Hort Innovation

Final Report

Implementing best practice of avocado fruit management and handling practices from farm to ripening distribution centre

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Delivery partner:

Department of Agriculture and Fisheries

Project code:

AV18000

Project:

Implementing best practice of avocado fruit management and handling practices from farm to ripening distribution centre (AV18000)

Disclaimer:

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Public summary

This project identified and promoted improvements to practices in avocado supply chains from farms to retail distribution centres. The project team benchmarked farm and supply chain practices and performance, for review by industry supply chain personnel, and for the development of information resources. The most recent representative benchmarking of quality performance was undertaken in 2015 and projects leading up to 2019 suggested poor anecdotal adherence to best practice cool chain management.

Over the four years of 2019 to 2023, 179 supply chains were monitored with fruit originating in the five Australian production districts of Far North Queensland, central Queensland, central New South Wales, the Tristate area and south-west Western Australia. Data on farm/pack shed practices, cool chain practices and resultant fruit quality from supply chains was benchmarked and shared with the industry. The project identified and communicated the annual and district trends as well as the variability in fruit quality and management practices.

A key finding was that there is generally good fruit quality emerging from the avocado supply chains, with 87% of the individual fruit monitored meeting consumer expectations. This is very close to the industry's repeat purchase target of 90% of fruit with less than 10% damage. In response to this finding, the project team focused efforts on tracing back and identifying root causes in the 34% of supply chains not meeting the industry target for quality. The primary causes of suboptimal post-harvest quality were found to be: ineffectiveness of in-field disease control programs and coverage; the poor health of trees; unfavourable periods of weather; poor tree nutrition, the lack of postharvest fungicide treatment; and longer transit times in the supply chains.

The sampling of fruit that developed a nationally-representative fruit quality dataset was changed in the fourth year of sampling to a hybrid approach engaging marketers and pack-sheds, to make the process of sampling more cost-efficient. This had the added bonus of increasing the engagement of national marketers.

The project team took an agile approach to the development and delivery of training and information resources during the 2019 - 2023 period. Activities included face to face and virtual discussions, workshops, best practice resource content development and the delivery of a collection of articles and videos to help support adoption and supply chain management practice change.

Keywords

Avocado, fruit quality, cool chain, temperature, disease management

Introduction

A suite of previous R,D&E projects completed between 2005 and 2018 focused on improving industry capacity to supply fruit quality to a standard that meets the expectations of Australian consumers. In particular, temperature management in domestic supply chains was found to be variable in AV15004 and AV15010, but the link to fruit quality was not clear.

This project was undertaken to

- Measure changes in avocado post-harvest fruit quality (against the industry fruit quality target) and fruit robustness, quantifying the quality variability between farms and across value chains to consumers.
- Undertake a gap analysis of supply chains practices and then developing a targeted program to improve and implement best practice in those areas identified as being the highest risk/lowest performance.
- Monitor and measure the impact of practice change, utilising existing industry communications and extension channels to leverage program activities and drive adoption.

Methodology

The project methodology was made up of two concurrent parts. The first was the benchmarking of fruit quality, practices and performance in avocado domestic supply chains. The second part was a program of industry engagement to promote adoption of best practice by collaborating with broader industry personnel, to identify opportunities to improve fruit quality reaching the consumer.

The benchmarking approach evolved during the four years of the project

- From February 2019 to June 2020, data was collected from a minimum of 40 supply chains each year, from

the five districts in North Qld, Central Qld, central NSW, Tristate and WA, that direct fruit to Sydney and Melbourne. 90% of fruit sampled were Hass and the other 10% were Shepard. Data was collected about management practices used by each chain partner, temperature management through the supply chain from the farm to the retail distribution centres and fruit quality at medium to soft ripe stage. Project staff compared this data with the business' results, identifying areas for improvement and training.

- From Jul 2020 to Jul 2022, traceback investigations of those consignments the had >10% of fruit with >5% rots (where >5% rots is equivalent to >10% damage) was initiated to identify the root cause of problems. This offered timely engagement with those supply chains having poor fruit quality problems. Fruit maturity data was also recorded using near infra-red spectroscopy (NIR) to quantify the extent to which fruit maturity contributed to variability in ripeness. Spray diary information was collected for one year (5 districts and 40 supply chains) together with weather conditions to gauge the variability and impact of pre-harvest sprays. Duplicate sampling/measurement in each supply chain was also added to allow for the second sample to be stored (@5˚C for Hass and 7˚C for Shepard) for an extra 14 days prior to ripening. This robustness test simulated a supply chain closer to 30 days in length, likely in a crowded marketplace in an on-production year when demand cannot keep up with supply.
- From Aug 2022 to Mar 2023, temperature monitoring was ceased. Instead of being arranged at the pack sheds, sampling was planned at the distribution centres based on known supply chain relationships between growers, pack-sheds, wholesalers, ripeners and marketers. At the same time, the sampling rate was increased from 40 supply chains per year to 90 per year and tracebacks on the poor quality results identified in retail sampling (AV19003 project) was trialled.

Industry engagement for the entire project period (Feb 2019 to Mar 2023) included

- Provision of detailed confidential reports to supply chain businesses.
- Development of regional benchmarking reports to present non-confidential versions (de-identified results) to annual workshops of interested packhouse managers and growers in each of the five growing regions.
- Delivery of benchmarking presentations at AV17005 regional forums.
- A suite of information products including 2 case studies, 3 factsheets, 2 videos, annual webinars, 3 specialist speakers at regional workshops, 40 pages of updated and new BPR content and 5 Talking Avocado magazine articles.

The project governance and management provided the setting and oversight of project activities to ensure that the project team adhered to the monitoring and evaluation plan. For this project, the Department of Agriculture and Fisheries in consultation with Horticulture Innovation, established and managed a Project Reference Group which met every six months to provide governance and oversight of AV18000. This was supported by a review of the project after the first 12 months, which was undertaken by the avocado Strategic Investment Advisory Panel. Key project staff also met virtually every one to two months via the Project Management Committee. The project team were diligent in recording and distributing minutes, managing the operational aspects of the project, reviewing progress and ongoing planning of the project activities. This was particularly important through the ever-changing period of the covid-19 pandemic.

Results and discussion

This benchmarking project set about collecting industry supply chain data and in response, working out how to adapt best practice for a range of Australian production districts.

The project was designed to focus in on the effects of management practices on fruit quality by isolating the influence of other factors known to affect fruit quality and to ensure that sampling was done in a representative manner. This included the likely influencing factors of ripeness (measured as firmness), the impact of different assessors on the fruit quality assessment results, maturity (measured using dry matter), any bias associated with fruit from one production district or one production year. More detail on how the impact of these factors was isolated is included in appendix 1.

The findings for the avocado industry

a) Fruit quality reports and trends
b) Root cause analysis using tracebacks
c) Variability in grower practices
d) Dry matter impacts on ripeness

(a) Fruit quality reports and trends

Fruit quality assessments were reported to the relevant pack shed staff. These reports consisted of detailed assessment of every piece of fruit, supply chain tracking (for the first three years of the project) identifying temperatures and locations along the supply chain, and images of the fruit on receival and at the medium to soft ripe assessment. A visual illustration of a typical assessment report provided to pack shed staff is presented in appendix 2.

Monitoring of fruit quality intercepted from Australian supply chains over the past four years has identified that on average, the industry is close to or meeting the industry quality standard of 90% of fruit with less than 10% of defects indicated by the red dotted line in figure 1. Note the impact of the latter two wetter years (2021 and 2022) on fruit quality.

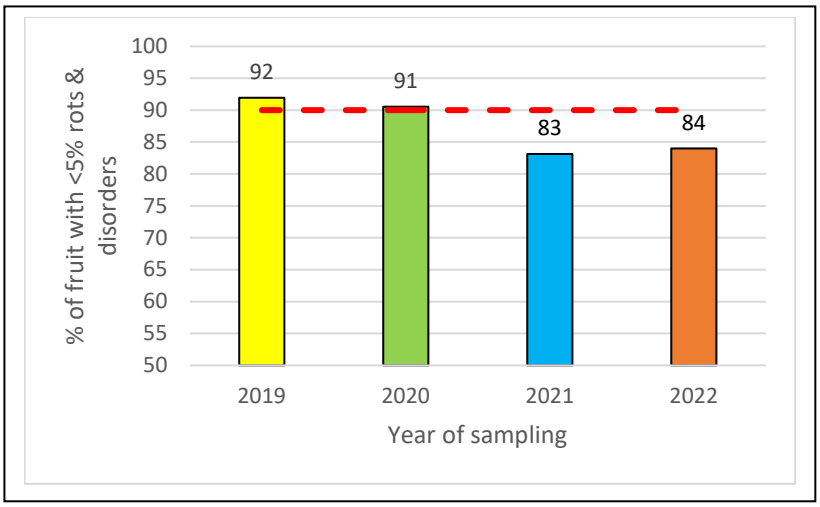


Figure 1: Average percent fruit quality that met the industry standard by year.

There are significant differences in quality coming from different production districts reflecting different weather pressure and local management of fruit rots in particular (figure 2). The red dotted line is again, the industry quality standard. Note that no data was collected in early 2020 from North Queensland due to Covid-19 lockdowns.

