies and a fruit marketer. A retail representative is still being negotiated. Several of the participants are involved with the Hort Sector SAP project advisory group (PAG) and have been involved in interviews and workshops associated with that aspect of the project. A couple of the growers may not be very technologically literate and are participating in this type of workshop for the first time.

This is the first of two workshops with the Melon Reference Plan during the project. It focuses on **hotspots and root causes** while the second workshop will test the proposed solution and ideas in the draft strategy.

Time	Key activity	Facilitator/s
10.00 10.10am	INTRODUCTION • Opening & Welcome, Acknowledgement to Country & Housekeeping (note the workshop is being recorded, use of chat function and hands up icon) • Introduce other Facilitators. • Overview of workshop • Introduce MS/CC to discuss: ✓ the competition statement, ✓ definition of food waste, ✓ scope pf this project i.e., the supply chain goes from paddock to purchase (i.e., retail). Food waste in households or the service industry are not being investigated. Commence workshop. **ICEBREAKER – WELCOME** • Introduce Mentimetre online tool - participants to log in and complete first question "what is your preferred name?" • Welcome each and ask where they are from or other small talk topic. Remind of chat and hands up functions or other ways of getting attention	DA CC/MS MM
10.15-10.22	**ICEBREAKER** Quick responses to a series of multiple-choice questions using Mentimetre. Responses to be displayed as vertical bar graph – limited discussion. 1. How are you involved in the melon Industry? 2. What % (approximately) of food waste is there in your operations or in the part of the industry that you work in? 3. How urgent do you think it is to address food waste in the Melon industry? 4. Is your organisation aware of the main sources of food waste within it? 5. Are there strategies/interventions in your organisation to address food waste? 6. Do you think these strategies/interventions are effective? i.e., are they reducing food waste	MM & DA
10.22-11.10 (approx. 15 mins per hotspot although more likely the first will be longer)	**Identifying The Potential Food Waste Hotspots in The Melon Supply Chain, Their Relative Quantum, Causes and Potential Initiatives to Reduce** **ACTIVITY 1** Mentimetre activity to identify the top 3 waste hotspots in the Melon supply chain stages. **ACTIVITY 2** Take each of these individually, beginning with the number one hot spot and approximate the amount of waste (multiple choice). Discussion prompts:	MM & DA

<table>
<tr><td></td><td>

Discuss how do they know this, what evidence do they have of waste qty and what tools do they use to measure?
Discuss for melons – what is the best unit to measure waste?
Do they consider this to be a satisfactory level – why?
Discuss how do they know this, what evidence do they have?

<u>ACTIVITY 3</u> Describe the causes of number one hot spot. (Work from symptoms – root cause through unpacking discussion.
Discussion prompts:

Common causes of food waste across the supply chain
What causes a cause of waste?
Underpinning causes – why, why, why take symptom through to the root cause.
Food waste causes that occur but don’t manifest until later stages of the supply chain.
Triggers for top-level causes
Connectivity between causes

<u>ACTIVITY 4</u> Identify strategies and initiatives that are being used to reduce food waste at this point of the supply chain.
REPEAT ACTIVITY 2, 3 AND 4 FOR HOTSPOT NO. 2 THEN HOT SPOT NO.3
</td><td></td></tr>
<tr><td>11.15</td><td>
DEEPER DIVE INTO CAUSES AND INTERVENTIONS
Use Mentimetre to identify which of the factors impacting Melon food waste the supply chain actors have control over or no control over and to dig into deeper root causes.

Through discussion tease out:

Is there a potential to influence if not control – how to influence? What would it take? i.e., the enablers – what are the constraints to influencing food waste in Melon industry?
Lessons from other crops re causes or control/influence.

</td><td>MM & DA</td></tr>
<tr><td>11.25</td><td>
EVIDENCE BASED DECISION MAKING
Mentimetre activity to identify nature/reliability of data (slide 22)
Through discussion tease out:

The importance supply chain actors place on data – the value they see of having it.
How data is used to inform practice/decision making.

