Final report

Evaluation of methyl bromide fumigation on avocado quality

Project leader:

John Golding

Delivery partner:

NSW Department of Primary Industries and Regional Development

Report author/s:

John Golding and Thuy Pham

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Level 15
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Telephone: (02) 8295 2300

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Public summary

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Methyl bromide treatment is a widely used market access treatment for many Australian horticultural crops and is widely used and accepted around the world. However, the effects of methyl bromide treatment on avocado fruit quality have shown inconsistent results. The project assessed the effects of two commercial methyl bromide treatment schedules on fruit quality of both Shepard and Hass avocados for a total of three different fruit tolerance trials. Within each trial, the project explored whether pre-treatment practices such as avoiding cold storage prior to treatment can improve or affect final fruit quality outcomes. Standard fruit quality assessments after treatment and storage with shelf life were assessed. The results showed minor differences in fruit quality between treated and untreated fruit after fumigation and after storage. However, these small differences were considered to have little to no commercial impact. This project was crucial for updating industry knowledge and guiding quality management practices across both domestic and export supply chains. Improved market access and increased diversification of export markets will increase growers' profitability.

Technical summary

Market access is crucial for the long-term profitability and sustainability of the Australian avocado industry. There is an increasing supply of avocados within Australia which necessitate increasing export opportunities for Australian avocados. However, these new export opportunities can be limited by phytosanitary quarantine barriers which require end-point treatments to ensure control of quarantine pests (e.g. Queensland fruit fly).

Methyl bromide treatment is a widely used market access treatment for many Australian horticultural crops and is widely used around the world. However, the effects of methyl bromide treatment on avocado fruit quality have shown inconsistent results. There has been little recent research reported on the tolerance of avocados to methyl bromide treatment. In a large study of 30 major and minor avocado cultivars in commercial production in Florida, 21 (70%) cultivars withstood methyl bromide fumigation (32 g/m^3 for 2.5 hours at 21.1˚C) followed by 7 days of storage at 7.2˚C (using USDA treatment schedule T101-a-2). While 14 cultivars tolerated treatment schedule (T101-c-1) consisting of methyl bromide fumigation at 32 g/m^3 for 4 hours (at 21.1˚C), followed by 3 days of storage at 7.2˚C (Witherell et al., 1982). Furthermore, other scientific literature has shown that the effects of methyl bromide fumigation on avocado fruit quality are variable.

To overcome this knowledge gap, this project assessed the effects of two commercial methyl bromide treatment schedules on fruit quality of Shepard and Hass avocados for a total of three different fruit tolerance trials. In consultation with the Project Reference Group (PRG) and technical experts, the following methyl bromide fumigation protocols were tested: 32 g methyl bromide per m^3 at 21 ^oC for 2 hours, and 24 g methyl bromide per m^3 at 26 ^oC for 2 hours. The fumigation was conducted by a licenced fumigator at NSW Department of Primary Industries and Regional Development (NSW DPIRD) in purpose-built methyl bromide research fumigation facilities at Somersby. The treatment conditions were tightly controlled and monitored to ensure proper treatment in an independent replicated manner. Within each trial, the project explored whether pre-treatment practices such as avoiding cold storage prior to treatment and delaying fumigation treatment can affect final fruit quality outcomes. In each trial, half of the fruit were treated with methyl bromide immediately upon receival at NSW DPIRD (i.e. when the temperatures had reached the required conditions), whilst fumigation of the other half the fruit was delayed by 2 days, in which time the fruit were stored at 20 ^oC for 2 days before the methyl bromide treatment.

After methyl bromide fumigation, fruit were degassed and either ripened and fruit quality was assessed after shelf-life, or fruit were stored for an additional 2 weeks at 7 ^oC then ripened and fruit quality assessed after a standard shelf-life period of time. Standard fruit quality assessments included weight loss, external colour (subjective and objective assessment), fruit firmness and colour (subjective and objective assessment), body rots, stem end rots, skin spotting, appearance of vascular tissue and flesh browning.

The results showed minor differences in fruit quality between treated and untreated fruit after fumigation and after storage. However, these differences were considered to have little to no commercial impact. This project was crucial for updating industry knowledge and guiding quality management practices across both domestic and export supply chains. The project will guide future R&D investments for improved market access and increased diversification of export markets will increase growers' profitability.