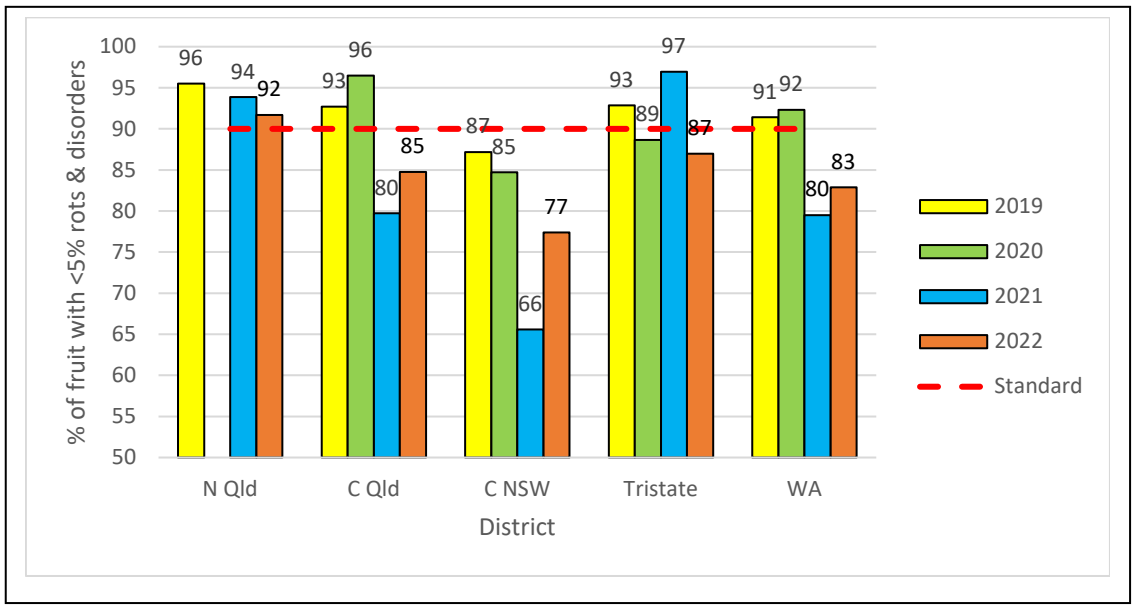


Figure 2: Average individual fruit quality by production district (North Queensland, Central Queensland, Central New South Wales, the Tristate -Waikerie to Mildura, and south-west Western Australia).

(b) Root cause analysis using tracebacks

Those supply chains not meeting the industry standard were investigated with the pack shed staff, using tracebacks to identify the most likely cause of the poor fruit quality. The primary causes of poor quality were: missed orchard fungicide sprays; phytophthora affected trees (poor block health) and periods of really wet weather (poor weather) (figure 3).

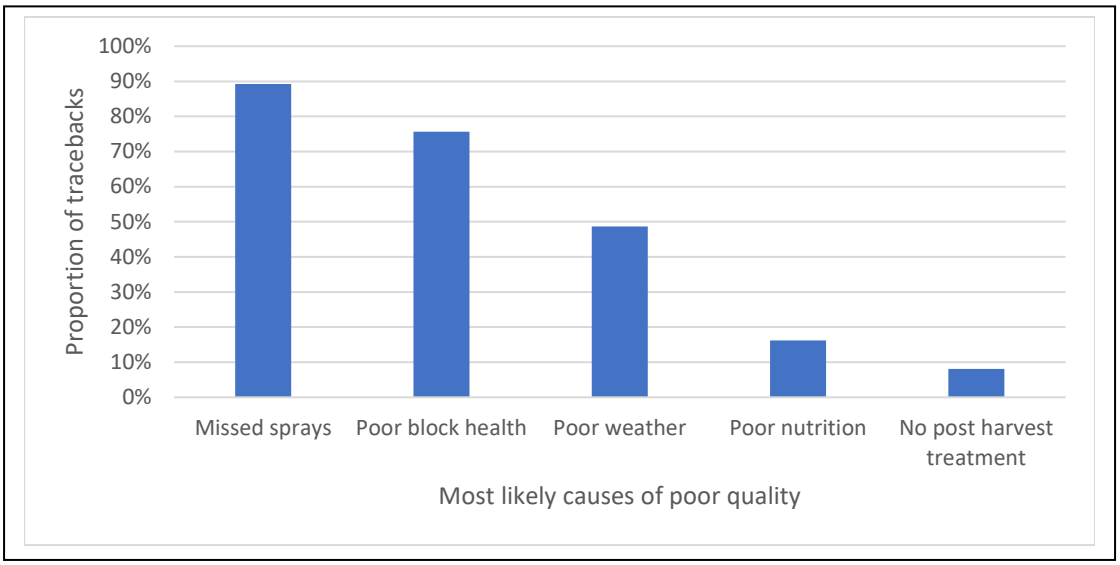


Figure 3: The primary root causes of poor fruit quality, as identified through the use of traceback investigations.

Undertaking traceback investigations in 2022, being a La Nina year, the team repeatedly encountered instances where the high incidence of rots was considered inevitable by some growers. However, consultation with growers also identified a wide range of opinions about what is a reasonable interpretation of best practice orchard fungicide management for each district, which is heavily influenced by practices used in the past and in dry years. Regional forums offered the opportunity to review how the best practice guidelines should be interpreted by growers, especially those new to growing avocados. Regional forums, benchmarking workshops, face-to-face discussions,

information products and regional project staff located in the major production districts have all been vital to the review of quality and practices in this project.

(c) Variability in grower practices

While grower, pack shed, transport, wholesaler and ripener practices were benchmarked across the production districts, the area of most significant difference that correlated to instances of poor fruit quality was the number of field fungicide sprays applied through the year (2021). The blue bars in figure 4 represent the number of copper sprays used by collaborators and the orange bars represent the number of Azoxystrobin (e.g. Amistar®) sprays.

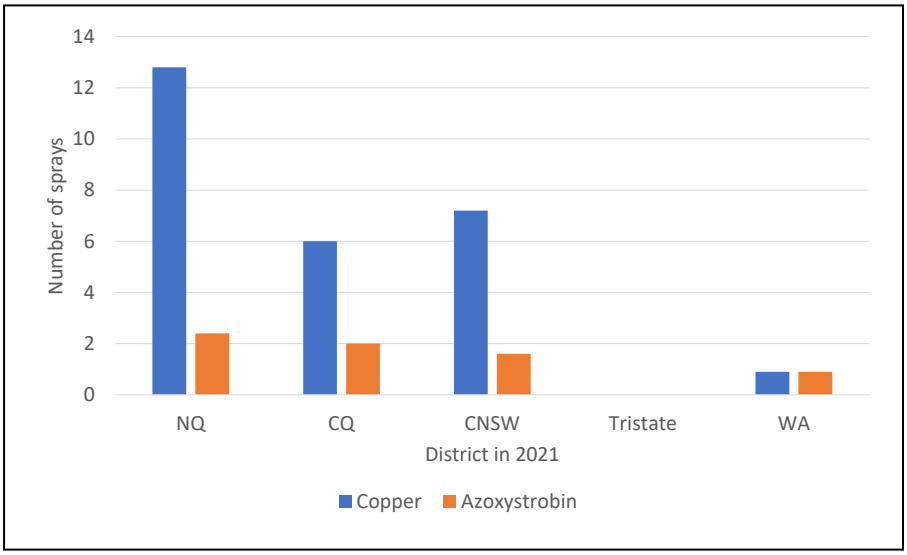


Figure 4: The average number of copper (blue bars) and azoxystrobin (orange bars) sprays applied in the five production districts in 2021.

(d) Dry matter impacts on ripeness

Figure 5 investigates whether there is a relationship between fruit maturity (using dry matter) and ripeness (using firmness). There did not appear to be a clear relationship between dry matter and ripening time within the range of the dry matters examined. If this is the case, there would be no precedent for retailers to ask pack sheds to segregate fruit based on dry matter to improve the evenness of ripeness in retail displays.

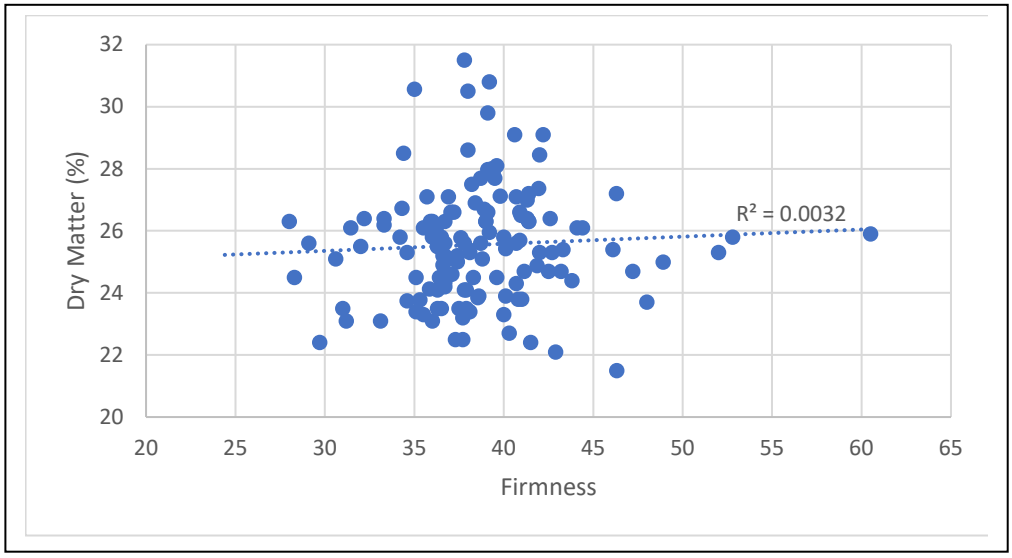


Figure 5: Investigation of whether there was a clear relationship between dry matter and firmness of fruit at

assessment.

(e) Variability in fruit quality

There are three means of assessing variability used in the following section. The first is by comparing averaged results, which also offers the opportunity to examine trends. The second is by visually inspecting box and whisker plots to examine both trends and variability of the dataset. The third is by comparing objective numerical standard deviation of a population results which looks at a measure of variability alone.

The average fruit quality monitoring result in the 2022 La Nina year was at 84%, compared to the 92%, 90% and 83% averages achieved in the 2019, 2020 and 2021 seasons respectively. This illustrates the year-to-year variability **between consignments** around the overall average of 87%, which narrowly failed to meet the repeat purchase quality target adopted by industry of 90% of fruit with less than 10% damage.