</td><td></td></tr>
<tr><td>11.30</td><td>
PRIORITISATION CRITERIA
Explain that we are likely to identify a lot of potential strategies during the duration of this project through both research and engagement, therefore it will be important to prioritise them. We will use the following criteria to priorities them. Please ask them to insert weight (1 -5, 1 refers to moderately important and 5 refers to highly important). The participants can use same weight for more than one criterion.
<table>
<tr><th>Criteria</th><th>Description</th></tr>
<tr><td>1. Food waste volumes (and perishability)</td><td>Prioritise solutions that tackle large volumes of food waste. When evaluating performance against this criterion, consider whether the initiative is likely to reduce overall food waste, or just displace the issue (i.e., moving the food waste from one point in the value-chain to another).</td></tr>
<tr><td>2. Food recovery hierarchy</td><td>Prioritise solutions that move waste further up the hierarchy. For example, prioritising measures that ‘prevent’ food waste over initiatives that ‘recycle’ food waste.</td></tr>
</table>
</td><td>DA & CC</td></tr>
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	3. Replicability	Prioritise solutions that are applicable across the wider industry (rather than an individual organisation).	
	4. Technical feasibility	Prioritise solutions that are low-tech and/or have been demonstrated to work elsewhere (rather than bleeding edge initiatives).	
	5. Financial feasibility	Prioritise solutions that are likely to result in a positive financial return, based on industry experience with similar initiatives.	
	6. Complexity	Prioritise solutions that are less complex to implement, including the number of stakeholders required to drive the change, alignment with existing policies/ legislation, etc. Also consider complexity within individual organisations to implement solutions given constraints (e.g., staff availability).	
	7. Others		
	Discussion Questions? **1.** Do you disagree with any of these, or can you see any omissions? **2.** Weight		
11.40 Choose which seem relevant based on earlier discussions according to the amount of time	**STRATEGIC DISCUSSIONS** Use Mentimetre tool it may be easier and quicker to do these as a discussion rather than requesting participants to write into Mentimetre. • It is suggested that food waste is caused because Melon growers are growing as much as they can and trying to find a market for it. A supply-driven model. Comment? • Supermarket specifications set the benchmark for what is saleable (i.e., what they believe the customer will purchase) - in terms of waste is the problem the specification or the product quantity and quality? • "There's not much you can do to add value or stabilise a melon' do you agree with this comment? What are the implications? • "Melon growers just don't work well together" is this true? is it a constraint to reducing food waste? how can it be overcome? • In terms of on farm waste- what can we do to control - agronomic and management issues, damage on farm and damage in the shed?		MM & DA
11.50-12.00	EXTRA FOOD WASTE STRATEGIES/INITIATIVES Other than what has already been discussed, what initiatives are you aware of that could contribute to (largely in melons but thoughts for other Hort crops will be accepted) **1.** Stop food waste **2.** Reuse food waste **3.** What can you do differently to reduce food waste? Is there information/communication and collaboration points and feedback looks across the value chain around food waste. Concluding the workshop with key summary and updates on next workshop.		DA & MM

Table A2.4: Workshop 2 Runsheet and Activities

Workshop 2: Melon Hotspots and Root Causes Analysis

Time, day and date: 2 pm to 4 pm, Tuesday May 30th.

- **Venue: Online (Zoom):**

Facilitators Ms. Margaret Marty (MM), Prof Hurriyet Babacan, (HB), Dr Azad Rahman (AR), Carolyn Cameron (CC), and Melissa Smith (MS)

Technical Support: Dr. Azad Rahman

Focus of the workshop:

- To present the key findings obtained through content triangulation from the literature review, the interviews and workshop 1.