Keywords

avocado; market access; quarantine; fruit quality; exports

Introduction

Improved market access and maintenance of fruit quality through the supply chain is essential for the Australian avocado industry, supporting the growth of fresh avocado exports. Methyl bromide treatment is a widely accepted end-point treatment however there is a lack of reliable information on its effects on final fruit quality which limits making informed decisions on industry market development. This project delivered a greater understanding within the Australian avocado industry of how methyl bromide treatment impacts final fruit quality and shelf life of Shepard and Hass avocados.

There has been very little recent research reported on the tolerance of avocados to methyl bromide treatment and the reported effects on avocado fruit quality have been variable. In the 6 avocado cultivars trialled in Florida (Loretta, Black Prince, Beta, Choquette, Leonas and Booth 7), Carrillo *et al.* (2017) showed that methyl bromide treatment (from USDA treatment schedules - T108-a-2, T108-a-3 and T101-c-1) resulted in both internal (pulp) and external (skin) damage in all cultivars. In another large study of 31 cultivars in Hawaii, Ito and Hamilton (1980) showed all cultivars exhibited varying degrees of tolerance to methyl bromide fumigation as indicated by the extent of skin damage, but the fruit of all cultivars were affected. Fumigation damage during ripening was masked on dark-skinned purple to black fruit. Furthermore, the majority of green-skinned types showed obvious fumigation damage (Ito and Hamilton, 1980). However, Spalding *et al*. (1977) showed that methyl bromide fumigation did not result in skin injury immediately after treatment but increased anthracnose decay in four major avocado varieties. In another large study of 30 major and minor avocado cultivars in commercial production in Florida, 21 (70%) cultivars withstood methyl bromide fumigation (32 g/m^3 for 2.5 hours at 21.1˚C) followed by 7 days of storage at 7.2˚C (USDA T101-a-2) (Witherell *et al*., 1982). While 14 cultivars tolerated treatment T101-c-1 consisting of methyl bromide fumigation at 32 g/m^3 for 4 hours (at 21.1˚C), followed by 3 days of storage at 7.2˚C (Witherell *et al.,* 1982). The overall conclusion from the literature is that the effects of methyl bromide fumigation are variable.

To facilitate the development of potential data packages to allow the export of Australian avocados to phytosanitary export markets, this project assessed the effects of two methyl bromide fumigation schedules on avocado fruit quality following controlled handling, temperature and treatment conditions. The results of this project are crucial for updating industry knowledge and guiding quality management practices across both domestic and international supply chains.

Methodology

In consultation with the Project Reference Group (PRG) and technical experts, the following methyl bromide fumigation protocols were tested:

- 32 g/m^3 at 21 ^{o}C for 2 hours, and
- 24 g/m^3 at 26 ^{o}C for 2 hours.

These treatment schedules were in-line with other commercial fumigation schedules. Freshly harvested and packed avocado fruit were provided by Avolution and The Avocado Collective for the fruit tolerance trials (Table 1). All fruit were transported at ambient temperatures and were not refrigerated at any time before fumigation (Figure 1).

In each experiment 60 trays of export grade quality fruit were harvested at commercial maturity. Fruit were transported to Sydney / Ourimbah at ambient temperatures (non-refrigerated). Half of the fruit were treated upon arrival and the other half were stored for 2 days at 20^{o}C before treatment.

Before treatment, all fruit was allowed to equilibrate to its target treatment temperature (21 ^{o}C or 26 ^{o}C) prior to treatment with methyl bromide. The fruit treated upon arrival was designated ‘Time 1” while the fruit kept at 20 ^{o}C for an additional 2 days before fumigation was designated ‘Time 2’.

Table 1. Summary of avocado fruit trialled in the fumigation tolerance trials.

	Type	Region	Count/Size grade	Pick / pack date
Experiment 1	Shepard	Bundaberg (Qld)	23	14 April 2025
Experiment 2	Hass 1	Bundaberg (Qld)	20	23 June 2025
Experiment 3	Hass 2	Blackbutt (Qld)	25/28	1 September 2025

At each of the fumigation times, fruit were treated with one of two methyl bromide treatment schedules:

Treatment 1. 32 g/m^3 at 21 ^{o}C for 2 hours, and

Treatment 2. 24 g/m^3 at 26 ^{o}C for 2 hours.