Since 2019, the project has focused on the relatively smaller number of supply chains that did not reach this industry fruit quality target, rather than trying to marginally improve the performance of all supply chains. The percent of supply chains at or above the industry target of 90% of fruit with <10% damage was 80%, 77%, 68% and 51% in 2019, 2020, 2021 and 2022 respectively. This confirms that alongside the poorer fruit quality in the past two years, there was also a notable rise in variability of average consignment fruit quality. This can be illustrated by examining the box and whisker plot (figure 6) of fruit quality variability between consignments within each of the four years of monitoring, confirming an increase in variability of fruit quality results.

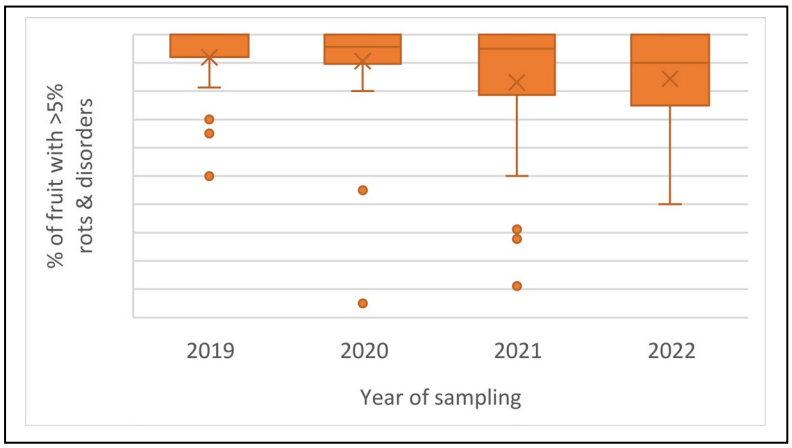


Figure 6: Box and whisker plot of the fruit quality results for each of the four years of monitoring.

This increased variability is most likely due to the La Nina weather patterns, fruits in longer supply chains with more congested low-priced markets, and some marginally higher and more variable dry matter fruit (figure 7) due to delayed harvests as growers manage workforce issues in the wake of Covid-19. The data indicates that these factors have had a more significant impact on fruit quality than the industry practice changes listed in the results below. Note that while firmness averages remained fairly steady the variability in firmness fluctuated from year to year (figure 8).

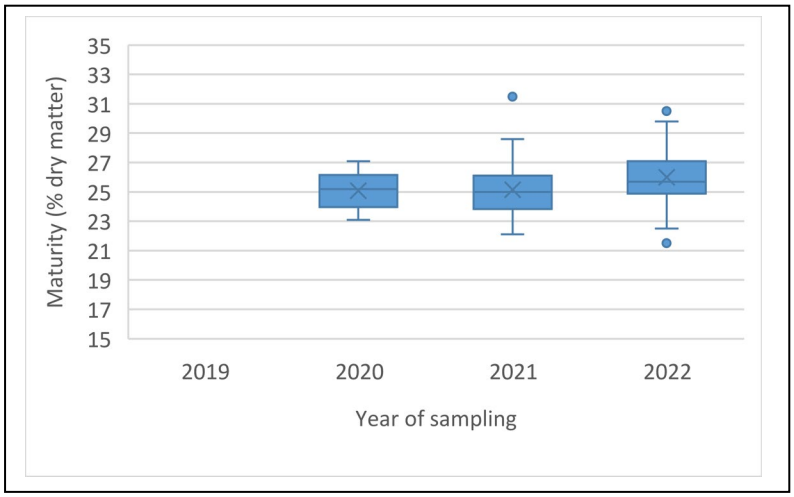


Figure 7: Box and whisker plot of the dry matter of fruit sampled in the three latter years of monitoring.

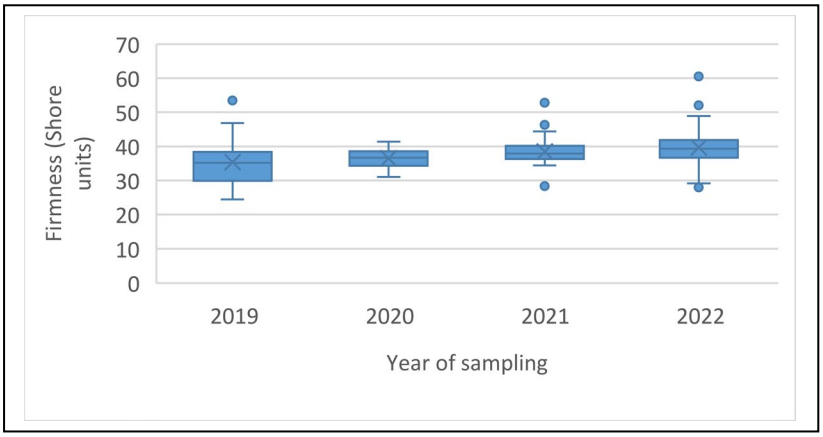


Figure 8: Box and whisker plot of fruit firmness at assessment for each of the four years of monitoring.

This project also took the opportunity to quantify the variability **within consignments**, and in doing so was able to benchmark the variability (using standard deviation) of ripeness (firmness), dry matter and temperature management. The average standard deviation of firmness within consignments (table 1) indicated no significant trend increasing or decreasing the variability of fruit firmness within consignments over the years.

Standard deviation of	2019	2020	2021	2022
Firmness	4.7	4.5	4.8	4.6
Dry matter	-	1.5	1.3	1.5
Transport temperature	1.4	1.3	1.8	-
Storage temperature	1.1	1.9	1.3	-
Ripening temperature	1.7	2.4	2.7	-

Table 1: Average standard deviation of measurements within consignments for the four years of monitoring.

The average standard deviation of dry matter readings from the point when this was measured in 2020 again indicating relatively tight ranges of dry matter within consignments and no significant trend increasing or decreasing the variability of maturity within consignments over the project term.

The average standard deviation of supply chain temperatures were low, similar to the level of variability for dry matter (Table 1). The rise in variability of ripening temperature variability may simply reflects the difficulty in defining when the phase of ripening starts and finishes and whether the warmup and cool down phase should be included in the ripening phase.

Implications for ongoing fruit quality project methodologies

During the initial project methodologies development phase and again as the project undertook agile variations to that methodology, there were a number of important findings. These were used to inform the approach for subsequent fruit quality monitoring investments. These are listed in appendix 3. For example, this includes choosing the ideal stage of ripeness for assessment of fruit quality.

The project team also undertook to investigate and report on quality monitoring approaches in New Zealand. While contact has been made with key quality staff from NZ Avocado a number of times, face to face time at the World Avocado Congress in April has been earmarked to share insights on quality programmes that are a huge focus for both the Australian and New Zealand avocado industries.

Avocado industry confidence in the findings from this benchmarking

This project was designed to offer both the transparency of findings (for industry) and the confidentiality of findings (for the individual collaborators). Appendix 4 outlines some of the critical elements designed to achieve this balance over the 2019 to 2022 period and offer some insights to the confidence expressed by both individuals and industry in the findings. These include the use of high-quality images, supply chain tracking and transparency, the regular sharing of findings with industry using a variety of channels, support from the industry based Strategic Investment Advisory Panel and the project Reference group and the priority assigned to the work in industry strategic planning.

Industry changes prompted by the findings

It is certainly important to recognise the diversity of practice change resulting from this monitoring and benchmarking project. The changes made by project participants have included:

- Changes to fungicide spray programs, equipment and phytophthora management
- Changes to postharvest fungicides and their application
- Changes to fertiliser programs, including amounts, ratios of elements and timing.
- Improved real-time monitoring of supply chains, especially the pack-shed departure temperatures
- Assessing and feeding back information to growers on the fruit quality that reaches the consumer
- Exporters being more aware of fruit quality risk and putting in place procedures to manage those risks

Case studies from these changes listed above were published in the Talking Avocados article listed in the references section of this report.

Rot prevention strategies

As a result of the tracebacks undertaken on those consignments with performance below the 90% industry standard, the project team and collaborators gained a better idea of the risk and management strategies (figure 9) effective at managing rots and flesh discolouration. There are several risk factors that influence the development of anthracnose body rot, stem end rot and flesh discolouration. To manage these risk factors, there are a number of rot mitigation strategies that growers, pack shed managers and supply chain partners can use to reduce the risk.

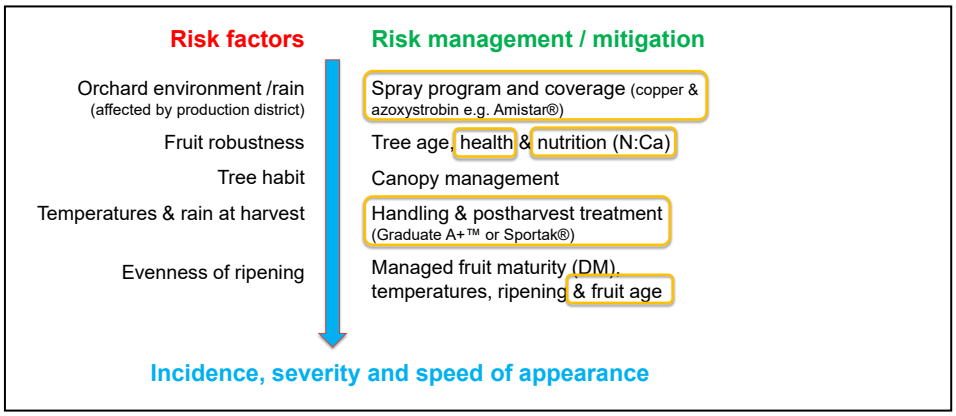


Figure 9: Risk factors and risk mitigation used to manage the incidence, severity and speed of appearance of

body and stem end rots in avocados. The yellow boxes indicate those strategies that were most commonly identified as the root causes of poor quality in tracebacks.

The practices identified most regularly as the root causes of poor fruit quality in tracebacks include:

- Infection of fruit in the orchard, which is influenced by production district, rainfall and humidity conditions, in-field hygiene, the fungicide spray program, tree habit, tree age, tree health and nutrition,
- Effectiveness of controls in the pack-shed through postharvest fungicide application, and
- Promotion of that infection in fruit, which is linked to the storage length and conditions, ripening conditions, as well as the evenness of ripening.