• To present the process that led to shortlisting the solutions to reduce food waste from melon supply chains (farm to retail) • To discuss the short-listed solutions		
<u>CONTEXT NOTES</u>: This is the second workshop with this group which includes growers, industry reps, marketers, retailers, and a market information provider.		
Time	**Key activity**	**Facilitator/s**
2.00	**Introduction** • Opening & Welcome, Acknowledgement of Country • Introduce other Facilitators and around the Board of those in attendance. Overview of today's workshop - agenda (S2) • Housekeeping (note the workshop is being recorded, use of chat function and hands up icon) (S3) • Introduce Melissa/Carolyn to discuss: ✓ the competition statement, ✓ definition of food waste, ✓ scope of this project i.e., the supply chain goes from paddock to purchase (i.e., retail). Food waste in households or the service industry are not being investigated. (S4)	HB CC/MS
2.15	**Purpose of today's workshop**	MM
2.17 - 2.32	**Key Findings Through Triangulation of Research Methodologies** **Presentation with opportunity for group to comment.** • Hot spots and root causes – in the supply • Systemic waste causes • Interventions – Prevention • Interventions – Value Add • Other key messages	MM
2.32	**PREPARATION FOR GROUP ACTIVITY** • Discuss the shortlisting process and summarise the shortlisted strategies. • Explain process for group activity. • Use break-out rooms to divide participants, provide recording sheet for facilitators	MM AR
2.45	**GROUP ACTIVITY** **Group 1 – Strategies 1-5 plus other, Group 2 – Strategies 6-10** Break out rooms to discuss: 1. Value of the strategy - think about: • Financial feasibility/ Technical feasibility/ Volume to be impacted and the Australian food and drink recovery hierarchy. • Is it relevant/appropriate/ will it gain support/will it make a difference? • What we want to achieve through this strategy? 2. Generate Actions that could be included. 3. Suggest a Time frame: Quick win (short-term, 1-3 year), medium term (3-5 year) and long term (5-10 year) 4. Nominate Who will take the lead? Who else can contribute? **Notes to be taken on discussion recording template.**	MM / HB
3.30	**<u>Report back from group activity</u>** Each group chooses 5 key points they would like to make about the strategies they were reviewing and offers any strategies they identified as being omitted. •	MM
3.45	Summary and wrap up	HB
4.00	Workshop close	HB

Table A2.5: Workshop 2 Group Activities Recording Template

Strategies	Feedback on strategy including financial feasibility/ technical feasibility/ volume of waste to be impacted / outcome	Actions that could be included as part of this strategy	Time frame for the strategy – or possibly actions Quick win (s/t, 1-3 yr) medium term (3-5 yr) long term (5-10 year)	Leadership and participants	Other comments
Strategy 1 Ensure a consistent supply of **skilled labour** for the Melon industry and supply chain.					
Strategy 2 Encourage **best practice production** to improve product quality and reduce on-farm waste.					
Strategy 3 Enhance **R&D** for pest and disease management and genetic development.					
Strategy 4 Plan and maintain **supply and demand balance** in the production system (e.g.: improved forecasting, alternative contract options and diverse market development).					
Strategy 5: Improve **transport and storage** to reduce melon damage and deterioration.					
Strategy 6: Develop a strategy to **change consumer perceptions**. – improve confidence and trust in fruit quality and increase demand.					
Strategy 7: Explore melon **processing options to determine** the feasibility of value-added products and the infrastructure and investment requirements.					

Strategies	Feedback on strategy including financial feasibility/ technical feasibility/ volume of waste to be impacted / outcome	Actions that could be included as part of this strategy	Time frame for the strategy – or possibly actions Quick win (s/t, 1-3 yr) medium term (3-5 yr) long term (5-10 year)	Leadership and participants	Other comments
Strategy 8 Maintain an awareness of new and emerging technology and consider the application to the Melon industry and quality throughout the supply chain.					
Strategy 9 Develop better waste **data collection** mechanisms across the melon supply chain.					
Strategy 10: **Other** (any omissions?) Retail behaviour and staff education					

2. Key Findings from the Melon Reference Panel

This summary was prepared by collating interview and workshop insights for use by the research team during the data collection and triangulation phases.

2.1 Where are the hotspots?

- The largest point of food waste in the melon supply chain **is on Farm**. This usually occurs in the field where the decision point– "**is it worth sending?"** arises. Melons – especially watermelons are largely picked, and graded in the paddock and if they are deemed suitable to send to market are packed into 300kg cardboard bins in the field, if not- they are left in the paddock. This decision is made by evaluating criteria for saleability including ripeness, evidence of damage/disease, size and shape etc. Growers suggest that as much as 40% of the crop may be wasted at this point. Rock and Honeydew melons need to be cleaned and are sent to the shed for washing, packing and grading into trays that reflect their size. This then becomes the '**is it worth sending?"** decision point – although some of this occurs in the field.

- melon producers tend to be very cognisant of what they will be paid for and what they won't and given that they have already invested in the whole crop, further investment in packing/packaging/transport etc needs to provide a return. Watermelons, particularly, are very large and heavy and are expensive to transport so if it isn't going to provide a financial return it is better to cut your losses and leave it behind.

- Other hot spots where melon food waste is created include the following, they are not ranked as the actual quantum lost at each point is unclear- even under debate. Individually is not likely to be anywhere near the amount lost on farm.