After treatment, treated (and corresponding control) fruit were degassed and half of the fruit were ripened at 18 ^{o}C with 5 ppm ethylene and 90 % relative humidity (RH). After ripening the fruit were transferred to 20 ^{o}C storage / shelf life for 2 days before fruit quality assessments. The other half of the treated fruit were stored in air at 7 ^{o}C for 2 weeks. After cold storage, the fruit were warmed to 18 ^{o}C and then ripening was initiated with 5 ppm ethylene and 90 %RH. After ripening the fruit for 24 hours, the fruit were transferred to 20 ^{o}C storage / shelf life for 2, 3 or 4 days (depending on the ripeness of the fruit – as described in the Methods for each trial) before fruit quality assessment (Table 2). A generalised plan of the handling, treatment, storage and ripening that was used in each trial is presented in Figure 1. A summary of the timetable for the fruit quality assessment times for all trials is presented in Table 2.

Three replicates were allocated from the same batch of fruit. Each replicate was treated in a separate fumigation chamber, i.e. independent application of the treatment (Figure 2). Untreated (control) fruit from the same batch were handled and stored in the same way but without methyl bromide treatment.

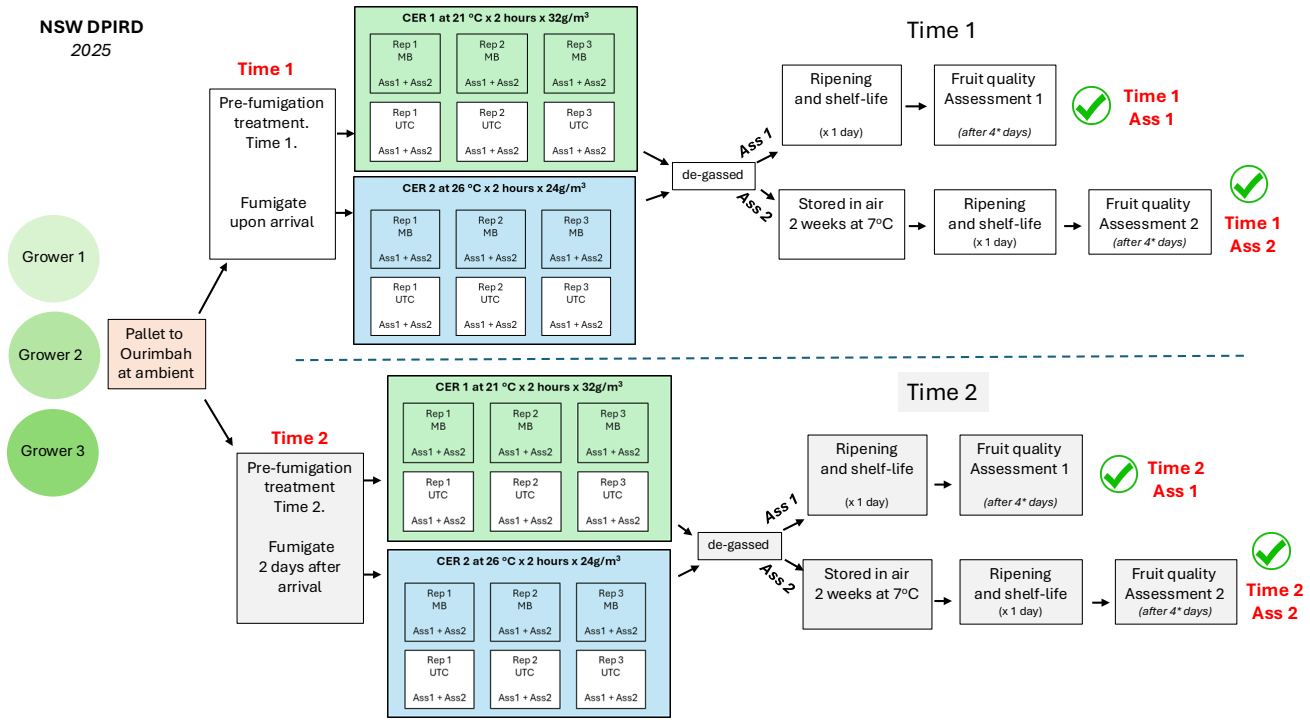

Figure 1. Generalised plan of handling, treatment, storage and ripening of avocados for fruit tolerance trials.

Table 2. Timetable of fruit quality assessment times.