This project confirmed that there are a small number of best practices that have the greatest impact on the risk of the incidence, severity and speed of appearance of anthracnose and stem end rot. They include:

- An effective, timely and responsive in-field spray program utilising a combination of copper (or Serenade Opti®) & azoxystrobin (Amistar® or Luna Sensation®) orchard sprays, applied as per label recommendations.
- Healthy active trees in relation to tree age, disease status (Phytophthora) and nutrition (with a suitable Nitrogen:Calcium balance in the fruit for fruit robustness)
- Canopy management maintaining an open tree structure to reduce likelihood of infection and allowing good spray coverage
- Appropriate handling during harvest and packing plus the use of a postharvest fungicide treatment (Graduate A+™or Sportak®) suitable for their destination market.
- Management of factors to promote even ripening and good fruit quality for the consumer. These factors include a minimum dry matter of 23% for Hass, uniformity of fruit maturity in the consignment, storage and transport at 5˚C, best practice ripening, effective ripening processes and aiming for a total chain time of <15 days when the fruit reaches the consumer.

Avocado growers often apply their own interpretation of the priority of these factors and the associated management controls suitable for their business. It should also be noted that these sources of infection usually operate in combination, i.e. the more sources that are in play, the greater the risk of significant quality issues occurring.

Outputs

Table 2. Output summary

Output	Description	Detail
Quality assessment protocol	An assessment protocol was developed for this project and then refined for use in export fruit quality assessment	The standard assessment protocol was developed and shared with commercial assessors and research partners in other RD&E projects. Development work has continued to morph the protocol into an app to improve efficiency and reduce the opportunities for transcription error.
Standard for ripeness assessment	Objective and consistent ripeness assessment was critically important for confidence in the findings.	The new standards for objective firmness assessment included mapping the shore scale against the existing industry ripeness categories as well as standard procedures for use of durometers. The new standards were published via video and factsheets for Shepard and Hass.
Supply chains monitored and reported	Practices relevant to fruit quality by supply chain partners, supply chain conditions (temperature and location) and fruit quality assessment at ripe were monitored and reported to pack shed managers	Detailed monitoring results of 179 supply chains over the 4 years of the project were assembled, analysed, sent to and then discussed in person with pack shed managers. When surveyed, most collaborator pack-shed staff rated the individual reports, discussions, updates on trends and information products as very useful.
Deidentified dataset	Industry fruit quality and supply chain performance was benchmarked	The emerging dataset was made freely available to anyone on request during the four years of its compilation.
Tracebacks undertaken	46 tracebacks undertaken	Tracebacks were undertaken to identify the root causes of poor quality with the results presented to industry in face-to-face presentations and webinars.
Regional forum presentations	29 face-to-face presentations	The locations, dates and attendance of these has been progressively reported in milestone reports. Average attendance estimated at 120 people per forum.
Production district workshops	17 face-to-face workshops	The locations, dates and attendance of these has been progressively reported in milestone reports. Average attendance estimated at 10 people per workshop.
Wholesaler's workshops	6 face to face presentations	The locations, dates and attendance of these has been progressively reported in milestone reports. Average attendance estimated at 10 people per workshop.
Factsheets	3 factsheets delivered	Refer to 'References' section in this report for a detailed list of the three factsheets.
Case studies	7 case studies undertaken	Case studies were promoted through talking Avocados articles. Refer to 'References' section in this report.
Videos	5 videos delivered	Videos were used in preference to training events as they were both predictable and preferred during the Covid-19 pandemic, which had a significant influence on the extension activities during this project. Refer to 'References' section in this report for a detailed list

Output	Description	Detail
		of videos.
Webinars	4 targeted webinars	The dates and attendance of these has been progressively reported in milestone reports. Average attendance estimated at 40 people per webinar. The recordings of webinars are loaded onto the Best Practice Resource in Library/Videos including that last two as videos on Spray schedules https://www.youtube.com/watch?v=O9QHiLItqZY and fruit quality over the past four years https://www.youtube.com/watch?v=2aShECud0Jc
Best Practice Resource updates	45 pages of updated content in the Best Practice Resource	There were significant revisions and additions to 45 pages of content in the Best Practice Resource.
Industry magazine articles	17 articles were published	Refer to 'References' section in this report for a detailed list.
Industry e-newsletter articles	Approximately 15 articles were published	About 15 small articles were used to promote activities and information resources such as videos and recordings of events during this project. No detail is presented on these.
Conference presentations	Hort Connections, Avo Connections, World Avocado Congress	The project team took the opportunity to present at industry conferences each year of the project. The conference presentations are available on the Best Practice Resource website.
Export forums	4 face-to-face presentations at forums in 2022.	AV18000 presentations were delivered at 4 of the 5 Avocado Export Regional Forums in 2022. Presentations and videos of presentations have been added to the Best Practice Resource website as a legacy product.

Outcomes

Table 3. Outcome summary

Outcome	Alignment to fund outcome, strategy and KPI	Description	Evidence
Applied a systems approach to improving quality through the supply chain	Avocado SIP 2022-2026	Tracked quality trends by year, by production district and by packing sheds over 4 years from 40 supply chains per year	Deidentified benchmark data shared with industry.
See above	See above	Quantified the variability in quality, specifically rot and disorders at eating ripe	Variability of quality, ripeness and maturity was analysed, tracked and reported against targets.
See above	See above	Quantified the variability in fruit robustness using a storage challenge	A storage challenge was developed and used to benchmark fruit robustness across the industry with relevant data shared with pack shed managers.

Outcome	Alignment to fund outcome, strategy and KPI	Description	Evidence
See above	See above	Audited on-farm and supply chain practices sharing the benchmarking data with the industry	Variability in on-farm practice data prevented a significant association with fruit quality, but the benchmarked production district differences were presented to industry via webinars and face to face presentations.
See above	See above	Evaluated the impact of variations in the cool chain	Cool chain variations from best practice failed to have a significant influence on fruit quality, most likely due to the short domestic supply chains of average 16 days.
See above	See above	Investigated the impact of dry matter on resultant fruit quality	Within the studies range, dry matter failed to have a significant impact on fruit quality or ripeness.
See above	See above	Identified the root causes of poor fruit quality instances using tracebacks	The main root causes identified include adequacy of the fungicide spray program, poor block health and unfavourable weather.
Delivered extension services to support change in quality through the supply chain	Avocado SIP 2022-2026	Developed information materials and shared those via a variety of channels	Details of information products are listed in the outputs and references sections of this report. Most outputs were overdelivered based on contracting.
See above	See above	Supported key supply chain members (primarily growers, packhouse operators, transporters and ripeners) to identify where key practices can be improved, and to provide the knowledge and technical support needed to implement these improvements	Key supply chain members were targeted with a mixture of passive information products plus active engagement activities such as workshops, discussions forums and webinars. These are listed in the outputs and references sections of this report.
See above	See above	Improved practices in fungicide spray scheduling and application, orchard nutrition and temperature management, and documented those as case studies	These were collected as case studies and mainly reported as Talking Avocado (see references) articles to ensure distribution and legacy.

Monitoring and evaluation

Table 4. Key Evaluation Questions

Key Evaluation Question	Project performance	Continuous improvement opportunities
Impact: What has changed as a result of the project activities and is the change as planned for the agreed target?	The project provided a deidentified insight into supply chain practices, the capacity to develop supply chain feedback loops and in many instances improvements in fruit quality results. Unintended outcomes included the opportunity to examine the impact of La Nina and El Nino years on fruit quality through the representative industry sampling, even during the covid-19 pandemic.	AV22011 is set to continue monitoring changes arising from AV18000, including adoption of: the ripeness stage of assessment, the fruit quality assessment methodology and sampling number, the use of tracebacks, the storage robustness challenge, the metric of the % of supply chains failing to meet the industry standard and targeting of higher risk suppliers for additional attention. The fruit quality assessment methodology is being reviewed for efficiency of data capture and data utilisation, before conversion to an app in AM21000.
Effectiveness: Have the planned activities, outputs and agreed target outcomes been achieved?	The output targets for engagement and supply chain monitoring were consistently over-delivered and all milestone reports were accepted by Hort Innovation. Through careful design, variations, subcontracting and reporting, the agreed target outcomes were all delivered.	AV22011 is set to continue the monitoring and industry engagement with direct translation to outcomes in the Avocado Strategic Investment Plan.
Appropriateness: Has the project met the needs of the intended beneficiaries?	When surveyed, most collaborating pack-shed staff rated the individual reports, discussions, updates on trends and information products, as very useful.	AV22011 is set to continue consulting collaborators to ensure their needs are met.
Efficiency: Could the project have achieved the agreed targets in a more efficient way?	Survey results from the project team suggested an even split between ‘no’ and ‘maybe’ as responses to this question. Improvement suggestions included a focus on fewer production districts, and more engagement with handlers and ripeners though they are hard to engage. Survey results from the Project Reference Group suggested an even split between ‘no’ and ‘maybe’ and ‘yes’ as responses to this question. Improvement suggestions included a more focus on field fungicide management, effects of nutrition, post-harvest fungicides, fruit age	AV22011 is set to continue consulting collaborators to ensure efficiency in delivery.

Key Evaluation Question	Project performance	Continuous improvement opportunities
	and assessment of waste levels in retail stores and to get pack sheds and wholesalers undertaking the monitoring of fruit quality.	
Legacy: Will the project outcomes continue to grow or at least be maintained after the completion of the project?	Survey results from the project team suggested a split between 'yes' and 'maybe' as responses to this question. This is mainly due to outputs being housed on the BPR, having a commercial assessor supporting the industry monitoring, the use of tracebacks in and outside of ongoing RD&E projects, the opportunity to use apps to make quality assessments more rapid and the likelihood that project findings from this work will be built upon in other RD&E projects. Survey results from the Project Reference Group suggested all respondents said the outcomes will continue to grow, but will require the issue of quality to be kept front and centre for the attention of supply chain personnel. Key information products with a legacy includes factsheets, videos, case studies Talking Avocado articles & BPR content.	AV22011 is set to continue consulting collaborators to ensure project outcomes continue to grow.