- Testing the quality of the ripeness and quality of a melon is a destructive process and is only revealed when the fruit is cut. Most external symptoms of a problem are picked up on farm and the fruit is rejected at this point.

- A further (external) quality check is undertaken at the market or distribution centre. if the fruit arrives and does not make quality standards or if there is an oversupply it may be rejected, and attempts are made to find an alternative home even if it is at a reduced cost. Damage caused during transport often becomes evident at this stage or even later in the supply chain.

- RETAIL. The amount of waste on the shop floor (retail) is under debate and there are conflicting reports of the quantum. These may differ according to whether the fruit is offered whole or cut. Retailers want customers to have confidence that what they are buying is of good quality and are reluctant to offer fruit that may lead to a bad experience and discourage the shopper from returning.

- TRANSPORT. While the proportion of melons lost during transport is probably not in the league of the other supply chain stages it should be avoidable. Melons are often stacked 3 large cardboard bins on pallets high and bins are known to collapse and create "fruit salad in the truck" Fruit is also known to be temperature impacted or have accelerated ripening during transport – if this is the case the waste will actually occur at the market or the Distribution centre.

- In the melon industry the product is owned by the grower until it is accepted by the retail purchaser. Growers/ Marketers/agents tend to work very hard to ensure that all fruit is sold – to someone, even if it means accepting a price reduction. If the melon is edible and unsellable in a major metropolitan centre, it may be offered to a food rescue organisation.

- The forces of supply and demand come into play along the Melon supply chain and influence price variability and the acceptable quality level impacting the decision point to progress through

the supply chain.

2.2 What causes Melon food waste?

- On farm waste can be caused by weather damage, too much rain, not enough rain, sunburn, and major events like floods/droughts.

- Agronomic issues/ practices e.g., crop disease (of which there are many – see photos supplied), pest management (insects, grubs, wild pigs), plant nutrition and water supply can all cause damage which makes the fruit unacceptable for sale. Melons are grown in very large paddocks outside - subject to the elements and a lot of factors that can't be controlled. Growers suggest that crop disease is unpredictable and although trials are conducted, and treatments are available it is still very 'hit and miss'.

- Oversupply Melon growers as a cohort grow more than they need to, to make sure that enough is saleable. Although melons can be grown around Australia all year round, and some growers make an effort to time their crop so as not to coincide with other producing areas it is difficult to forecast demand and to restrict supply to the appropriate amount. This is exacerbated by the very short lead in time – a farmer who may not have success with another crop may decide to turn to watermelons in an attempt to get a better return and can have a crop for sale in a couple of months. These ad hoc growers are known to detrimentally effect supply and may not produce the best quality fruit thereby jeopardising the quality proposition that the regular and serious growers are promoting.

- Supply and demand are not necessarily transparent and can create an incentive for growers to plant more which then creates more waste and/or lowers the price.

- Some growers focus on quality product while others focus on quantity – the latter can flood the market with poor produce leading to a reduction in price/return for all – if the price is too low some growers will withdraw and not send – product goes to waste – the ad hoc growers referred to above increase this issue.

- Seasonal supply – traditionally melons are seen as a summer fruit, so demand is less in winter, if supply is high waste is high.

- Propagation of watermelons is done through the planting of seeded melons known as "propagators" given that customers have shown a preference for seedless melons these propagators, although edible are left in the field. It has been suggested that up to one in four melons in a paddock is a propagator.

- Labour force issues on the farm including lack of staff availability at the right time and the cost of labour, workforce turnover and transience and lack of skills/experience/ training all lead to crop being left behind or damaged or inappropriately graded or packed – before it leaves the farm.

- Harvest loss/waste can be human error (bad technique, mechanical damage, poor timing).

- Inappropriate varieties or growing area. Need to grow the right variety in the right place that produces the best quality and reduces risks. Poor growing conditions produces low quality fruit which discourages purchase and drives the price down.

- Retailers suggested that consumers have high aesthetic and quality standards (specifications) and require these from growers (and across the supply chain) so substandard product is rejected on farm, in packing/grading, retail. There was a perception across the

reference panel that as a society we have set our expectations too high over a long period of time and we are looking for 'perfection' and buying on appearance not necessarily taste or nutrition This can lead to the rejection of a melon because it has a scratch or patchy skin.

- As a large fruit, consumers rarely buy whole watermelons – they are heavy to carry, difficult to refrigerate and become over ripe quickly. This leads to a retail preference for smaller or cut melons. Consumers also prefer seedless melons which has contributed to the waste of the propagators discussed earlier.