Assessment time	Description	Fumigation time	Handling / ripening / shelf-life time
1	Time 1 – Time zero	Assessed at fumigation Time 1 (fumigated upon arrival)	
2	Time 2 – Time zero	Assessed at fumigation Time 2 (fruit held for 2 days at 20 °C before fumigation)	
3	Time 1 Assessment 1	Pre-fumigation treatment 1 = fumigate upon arrival	Ripened and stored at 20 °C for 4/3/3 days* (Assessment 1)
4	Time 1 Assessment 2	Pre-fumigation treatment 1 = fumigate upon arrival	Cool stored at 7 °C for 2 weeks then ripened and stored at 20 °C for 3/3/3 days* (Assessment 2)
5	Time 2 Assessment 1	Pre-fumigation treatment 2 = fumigate after 2 days at 20 °C	Ripened and stored at 20 °C for 4/2/3 days* (Assessment 1)
6	Time 2 Assessment 2	Pre-fumigation treatment 2 = fumigate after 2 days at 20 °C	Cool stored at 7 °C for 2 weeks then ripened and stored at 20 °C for 2/2/2 days* (Assessment 2)

** Days of shelf-life at 20 °C after ripening before quality assessment of Shepard / Hass 1 / Hass 2 storage trials, respectively.*

Fruit quality assessments were conducted in accordance with standard industry assessment. At each assessment time the following quality measures were assessed; weight loss, external colour (subjective and objective assessment), fruit firmness and colour (subjective and objective assessment), body rots, stem end rots, appearance of vascular tissue and flesh browning. Detailed materials and methods are presented in Appendix 1.

Figure 2. Treatment of avocado fruit in purpose-built fumigation chambers at NSW DPIRD (left). Note separate fumigation chambers for each independent replicate of each fumigation treatment. Monitoring fruit pulp temperatures during treatment (middle) and assessing fruit quality at NSW DPIRD (right).

Results and discussion

There were no consistent effects of the two methyl bromide schedules on the fruit quality of Shepard and Hass avocados following storage and shelf life. When statistical differences in fruit quality between untreated and treated fruit were observed, these differences were considered to have little to no commercial impact. An overview of the results of the individual fruit tolerance trials are summarised in Table 3. These assessments compared the effects of methyl bromide treatment against an untreated control on the individual aspects of avocado fruit quality; weight loss, external colour (subjective and objective assessment), fruit firmness and colour (subjective and objective assessment), body rots, stem end rots, appearance of vascular tissue and flesh browning.

For each methyl bromide treatment schedule, fruit quality was assessed at 4 different assessment times (Table 2). The results showed that as the fruit was stored for longer periods of time, fruit quality declined with increasing levels of rots (body rots and stem rots) and increased flesh discolouration. However, the overall fruit quality in all experiments was still good even after at the final assessment time (Assessment 2).

There were no differences in quality outcomes between the different methyl bromide treatment schedules (Treatment 1. 32 g/m^3 at 21 ^{o}C for 2 hours, and Treatment 2. 24 g/m^3 at 26 ^{o}C for 2 hours). There were no consistent differences between treated and non-treated fruit for each treatment schedule (Table 2).

A snapshot of the effects of methyl bromide treatment, cold storage and shelf life is presented in Figure 3. This comparison is of Hass avocados (Hass 2) which were treated with the highest methyl bromide treatment concentration (32 g/m^3 at 21 ^{o}C for 2 hours) following a delay of 2 days at 20 ^{o}C before fumigation. After fumigation, this fruit was de-gassed and cool stored at 7 ^{o}C for 2 weeks then ripened then stored at 20 ^{o}C for 2 days for shelf life (Time 2 - Assessment 2). This is the worst-case scenario for delays, treatment and storage, and the results showed no difference between treated and untreated fruit which went through the same handling and storage regime.

A summary of the results for each trial is presented below. The full results and detailed descriptions of the individual experiments for Shepard, Hass 1 and Hass 2 are presented in Appendices 2, 3 and 4, respectively.

Shepard. In general, there was no effect of either of the different fumigation treatment schedules on fruit quality (weight loss, external colour (subjective and objective assessment), fruit firmness and colour (subjective and objective assessment), body rots, stem end rots, appearance of vascular tissue and flesh browning. As expected, skin spotting increased in all treatments with storage and shelf life. Methyl bromide treatment slightly increased the levels of skin spotting at some assessment times, but this was not considered commercially significant.

Hass 1. There were no commercial differences in fruit quality between treated and untreated fruit after storage and shelf life. Some of the treated Hass fruit remained greener for a short period of time after initial treatment, but after storage and shelf life these differences were no longer detected. In general, methyl bromide treatment did not negatively affect final fruit quality.