Recommendations

Follow on industry investment to improve fruit quality

- Invest in a follow on industry investment to build upon the learnings and improve fruit quality.
- Use consistent fruit quality assessment procedures across multiple quality projects, with consistent reporting for the collaborating supply chain personnel.
- Ensure that fruit quality assessments are undertaken at the transition between firm ripe and medium to soft ripe and that a durometer is used to improve accuracy of the assessment.
- Ensure quality assessments done on samples of at least 20 pieces of fruit due to the need for appropriate sensitivity against the industry quality standard. The 20 pieces should, if possible, come from at least 2 trays in the consignment.
- Remain vigilant to the need to calibrate geographically spread project staff undertaking quality assessments.
- Ensure that findings are conveyed using a mix of both active and passive channels to maximise timeliness, reach, impact and learning preferences.
- Review representativeness of sampling at least every two years to ensure trends are indeed national.
- Targeted workshops that review the adaptation of best practice in different production regions and supply chains should maximise opportunities for active involvement and exchange between all supply chain personnel.
- Targeted work should seek to better understand why library trays used at many pack sheds are not as useful as the developers thought they would be as feedback loops on fruit quality.
- Many fruit quality research projects will need development projects to adapt findings with dedicated extension component to maximise adoption.

Refereed scientific publications

None to report

Chapter in a book or paper in conference proceedings

Ainsworth NJ and Agnew JR. (2023) Improving domestic avocado quality to lift Australian consumer confidence. Abstract submitted for presentation at the 10th World Avocado Congress. New Zealand.

References

Information resources have been developed and made available using an array of passive and active channels, including the AAL Best Practice Resource. This provides a valuable legacy and ongoing resource for engagement and supports adoption and supply chain management behavioural practice change.

Factsheets

- The 'Assessing fruit firmness through supply chains' factsheet was first developed and launched on the DAF website on 28/8/2020, then updated on 4/2/2021, 16/8/2021 and 2/12/2021. The factsheet is available at https://www.daf.qld.gov.au/business-priorities/agriculture/plants/fruit-vegetable/supply-chain-innovation

- The "Choosing a single-use real-time logger, A new user's guide" factsheet was developed and launched on the DAF website on 1/11/2021. The factsheet is available at https://www.daf.qld.gov.au/business-priorities/agriculture/plants/fruit-vegetable/supply-chain-innovation

- The 'Postharvest disease treatments' factsheet was drafted in May 2021 and published as a Talking Avocados article in V33#1 p67-68. Due to a reluctance to hand out printouts of the TA article, the factsheet was reformatted as a pilot DAF factsheet and handed out at the series of export forums in May and June 2022. This primarily sought to raise awareness about the limited use of some fungicides for export consignments due to Maximum Residue Limit (MRL) restrictions.

Videos (not including recorded presentations)

- The "Why undertake fruit quality assessments?" video can be accessed via the YouTube link: https://www.youtube.com/watch?v=Pk-yzYzzrjA

- The "Activating and deploying a SIM real-time logger in fresh produce" video can be accessed via the

YouTube link: https://www.youtube.com/watch?v=Uy7YRqHxC1M

- The "Ensuring optimal spray coverage to deliver good avocado fruit quality" video can be accessed via the YouTube link: https://www.youtube.com/watch?v=tkKBJFZUy1k
- The "Calibrating spray equipment" video can be accessed via the YouTube link: https://youtu.be/QZSCRlCImW0
- The 'Selecting the right sprayer for your orchard' video can be accessed via the YouTube link: https://youtu.be/CgblcOGgpXU

TA articles

- Ainsworth, N (2019) 'Driving practice improvements in domestic avocado supply chains', Talking Avocados V30, #1, p60
- Ainsworth, N. (2019) Implementing best practice of avocado fruit management and handling practices from farm to ripening (AV18000), Talking Avocados, V30, #2, p38.
- Ainsworth, N. (2020) What was your fruit quality like in 2019? Talking Avocados V31, #1, p56-57.
- Faichney, E (2020) 'Harvesting during wet weather – consider all the risks', Talking Avocados V31, #2 p63-4.
- Ainsworth, N. (2020) AV18000 Avocado Supply Chain Feedback Project, V31#2, p40-41.
- Ainsworth, N (2020) 'Ensuring consumers get the ripeness of fruit that they want', Talking Avocados V31, #2 p68-9.
- Nettis, M. and Rudge, T. (2021) 'There is a place for NIR in Avocados' Talking Avocados V32#2 p71-72.
- Ainsworth, N. (2021) 'Fruit quality trace-back case study', Talking Avocados, V32#1, p55-56.
- McCauley, D (2021) 'WA grower uncovers risks to avocado fruit quality' Talking Avocados V32, #3, p66-7.
- Ainsworth, N. (2021) 'Is fruit maturity influencing variability in ripeness? Talking Avocados V32, #3, p68-9.
- Ainsworth, N (2021) '2021 was a challenging year for central NSW growers'. Talking Avocados V32, #4, p60
- Agnew, J (2021) 'Changed nutrition improves fruit quality', Talking Avocados V32, #4, p56-7.
- Mead, A (2022) 'Finetuning avocado supply chains through tracebacks', Talking Avocados V33, #1, p65-6.
- Dickinson, G, Ainsworth, N, Pattison E, Coates, L and Dann, E (2022) 'Postharvest Disease Treatments', Talking Avocados Vol 33, #1, p67-8.
- Ainsworth, N and Agnew J (2023) 'Good disease management is critical in La Niña years, even if the market price comes down!', Talking Avocados Vol 33, #4, p55-6.
- Ainsworth, N (2023) 'Tracebacks reveal risks to avocado fruit quality', Talking Avocados Vol 33, #4, p57-8.

Intellectual property

No project IP or commercialisation to report.

Benchmarking data was compiled in a de-identified form to protect individuals from reputational damage. This data is then freely distributed to anyone who is interested in it. The fruit quality assessment methodology is being reviewed for efficiency of data capture and data utilisation, before conversion to an app in AM21000.

A new rapid fruit quality assessment template and set of images has been developed by DAF during this project. This is now being adopted for use within the AM21000 Serviced supply Chains II project and is proposed to be used in the follow-on domestic avocado fruit quality monitoring project, AV22011.

Acknowledgements

As lead author of this report, I would like to acknowledge the dedication of the project team members including Nasser Abdi, John Agnew, Damien Armistead, Bridie Carr, Yiru Chen, Hayleigh Dawson, Geoff Dickinson, Ebony Faichney, Declan McCauley, Andy Mead, Terry Rudge, Dario Stefanelli and John Tyas.

For their informed guidance and support I would also like to recognize and acknowledge the Project Reference Group made up of John Tyas, Bianca Cairns, Daryl Joyce, Hayleigh Dawson, Simon Newett, Jim Kochi, Cormac te Kloot, Clayton Lynch, Kylie Collins, Stewart Ipsen, Adam Goldwater and Gordon Rogers.

Appendices

Appendix 1: Factors likely to affect fruit quality that were minimized.

(a) Impact of ripeness

We already knew that the ripeness of the fruit has a very large bearing on the rots levels that are able to develop and invade the fruit. As such we sought to assess fruit at a consistent stage of ripeness over the 4 years to remove the impact of ripeness on fruit quality and rots. The assessors were instructed to assess when the average of the sample of fruit had reached 40 shore units of firmness as an objective measure of ripeness. Over the four years the average firmness of all fruit in the 179 monitored supply chains was 38 shore units of firmness (figure 10). When the average firmness was trending up or down or considered a significant departure from 40 units, then the individual assessor was approached for an explanation.

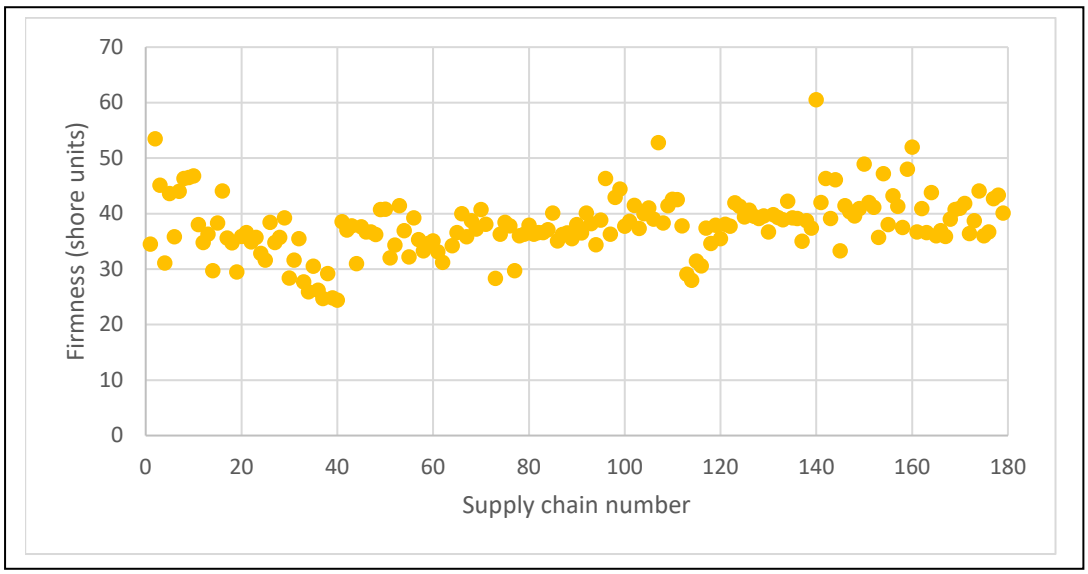


Figure 10: Average firmness at assessment for the 179 supply chains monitored over the four years of the project.

Out of interest the relationship between firmness and fruit quality was investigated to test whether any significant relationship existed given the procedural instruction to mitigate that factor. Figure 11 illustrates that the remaining relationship is very weak.