- Fresh food is not stable and has a limited storage/shelf life. Time from paddock to plate can be very short – esp. when ripening is not controlled. Melons cannot be picked green and later ripened, if picked green they won't ripen once they are ripe, a ripe melon has an edible life of 2-3 weeks after picked.

- Picking unripe fruit – that does not go on to ripen. A sampling project conducted by a large Supermarket demonstrated that all Honeydew melons it received during a month were all under ripe.

- Poor storage or transport esp. cold food chain – mixing products that have different temperature requirements in the one truck or cold room. Changes in temperature caused by mechanical failure or human error.

- Melons can also be damaged in transportation. If not packed properly, loads can move, and bins can collapse. Rough roads and drivers in a hurry increase this risk. A load of melons from Sunshine Coast to Sydney or Adelaide takes 3-5 days.

- As large fruit watermelons take a lot of transport cubic meterage, and this is becoming more difficult to secure freight space in a timely fashion – Reference panel members noted that this is being exacerbated by the recent collapse of several major logistical firms. If the grower can't or has to wait to source transport the fruit can ripen reducing its shelf life and saleability.

- Retail specifications look for uniformity in produce- nature is not uniform – melons vary in their size and appearance so there will always be some edible fruit that is not acceptable due to its appearance.

- In house policies and practices of retailers. Businesses large and small have standards that they expect for the fruit that they sell that align with the value proposition they are offering the consumer. There are reports that retailers discard cut melon in a short time after it is cut. While there are food safety standards that dictate the shelf life of a cut melon, there are suggestions that some retailers are discarding at a time milestone below this – increasing the waste.

- Labour force issues in the Supermarket. Workforce transience and age and rostering model can mean that the staff are not confident in the displaying and handling of horticulture product – this can lead to damage and waste.

- While melons are not as delicate as some other Horticultural produce there is still a risk of damage caused by People – on the farms, in the sheds, transporting products, in supermarkets.

3. Strategies to reduce Melon food waste

3.1 Prevention

- Improve the **road network and/or build the efficiency and capacity of the rail network** so product can arrive at market quicker and in better condition.

- **Crop breeding** to provide varieties with greater yield, greater resistance to disease/damage, closer to specifications or with longer shelf life.

- **Use of technology** that can gauge the ripeness and quality of the fruit without being destructive – sensors. Some of these are in current use but further work is needed at the moment a good picker is as reliable as the sensor. e.g., SCiO: Instant Produce Quality Analysis (https://www.youtube.com/watch?v=VeiYng1zNg4)

- "**Planned production**" - Grow what you can sell – less speculative growing and more alignment between demand forecasting and what is grown. The suggestion from project participants was to work with growers who strive for quality. Melons Australia is currently involved in a 'quality project' It was noted that younger educated growers tend take up new ideas better and quicker than older or multigenerational farmers with no off-farm experience.

- **Agronomic improvements.** Conducting research and trials into better farming practices e.g. – disease and pest control, fertiliser usage, irrigation, alternative varieties etc. Improved agronomics reduces waste caused by disease, plant nutrition and water issues.

- **Develop the capacity and knowledge of farmers.** Best practice farming generally produces higher yields and less waste. Best practice growers tend to be alert to emerging trends and initiatives and are willing to change/evolve – traditional and generational farms tend not to be so progressive in their thinking.

- By 2025 **food safety legislation will provide standards** in the melon supply chain. At the moment many growers and agents have this certification but not all. Compulsory certification may lift product quality and consumer confidence and reduce waste.

- **Cold food chain improvements** including real time data collection of location and temperature.

- Consider options to **strengthen or replace the current cardboard bin system** to prevent in transit damage.

- **Education of retailers** regarding handling, displaying, and communicating with customers on storing and using Melons.

- **Increase demand** for Melons so that more production is utilised – either domestic or export. Some export is currently occurring but is limited due to the risk of pest and disease. Could consider how these risks can be managed to open up additional export markets?

- **Educate the customers about the range of uses for Melons** – they are many more options than just peeling and eating fresh – e.g., recipe cards, web-promotion. The American website Recipes - Watermelon Board provides a range of alternative uses of watermelon. A simple internet search will also show other uses and recipes. Increasing the awareness of these options can reduce waste.