Hass 2. The results of Hass 2 experiment showed that in general, there was no commercial difference between untreated fruit and both methyl bromide treatment schedules of Hass 2 avocados. There were some minor statistical differences detected in some quality attributes such as statistical increase in rots at the final assessment times, but these differences were not commercially significant. In general, methyl bromide treatment did not negatively affect final fruit quality.

Table 3. Summary of the effects of methyl bromide fumigation treatment (32 g/m^3 at 21 ^{o}C for 2 hours, or 24 g MeBr/m^3 at 26 ^{o}C for 2 hours) on the ripening and storage of Shepard, Hass 1 and Hass 2 avocado fruit quality. Fruit were treated at two fumigation times (Time 1 = upon arrival, and Time 2 = after 2 days delay at 20 ^{o}C). Fruit quality was assessed on different batches of fruit after ripening and shelf life (Assessment 1) and also after 2 weeks storage, ripening and shelf life (Assessment 2). Each tray contained at least 20 fruit and each treatment was replicated three times. 'no' means no statistical difference detected between treated and untreated fruit at the same assessment time ($p \leq 0.05$). Significant differences ($p \leq 0.05$) between treated and untreated fruit are highlighted and described.

** Note that in these experiments, these statistical differences ($p \leq 0.05$) between treated and non-treated fruit did not result in commercial differences and were still acceptable.*

Table 3 continued. Summary of the effects of methyl bromide treatment on avocado fruit quality.

Shepard								
	32 g MeBr/m^3 at 21 °C for 2 hours				**24 g MeBr/m^3 at 26 °C for 2 hours**			
Quality parameter	Assessment 1		Assessment 2		Assessment 1		Assessment 2	
	Time 1	Time 2	Time 1	Time 2	Time 1	Time 2	Time 1	Time 2
Overall acceptability	no	no	no	no	no	no	no	no
Weight loss (%)		no	more*	no		no	no	no
Firmness (objective)	no	no	no	no	no	no	softer*	no
Firmness (subjective)	no	no	no	no	no	no	no	no
Skin colour (subjective)	no	darker*	darker*	no	no	no	no	no
Skin colour (L* value)	no	no	no	no	no	no	no	no
Skin colour (Chroma)	no	no	no	no	no	no	no	no
Skin colour (hue angle)	no	no	lighter*	no	no	no	lighter*	no
Skin lenticel spotting	no	no	more*	more*	no	more*	no	more*
Flesh bruising	no	no	no	no	no	no	no	no
Stem end rots	no	no	no	no	no	no	no	no
Vascular tissue	no	no	no	no	no	no	no	no
Diffuse discolouration	no	no	no	no	no	no	no	no
Body rots	no	no	no	no	no	no	no	no
Hass 1								
	32 g MeBr/m^3 at 21 °C for 2 hours				**24 g MeBr/m^3 at 26 °C for 2 hours**			
Quality parameter	Assessment 1		Assessment 2		Assessment 1		Assessment 2	
	Time 1	Time 2	Time 1	Time 2	Time 1	Time 2	Time 1	Time 2
Overall acceptability	no	no	no	no	no	no	no	no
Weight loss (%)		no	no	no		no	no	no
Firmness (objective)	no	no	no	no	no	no	no	no
Firmness (subjective)	firmer*	no	no	no	firmer*	no	no	no
Skin colour(subjective)	greener*	no	no	no	greener*	no	no	no
Skin colour (L* value)	lighter*	no	no	no	no	no	no	no
Skin colour (Chroma)	brighter*	no	no	no	no	darker*	no	no
Skin colour (hue angle)	greener*	no	no	no	greener*	no	no	no
Flesh bruising	no	no	no	no	no	no	no	no
Stem end rots	no	no	no	more*	no	no	no	no
Vascular tissue	no	no	no	lower*	no	no	no	no
Diffuse discolouration	no	no	no	no	no	no	no	no
Body rots	no	no	no	no	no	no	no	no
Hass 2								
	32 g MeBr/m^3 at 21 °C for 2 hours				**24 g MeBr/m^3 at 26 °C for 2 hours**			
Quality parameter	Assessment 1		Assessment 2		Assessment 1		Assessment 2	
	Time 1	Time 2	Time 1	Time 2	Time 1	Time 2	Time 1	Time 2
Overall acceptability	no	no	no	no	no	no	no	no
Weight loss (%)		no	no	no		no	no	no
Firmness (objective)	no	no	no	no	no	firmer*	no	no
Firmness (subjective)	no	no	no	no	no	no	no	no
Skin colour(subjective)	no	no	no	no	no	no	no	no
Skin colour (L* value)	no	no	no	no	no	no	lighter*	no
Skin colour (Chroma)	no	no	no	no	no	no	brighter*	no
Skin colour (hue angle)	no	greener*	no	no	no	no	no	no
Flesh bruising	no	no	no	no	no	no	no	no
Stem end rots	no	no	no	no	no	no	no	more*
Vascular tissue	no	no	more*	no	no	no	no	no
Diffuse discolouration	no	no	no	no	no	no	no	no
Body rots	no	no	no	no	no	no	no	more*