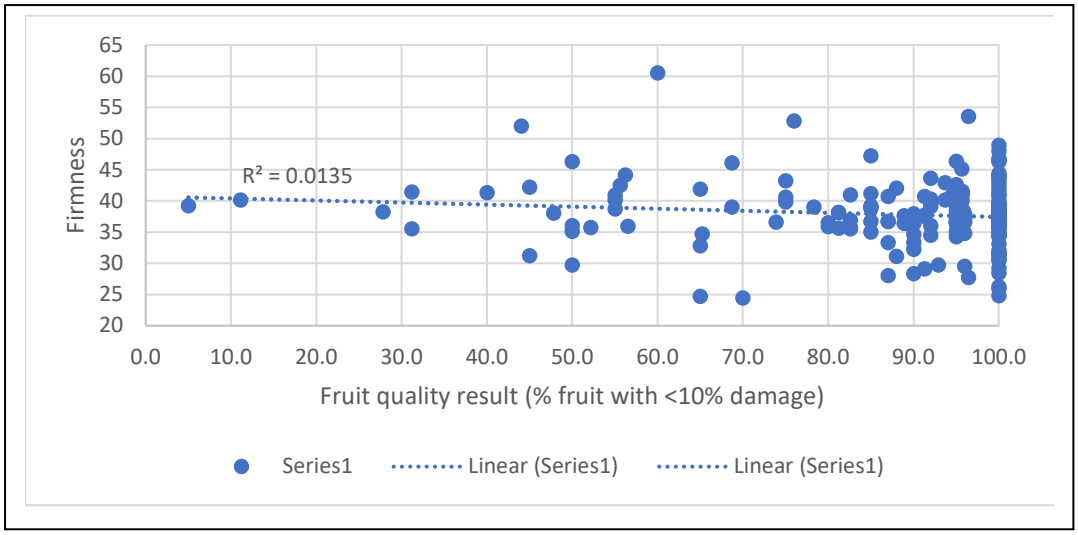


Figure 11: The relationship between firmness and fruit quality is weak

(b) Impact of different assessors

Recognising that different assessors in Sydney and Melbourne may record different fruit quality results, a number of steps were taken to mitigate the risk of this bias occurring.

- The project contracted reputable and experienced assessors who network well with wholesalers and who were involved with the project team in co-design right through the project.
- The project monitored whether different assessors in Sydney and Melbourne recorded the same average results (in measures of % fruit with <10% damage as well as average % damage). This is presented in table 5 and shows lower average results coming from Melbourne assessments but these may have been less robust samples that travelled further to Melbourne. However, the firmness and dry matter from samples were quite similar.
- A similar number of samples were taken in Sydney (85) and in Melbourne (92) to ensure the assessors had the same amount of regular assessments.
- Assessors in Sydney and Melbourne visited each other to verify how they assessed fruit.
- The results of split blind samples, where one went to Sydney and one went to Melbourne, were similar.

	Assessment location	
	Sydney	Melbourne
% fruit with <10% damage	92.5	81.7
% damage	1.5	3.6
Firmness at assessment	37.2	38.4
Dry matter %	26.0	25.1

Table 5: A comparison of results from different assessment locations

(c) Impact of maturity

Dry matter was checked as a measure of maturity on each sample from 2020 onwards, and figure 12 shows that it was reasonably consistent, within the recommended range and then used to investigate the relationship between dry matter and other fruit quality measures. This ensured that samples were not taken on the shoulder of the main supply season. Note that the minimum dry matter for Shepard is 21% while for Hass it is 23%.

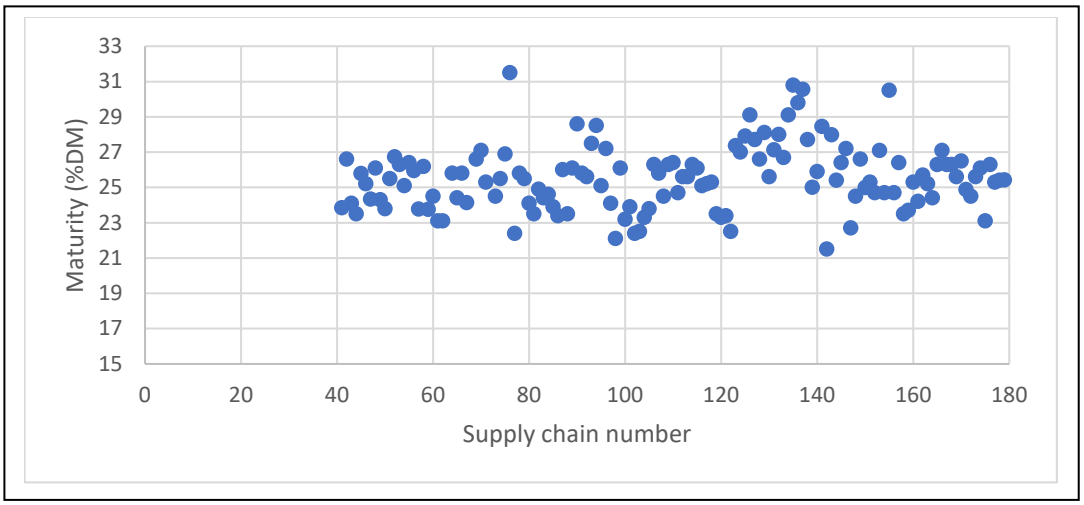


Figure 12: Average dry matter readings for the last three years of supply chain monitoring.

(d) Sample representativeness of Australian supply

Reviews of which supply chains were targeted for sampling were undertaken in early 2019 and then again late in 2022. In both instances the project had targeted both small and large pack sheds, and sample numbers were proportionate to the volumes supplied across the major avocado production districts in Australia.

(e) Supply chain monitoring over dry and wet years

The project inadvertently was timed to coincide sampling during both dry and wet years. This did have a noticeable impact on the risk, the incidence and the severity of rots, and illustrated whether many in-field spray programs were responsive enough to maintain consistent fruit quality (figure 13).

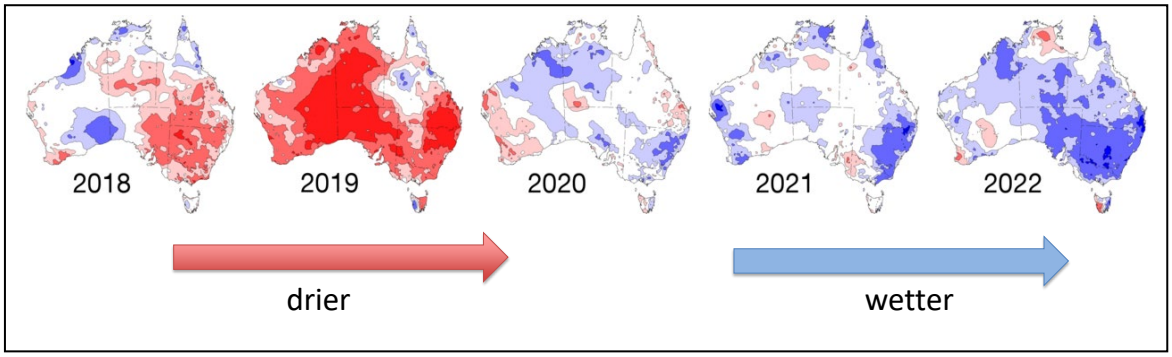
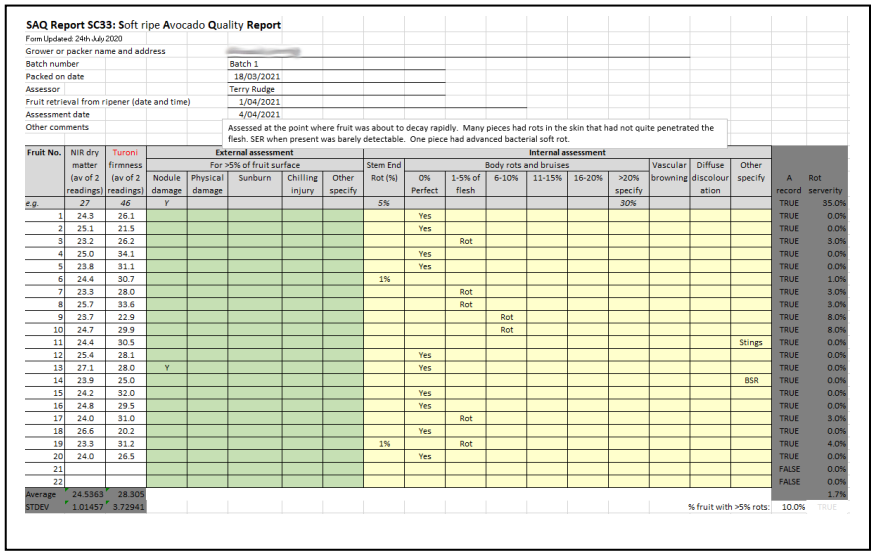


Figure 13: A visual representation of the dryness (red) and wetness (blue) in the four years of supply chain monitoring (Source; Bureau of Meteorology).

Appendix 2: Fruit quality reports to pack sheds

These reports typically consisted of detailed assessment on every piece of fruit (figure 14), supply chain tracking for the first three years of the project identifying temperatures and locations along the supply chain (figure 15), and images of the fruit on receival and at the medium to soft ripe assessment (figure 16) each of which was usually 200 to 500Kb in size.



SAQ Report SC33: Soft ripe Avocado Quality **Report**

Form Updated: 24th July 2020

Grower or packer name and address	[redacted]
Batch number	Batch 1
Packed on date	18/03/2021
Assessor	Terry Rudge
Fruit retrieval from ripener (date and time)	1/04/2021
Assessment date	4/04/2021
Other comments	Assessed at the point where fruit was about to decay rapidly. Many pieces had rots in the skin that had not quite penetrated the flesh. SER when present was barely detectable. One piece had advanced bacterial soft rot.