- **Promote the utility of the Melon**, its ease of eating, the nutritional benefit and how it aligns with a lot of popular dietary trends. Information on the correct and easy storage of melons would also further empower the consumer.

- **Nationwide promotional campaign** to get everybody conscious of food waste and playing their part.

3.2 Value add usage

- **Alternative foods via further processing** (e.g., beverages/freezing/drying) or value add (wine/chips/candy/ice blocks) The specifications for processing fruit are not as tight as fresh food, shelf life of frozen/ dried or otherwise stable foods last a lot longer than fresh. There is not currently a lot of this happening although the potential is there.

- Develop a **centrally located or mobile processing facility** that takes waste from a range of growers to achieve critical mass and consistent supply of product especially pulp for juice.

- Potential for a **cross industry processing facility** e.g., freeze drying could be applied to a range of horticultural products not just melons. Multi-use would increase the viability.

- Explore the nutritional analysis of melon rind investigate the potential as a supplement in a powdered form.

3.3 Food Rescue (FR)

- Generally, Melon growers will try everything they can to find a sellable home for their fruit – agents/marketers also try to assist them with this – sending to a FRO would be only done if there is no option to gain any monetary value from it.

- Sending Melons to food rescue is suited better to points in the supply chain in the metropolitan areas. For example, a bin/ tray of melons, if edible, at the market or distribution centre could go to food rescue easily and cost effectively. However, if a grower needs to pick the fruit and pack it so that it can be collected this process will incur costs to the grower that are probably not acceptable so the fruit will be left in the paddock.

- Some growers have roadside stalls where they sell produce that can't go to market – but this can often be more trouble than it is worth.

- A tax incentive for Gowers to donate to FRO would be well received and may offset the costs that are required to get the waste from the production site to the FRO.

3.4 Constraints to reducing Melon food waste. (Overcoming these could be seen as potential strategies)

- There is a **lack of reliable data available regarding melon food waste**, its quantum, and causes. Some growers are not aware of the quantity, or the value of the lost income currently associated with Melon waste. Most seem to recognise the potential improved financial benefit of being able to sell more of the crop.

- **Disposal of Melon waste on farm is fairly cost effective.** By leaving it in the paddock and then ploughing it through with the vine no additional cost is incurred. If it were to be sent to a dump or a processing plant or even collected for Food Rescue that would require picking, packing, and transporting and the associated costs. By decomposing and incorporating into the paddock farmers are adding nutrients to the soil and disposing of waste all very cheaply.

- Encouraging collaboration in a competitive environment is difficult – risks of loss of competitive advantage. "**Competitive tension"** Like most horticulture producers Melon growers can be very protective of their innovations and practices that give them a competitive advantage. Collectives can provide benefit but only when they are all in.

- There are so many **factors beyond the control or influence supply chain actors** e.g.,

weather and climate, diseases, pricing “you can do as much planning as possible but there are still so many variables – so many things are out of our control”. (Quote from a grower)

- **The scope of the industry** Melons Australia has about 140 members which includes a lot of ‘support players’ not just growers. Melons are grown all over Australia, but it is hard to get a handle on how many growers there are when they are not all members of melons Australia. Very few growers do both watermelons and honeydew/rock melons as the growing practices and the infrastructure needs are different. There are only a couple of large corporate businesses the others tend to be family operated. Melons have a high focus on food safety and biosecurity which needs to be managed and adds costs.

3.5 Other key messages

- **Consumer confidence** is important – Given the nature of a melon there are difficulties in providing assurance of quality without cutting the melon. Customers are risk adverse and want to trust that what they are buying is a quality product. One supermarket suggested that consumers who want a whole melon are inclined to buy 2 cut halves so they can see what they are getting – not one whole (that is too risky).

- **Questions regarding the definition of food waste** – is a Melon skin food waste? (there is a lot of that) What about produce that for some reason does not meet food safety – is this considered food waste? Should we distinguish between edible food waste and inedible? What about the propagators that were not grown to be eaten, even if they are edible that was not the intent of growing them

- It was claimed that the **Supermarket chains have incredible mark ups** e.g. $300/tonne to the grower sells in the retail store for $3/kg (i.e. $3000 gross) If the price is high the Supermarkets can stop buying for a few days until there is a glut and then the price drops and they can return to their mark up. (project participants in interviews)

- **Grow what you know you can sell** – plan and forecast demand and then grow that – this is still fraught with problems esp. ‘uncontrollable’ like weather.