Figure 3. External and internal appearance of Hass avocado fruit (Hass 2 experiment) treated with 32 g/m^3 at 21 ^{o}C for 2 hours following a delay of 2 days at 20 ^{o}C before fumigation. After fumigation, all fruit were de-gassed and cool stored at 7 ^{o}C for 2 weeks then ripened and stored at 20 ^{o}C for 2 days for shelf life (Time 2 - Assessment 2).
Untreated fruit that had not been fumigated are on the left and treated fruit are on the right.

Outputs

A summary of the project's outputs is presented in Table 4.

Table 4. Output summary

Output	Description	Detail
Regular updates to Hort Innovation and industry	Regular reports on project results were made available to industry through PRG and Hort Innovation	Detailed project updates were provided to PRG and Hort Innovation at all MS. Results and updates were also provided and discussed with Hort Innovation-approved parties e.g. additional project updates to industry and FASTA.
Final report	Final report including results of avocado fruit tolerance trials	This final report (MS190) delivered all project results including (a) the effects of methyl bromide fumigation on avocado quality and shelf life for Hass and Shepard, incorporating two different schedules and different pre-treatment management practices, (b) pre-treatment management practice recommendations that improve fruit quality undergoing fumigation, and (c) implications of findings for domestic and internation trade.
Project article and presentation	Communication of project results to broader industry through an article and presentation	A summary of the project results was reported to industry through an extension article. This was submitted for inclusion in the industry grower magazine – '*Talking avocados*' (presented in Appendix 5).
Project Reference Group	Project Reference Group to provide input to trial design and project communications	Regular consultation with the Project Reference Group with membership from key industry stakeholder groups was undertaken. Project updates, meeting reports and minutes were regularly distributed to the PRG during the project.
Project governance documents	Program logic, monitoring and evaluation (M&E) plan, risk register, stakeholder engagement/communication plan, 4-monthly milestone status reports	All key project governance documents (program logic, monitoring and evaluation plan, risk register, stakeholder engagement/communication plan) were delivered at Milestone 102 and accepted by Hort Innovation. All milestone reports were delivered on-time and provided a project progress overview suitable for public dissemination.

Outcomes

A summary of the outcomes of the project is presented in Table 5.

Table 5. Outcome summary

Outcome	Alignment to fund outcome, strategy and KPI	Description	Evidence
The project determined the tolerance of Australian avocados (Hass and Shepard varieties) to methyl bromide fumigation	SIP Outcome 1: Demand creation - Strategy 4. Improve technical access to high-value markets as identified within the export strategic plan	Three fruit tolerance / storage trials completed and reported. Milestone reports completed.	All PRG meetings held, minutes taken and distributed. All milestone reports completed. Final Report completed.
The avocado industry has a better understanding of the effects of methyl bromide fumigation on	SIP Outcome 1: Demand creation - Strategy 4. Improve technical access to high-value markets as identified within	Evaluation of methyl bromide treatment as an export market access treatment completed on two treatment	Final report delivered.

Australian avocados.	the export strategic plan	schedules.	

Monitoring and evaluation

The project performance as outlined in the project M&E plan and referenced to Key Evaluation Questions and is presented in Table 6.