Fruit No.	NIR dry matter (av of 2 readings)	Turoni firmness (av of 2 readings)	External assessment: For >5% of fruit surface: Nodule damage	Physical damage	Sunburn	Chilling injury	Other specify	Stem End Rot (%)	Internal assessment: Body rots and bruises: 0% Perfect	1-5% of flesh	6-10%	11-15%	16-20%	>20% specify	Vascular browning	Diffuse discolouration	Other specify	A record	Rot severity
e.g.	*27*	*46*	*Y*					*5%*						*30%*				TRUE	35.0%
1	24.3	26.1							Yes									TRUE	0.0%
2	25.1	21.5							Yes									TRUE	0.0%
3	23.2	26.2								Rot								TRUE	3.0%
4	25.0	34.1							Yes									TRUE	0.0%
5	23.8	31.1							Yes									TRUE	0.0%
6	24.4	30.7						1%										TRUE	1.0%
7	23.3	28.0								Rot								TRUE	3.0%
8	25.7	33.6								Rot								TRUE	3.0%
9	23.7	22.9									Rot							TRUE	8.0%
10	24.7	29.9									Rot							TRUE	8.0%
11	24.4	30.5															Stings	TRUE	0.0%
12	25.4	28.1							Yes									TRUE	0.0%
13	27.1	28.0	Y						Yes									TRUE	0.0%
14	23.9	25.0															BSR	TRUE	0.0%
15	24.2	32.0							Yes									TRUE	0.0%
16	24.8	29.5							Yes									TRUE	0.0%
17	24.0	31.0								Rot								TRUE	3.0%
18	26.6	20.2							Yes									TRUE	0.0%
19	23.3	31.2						1%		Rot								TRUE	4.0%
20	24.0	26.5							Yes									TRUE	0.0%
21																		FALSE	0.0%
22																		FALSE	0.0%
Average	24.5363	28.305																	1.7%
STDEV	1.01457	3.72941																	

% fruit with >5% rots: 10.0% TRUE

Figure 14: A typical soft ripe avocado quality report

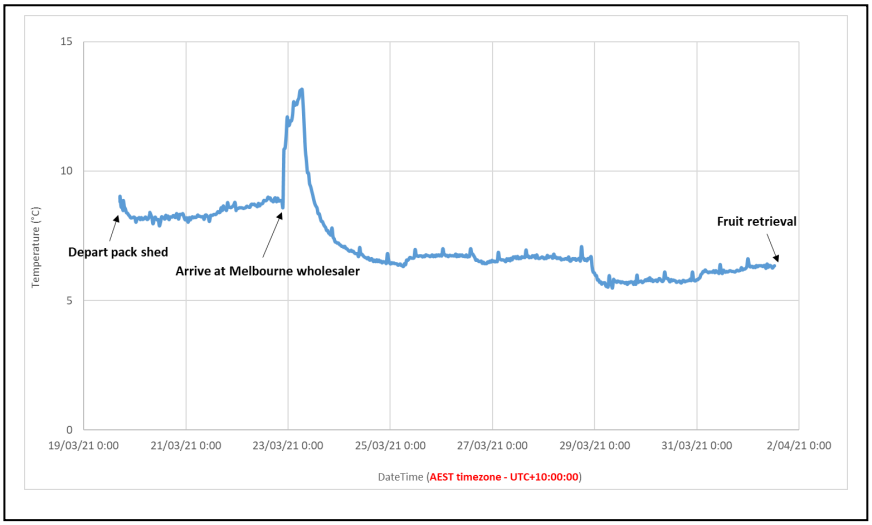


Figure 15: A typical supply chain tracking report, identifying temperatures and locations along the supply chain.

Figure 16: A typical set of high-quality images, averaging 200 to 500Kb each in size.

Appendix 3: Findings for ongoing projects that improve fruit quality

There were a number of project findings that will have more impact on the methodology used for subsequent investments in fruit quality by Hort Innovation, as opposed to findings that avocado growers and pack shed staff can implement straight away. These include choosing the ideal ripeness for assessment, a more sensitive quality measure to track project progress, a new measure of fruit robustness, that temperature in supply chains had limited effect on fruit quality in short domestic chains and the impact of a crowded market on quality.

(a) Choosing the ideal ripeness

The level of ripeness has an important impact on the expression and development of rots. The riper the fruit, the more the fruit express infections from the orchard. An effort to objectively measure ripeness prompted a shift from the use of silicon models to durometers. Then the avocado ripeness levels in silicon models were mapped against the shore scale using Bareiss and Turoni durometers. Recognising what rots the consumers would see is important and recognising that consumers wait until fruit is firm ripe for salads and medium to soft ripe for guacamole, we narrowed our focus to those two ripeness categories. Early in the project the project team realised that some fruit with differing reported nutrition can develop a corkiness of the skin, effectively masking ripeness readings at the bottom of the medium to soft range. So the project team chose to assess fruit quality when the ripeness was right at the transition from firm ripe to medium to soft ripe. The project team then published and promoted this to industry with DAF factsheets and videos.

(b) A more sensitive quality measure

In figure 17 you can see the average fruit quality for each of the 179 supply chains monitored where the red dotted line is the industry standard. Rather than tracking average fruit quality, a more sensitive quality measure was proposed to focus on the proportion of supply chains that did and did not achieve the industry standard. This measure enabled the project team to focus effort on supply chains that were likely to deliver the greatest quality improvement.

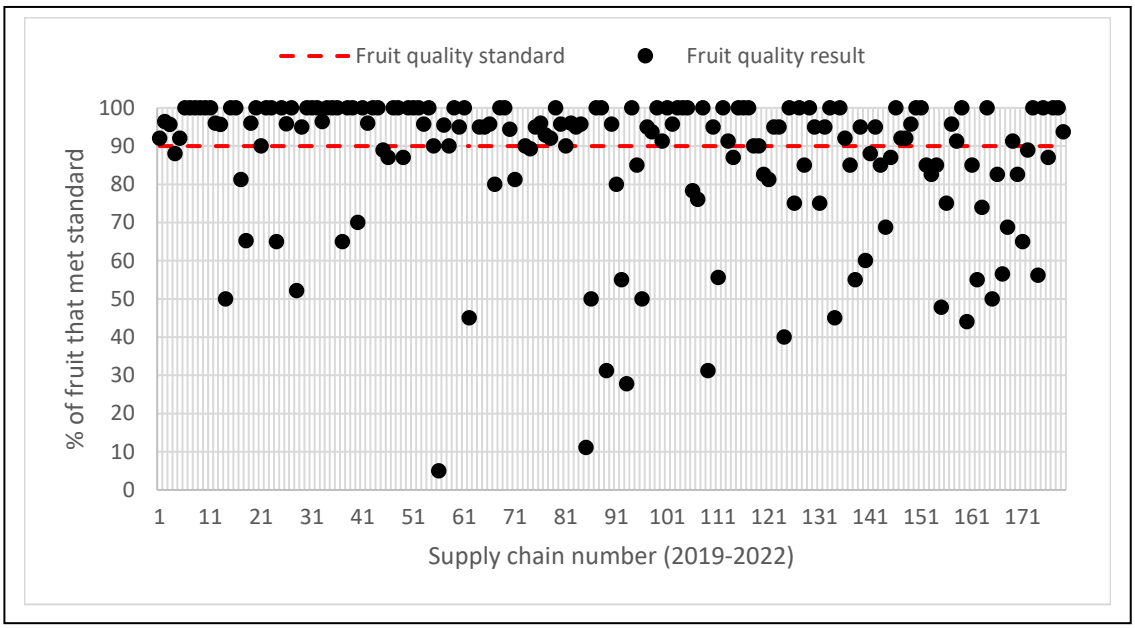


Figure 17: Average fruit quality for each of the 179 supply chains monitored

The ‘proportion of consignments’ is a measure for future investment likely to be more responsive (table 6) to projects that drive improvement in industry fruit quality.

Measure	2019	2020	2021	2022
Average fruit quality (% fruit with <10% damage)	92%	91%	83%	84%
Proportion of consignments that reached the industry standard	80%	77%	68%	51%

Table 6: A comparison of two quality measures, averaged over the four years of sample collection.

(c) A new measure of fruit robustness

At the end of 2019, the project was encouraged to add a measure of fruit robustness by testing the impact of increasing fruit age on rot development. Adding an extra 14 days of pre-ripening storage to the supply chains generally increased fruit age from about 16 to 30 days from packing.

Logically you would not expect an improvement in quality in these older fruit with more storage, so the proportion of samples in which we found quality improvement (in 13% of stored samples) should reasonably be considered sampling or variability error. Those with the same fruit quality, whether they were standard or stored, reasonably should reflects good robustness.

Figure 18 illustrates that if you subtract the sampling error from the proportion of samples in which the quality was worse, you can come to the reasonable conclusion that there is a level of poor industry robustness in 20% of samples.

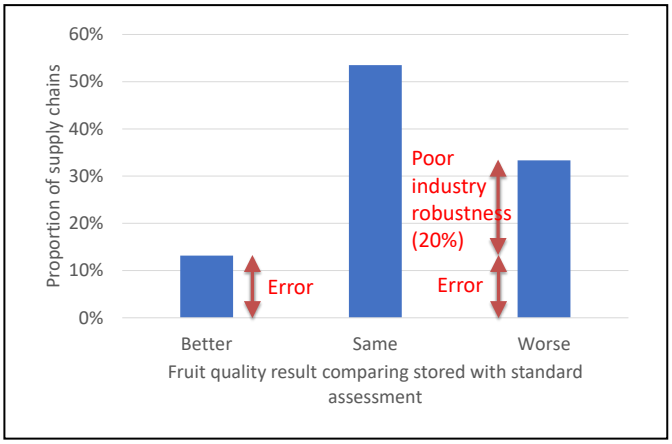


Figure 18: Comparing the samples in which the 'stored 'sample was better, the same or worse than the standard result suggests that there may be robustness risks in 20% of samples examined.

(d) Temperatures had limited effect on the fruit quality in the short 16-day domestic supply chains

Temperature monitoring of supply chains was a significant investigative effort in the first three years of supply chain monitoring, but wasn't found to have a significant impact on fruit quality. This was most likely due to the short (average of 16 days from packing to ripe) nature of the Australian supply chains monitored. This is examined in significantly more detail in appendix 5.