- We are in a sector that is powered by **driving farm prices down** – how do we change the paradigm so that it is about driving quality up? Demonstrate that it is worth paying more for a top quality and tasting product.

- Chep **pallets have been in short supply** and there are concern about the ongoing availability of cardboard to make the 300 kg bins – this is due to conservation of timber forests etc. This could complicate the transport of melons to market and potentially increase the amount of product unable to be moved and therefore wasted.

- Concern that big melon growers are unable to give their crop the attention that high quality needs only small growers can do this – however the big growers are getting bigger, and the smaller growers are getting squeezed out – not a positive future for the industry.

- Consider the **nutritional composition of Melons?** this may provide insights/opportunities for further usage in a processed form.

- Suggestion that melon waste should be measured in percentage – not in volume or weight.

- Participants suggested that there may be a **clash of business models given the difference between the drivers of retail business success and agri business profit?** The concept was explained by considering the retailer as a large corporate with shareholders and a responsibility to turn as big a profit as possible and the grower as someone who wants to get maximum return on their inputs but is impacted by a lot of factors beyond their control. The question raised was, does

the difference in business priorities create waste?

- **Is the 'free' market working properly** if the fundamentals of an efficient market are transparency and equal information being available to both the buyer and seller, the suggestion is no it is not working properly. Direct grower to supermarket relationships and confidential supply agreements has reduced the transparency and openness of information. It has been suggested that we need to get around the market power imbalance of a few major retailers and lots of growers. In terms of competition policy, the pendulum has swung to the total free market, there is not much regulation in the F&V market. Need to question, does a free market domestically suit the Horticulture Industry? Is there potential to consider options to the free market.

- Innovation is expensive, capital is tight and with interest rates increasing **funding for waste reduction strategies may be difficult.**

Appendix 3. Stakeholder Engagement Plan

International best practice standard for stakeholder engagement is provided by the International Association of Public Participation, IAP2. Their frameworks and guidance have informed effective stakeholder engagement for over twenty years. Allocation of stakeholders to the IAP2 Stakeholder Spectrum illustrates the impact and influence of the stakeholder on the Project. The IAP2 promise indicates the type and focus of engagement. These are matched with tools and initiatives for delivering effective stakeholder engagement.

Table A3.1 Stakeholder Engagement Plan to support the Melon Action Plan

Project name	Stakeholder Engagement Plan to support the Melon Action Plan	**Date:**	November 2022
Impact	Stakeholder impact increases along the spectrum		

INFORM	**CONSULT**	**INVOLVE**	**COLLABORATE**	**EMPOWER**
Promise:	**Promise:**	**Promise:**	**Promise:**	**Promise:**
We will keep you informed.	We will keep you informed, listen to and acknowledge concerns and provide feedback on how your input influenced the decision.	We will work with you to ensure that your concerns and aspirations are directly reflected in the alternatives developed and provide feedback on how your input influenced the decision	We will look to you for direct advice and innovation in formulating solutions and incorporate your advice and recommendations into the decisions to the maximum extent possible.	We will implement what you decide.
Stakeholders:	**Stakeholders:**	**Stakeholders:**	**Stakeholders:**	**Stakeholders:**
• Relevant government departments • Rural and food media	• SFWA and FFW CRC partners • RDCs • ARC • Transport Industry Assoc • Melon Farmers	• Transport Companies: e.g., TOLL, DHL, Fox, Nolan's • Food Retailers • Hort Innovation • QDES	• Melon Reference Panel • Major Food Retailers such as Coles & Woolworths • Major Melon wholesalers • Major Melon farmers/corporate operators. • Known expert in this area (if there is one)	• SFWA / FFW CRC • Melons Australia

Tools:	Tools:	Tools:	Tools:	Tools:
• Website • Information updates • Media release	• Website • Information updates • Sharing information - being told what's happening with option to respond.	• Website • Information updates • Share drafts with clear pathway to respond (could include topical workshops if sufficient interest?) [1]	• Advisory meetings • Agreement on Design Principles • Co-Design workshops • Initial Review of Drafts • Collaboration in developing collateral for others in supply chain.	Board Briefings Co-Design workshops

[1] CONSULT & INVOLVE – if a stakeholder interested, with good advice – can move within the Spectrum, e.g. some SFWA partners may seek higher engagement