Table 6. Key Evaluation Questions

Key Evaluation Question	Project performance	Continuous improvement opportunities
1. *Effectiveness* To what extent has the project evaluated the effect of methyl bromide as a postharvest phytosanitary measure for Australian avocados?	The project comprehensively evaluated the effect of methyl bromide treatment as a postharvest phytosanitary measure for the Australian avocado industry with fruit tolerance trials on Shepard and Hass avocado fruit.	The impacts of regional differences, on-farm management, pre-treatment handling (e.g. cooling) and postharvest handling scenarios upon fruit quality post fumigation could be evaluated.
Have all project activities, KPI's and outputs been achieved?	All project activities were successfully completed and reported.	All project activities were completed, and all KPIs / outcomes were met.
2. *Relevance* To what extent has the project met the needs of the Australian avocado Industry?	The project delivered the results of a series of fruit tolerance trials which will assist the avocado industry to make further investment decisions to improve market access.	A broader scope of industry requirements would have made the Project more applicable to different varieties, regions, handling conditions etc.
Are there any gaps or additional opportunities for research?	The impacts of different varieties, regional differences and on-farm management upon fruit quality post fumigation could be evaluated. Further work with different fruit handling scenarios, such as longer delays and cooling before treatment could be considered.	A wider scope of fruit and treatment conditions could have been evaluated.
3. *Process appropriateness* To what extent were the target engagement levels of industry levy payers achieved? Have regular project updates been provided to industry? Did the project determine the appropriate industry target segment for engagement? Did the project determine what level of engagement was required? Did the project engage with industry	The project engaged industry and Hort Innovation through regular PRG meetings. The PRG consisted of growers, exporters, industry representatives and Hort Innovation. Regular PRG meetings were conducted and reported. In addition, the results of the trials were frequently sent to PRG members (between PRG meetings). Updates to industry and research panels (with	Links between research projects and the avocado industry extension and communications projects could have been strengthened to increase industry awareness. However, these sorts of market access projects have some degree of industry sensitivity.

representatives for the appropriate target segment?	Hort Innovation approval) have been provided. An industry article of the key results has been submitted to '*Talking avocados*' to engage with the broader industry.	
4. Efficiency What efforts did the project make to improve efficiency? (including implementation of new technology, technique, practices, workflow etc.)	The project sourced high-quality fruit from leading commercial growers and treated the fruit within commercial times. This demonstrated the robustness of the project's outcomes.	Undertake comprehensive assessments to understand and manage treatment responses and manage fruit ripening through the handling, treatment and supply chain.

Recommendations

The following recommendations are made to build upon the results of this project and allow the avocado industry to make further progress in market access:

- Undertake further methyl bromide treatment research to allow the development of data packages that are required to facilitate new market access opportunities for Australian avocados.
- Examine the residue levels in treated fruit to ensure importing countries MRL levels are not exceeded.
- Examine the effects of methyl bromide treatment on fruit quality from different regions, times of the season, different handling conditions (e.g. delays in treatment and pre-treatment storage / cooling). Particularly examine the role of postharvest temperatures and handling conditions before fumigation to minimise fruit ripening during transit and to ensure fruit quality following fumigation, storage and shelf life is maximised.
- Examine the possible effects of potential methyl bromide injury, such as increased lenticle spotting, and explore pre-harvest and postharvest management factors to prevent and/or minimise these potential issues.
- Explore alternatives to methyl bromide fumigation as a phytosanitary treatment. Alternative options could include:
    - Making cold treatment an option for market access by overcoming fruit chilling injury. This may include the use of modified atmospheres to mitigate chilling damage during cold treatment (18 days at 3 ^{o}C).
    - . Development of novel combination treatments such as controlled atmosphere stress treatments and cold storage to kill quarantine pests whilst maintaining fruit quality.

Refereed scientific publications

Request submission for article for peer review and scientific publication:

Tentative title and journal - '*Effects of methyl bromide treatment on the quality of avocado fruit after treatment and storage*' - for submission / publication in New Zealand Journal of Crop and Horticultural Science. (https://www.tandfonline.com/journals/tnzc20)

The reporting of the results of this project to the wider scientific community will enhance Australia's R&D status and improve industry knowledge of the effects of methyl bromide fumigation on avocado fruit quality.

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Intellectual property

No project IP or commercialisation to report.

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Appendices (Confidential)

Appendix 1. Experimental summary, materials and methods

Appendix 2. Experiment 1. Effects of fumigation treatment on Shepard fruit quality

Appendix 3. Experiment 2. Effects of fumigation treatment on Hass 1 fruit quality – Trial 1

Appendix 4. Experiment 3. Effects of fumigation treatment on Hass 2 fruit quality – Trial 2

Appendix 5. Extension article

Appendix 6. Extension project poster