(e) Impact of a crowded market

It is proposed that in years of heavy supply (indicated by the blue bars in figure 19) this can result in the fruit spending longer in the supply chain (indicated by the orange line), putting more pressure on fruit quality.

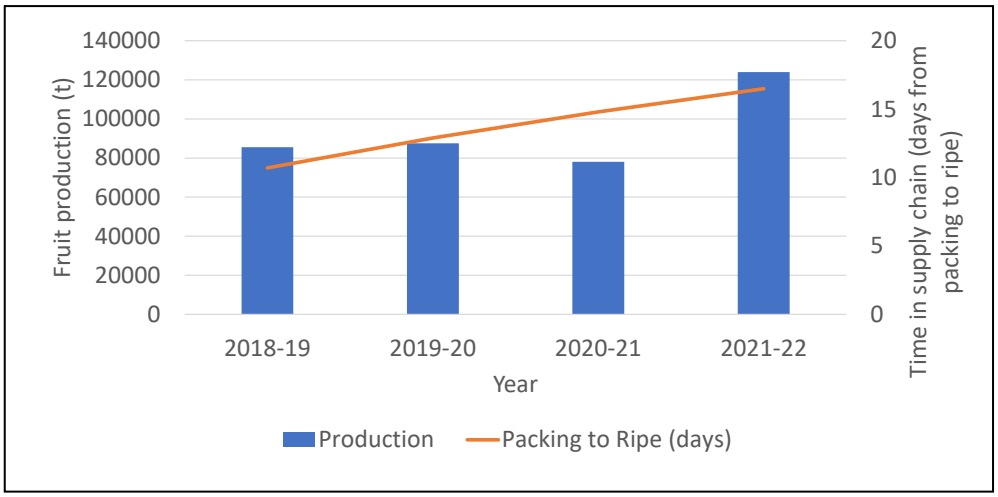


Figure 19: Graphical representation in changes to the volumes of avocados traded in the Australian market (blue bars) and the average time in supply chain recorded (orange line) during monitoring over the same four years of this project.

Appendix 4: Why pack shed staff had confidence in the project findings

There were several elements of the project methodology to ensure that pack shed staff regarded the project findings as credible. This included the inclusion of plenty of high-quality images of the fruit to verify the recorded of fruit quality findings. The tracking of the consignment through the supply chain offered information about risks in the chain. All deidentified findings were shared with avocado industry personnel, the support from the industry members of the Project Reference Group and Avocado Strategic Investment Advisory Panel had a significant role in the progressive design of the project, and finally the project was specifically designed around key elements of the Avocado Strategic Investment Plan.

(a) Verified assessments with images

Pack shed staff and supplying growers spent considerable time reviewing the results and at times, challenging the project methodology. Many, of course, then translated that interest into changes to their management actions in the shed and on the farm. Most assessment had 10-20 high quality images attached to the report to verify the scoring in assessments. The images for supply chain number 13 are presented in figure 13 in appendix 2 as an example. A video was also created to provide an insight into the assessment process and it's YouTube location is listed in the references of this report.

(b) Tracking the supply chain offered transparency

Undertaking tracking of consignments and recording of supply chain conditions, built confidence of pack shed managers in the fruit quality results, especially the information about fruit age and supply chain temperatures and locations.

(c) All findings shared with industry

It is important to recognise that this benchmarking work is not just research collecting data. It is about providing detailed reports to pack-sheds, and where possible the growers. The project had a significant industry engagement methodology which over the four years significantly over-delivered the number of contracted outputs. This included;

- Updating growers via Avocado Regional Forum presentations,
- Videos and factsheets were also used to dive into issues impacting fruit quality,
- Tracebacks through the supply chain to the grower were used to investigate poor fruit quality,
- Reviews of the BPR with Avocados Australia was undertaken to ensure the currency of the BPR and to provide a project legacy,
- Case studies of improved practices were captured in Talking Avocados magazine,
- A deidentified dataset was compiled and made available to any interested industry personnel as well as other avocado researchers, and
- Webinars and face to face workshops that targeted wholesalers & ripeners.

When surveyed, the collaborating pack-shed staff rated the individual reports, discussions, updates on trends and information products as very useful.

(d) Avocado SIAP & PRG supported co-design of project

The avocado Strategic Investment Advisory Panel (SIAP) reviewed project progress and recommended changes at a stop/go contract milestone at the end of year 1 (2019). The Project Reference Group met virtually every 6 months over the four years of the project to ensure the project was on track, making the most of opportunities to engage with the industry and to contribute to co-design of the project.

(e) The project was a strategic industry investment

Aligned to the 2017 to 2021 Avocado Strategic Investment Plan, the AV18000 project was designed to track quality trends against the 90% industry target, quantify the variability in quality by source, identify the root causes of poor quality, share information on quality trends, sources and causes and to improve practices in the lowest performance areas. This continued to align well with quality elements in the current 2022 to 2026 Strategic Investment Plan; i.e.

applying a systems approach to improve quality through supply chains and delivering extension services to change quality through supply chains.

Appendix 5: Impact of temperature management in supply chains on resultant fruit quality

Improved temperature management in domestic supply chains was an end of project Monitoring and Evaluation target. Averaging across the 40 supply chains monitored each year for the three years of supply chain temperature monitoring, with the exception of ripening temperatures, there was little discernible trend.

Individuals did make changes to their own supply chain temperatures upon discovering what was happening and this was captured in a case study. Improved temperature management through the supply chain is one of the practices known to influence fruit quality. Monitoring in this AV18000 project has confirmed and expanded understanding in this area.

Pack shed departure temperatures ranged from 5.0˚C to 28.4˚C and averaged 10.2˚C over the 122 consignments monitored and were quite variable between suppliers. 24% of consignments followed best practice (under 7˚C) while the remaining 76% of consignments were warmer and operating outside of best practice. District averages ranged from 6.1˚C to 13.5˚C (table 7). Departure temperatures remain the largest risk to effective temperature management in supply chains. Many pack sheds were challenged to improve their cool chains because of the need to fill the truck when it arrives for pick-up, which often overrides the best practice for all fruit to be at storage temperature before loading into the truck. Despite departure temperatures having a limited effect on quality in the short (16-day) domestic supply chains, pack shed staff did recognize the more significant risk to longer supply chain export consignments. To help manage this risk, there has been an increase in the use of real-time temperature monitoring of supply chains by pack-shed managers over the life of the project.

Pack shed departure temperatures				
	2019	2020	2021	2022
NQ	8.6		13.5	10.7
CQ	12.1	10.7	12.8	
CNSW	9.1	6.6	6.1	
Tristate	12.5	11.3	11.2	
WA	7.2	7.9	12.1	
Average	9.9	9.1	11.1	10.7

Table 7: Pack shed departure temperatures, averaged for each production district over the three years of monitoring of cool chains.

Average consignment **transport temperature** ranged from 4.5˚C to 15.5˚C, averaging 8.1˚C over the 122 consignments monitored. 39% of consignments were following best practice (under 7˚C) with the remaining 61% warmer and operating outside of best practice. District averages ranged from 6.2˚C to 11.1˚C (table 8). Temperatures in the trucks and trains were generally good considering the departure temperatures at the pack sheds. There were more instances of mixed loads in the Tristate district.

Transport temperatures				
	2019	2020	2021	2022
NQ	7.7		8.7	8.4
CQ	7.3	8.0	7.9	
CNSW	7.0	6.3	6.7	
Tristate	11.1	10.0	9.9	
WA	8.3	6.2	7.9	
Average	8.3	7.6	8.2	8.4

Table 8: Transport temperatures, averaged for each production district over the three years of monitoring of cool chains.

Average consignment **storage temperature** ranged from 4.1˚C to 18.3˚C, averaging 7.8˚C over the 122 consignments

monitored. 50% of consignments were following best practice (under 7˚C) with the remaining 50% warmer and operating outside of best practice. District averages ranged from 5.9˚C to 12.7˚C. The storage temperatures at wholesalers and distribution centres was also close to best practice (5˚C for Hass and 7˚C for Shepard), averaging across the Hass and Shepard consignments (table 9).

Storage temperatures				
	2019	2020	2021	2022
NQ	7.7		7.9	7.7
CQ	6.1	7.5	6.3	
CNSW	7.2	6.3	5.9	
Tristate	9.8	12.7	7.3	
WA	10.2	7.2	6.6	
Average	8.2	8.4	6.8	7.7

Table 9: Storage temperatures, averaged for each production district over the three years of monitoring of cool chains.

Consignment **ripening temperature** ranged from 9.2˚C to 23.2˚C and averaged 16.3˚C over the 122 consignments monitored. 67% of consignments were following best practice (between 15 and 20˚C) with the remaining 33% operating outside of best practice. District averages ranged from 13.9˚C to 18.1˚C. Yearly averages have been dropping from 17.5˚C to 16.1˚C to 15.4˚C to 15.8˚C for 2019, 2020, 2021 and 2022. This supports anecdotal comments that ripeners used cooler temperatures later in the project to reduce the risk of not meeting the supermarket DC firmness specifications on arrival and to deliver better fruit quality for buyers. The temperatures used in ripening was also aligned to best practice (table 10), which is why the temperature monitoring was discontinued early in 2022.

Ripening temperatures				
	2019	2020	2021	2022
NQ	18.1		17.0	15.8
CQ	17.8	16.5	14.5	
CNSW	17.8	16.3	16.2	
Tristate	17.6	16.3	13.9	
WA	16.3	15.4	15.3	
Average	17.5	16.1	15.4	15.8

Table 10: Ripening temperatures, averaged for each production district over the three years of monitoring of cool chains.

Analysis has failed to identify a significant link to the resultant fruit quality in the short domestic supply chains monitored. As such this element of the project was discontinued for this reporting period in the July 2022 variation to this project with Hort Innovation. It is of course more likely that temperature transgressions will lead to worsening fruit quality as the Australian domestic avocado market becomes increasingly oversupplied, presuming an increase in temporary storage times prior to and post ripening.