DEVELOPMENT OF FRUIT QUALITY DISORDERS IN NEW ZEALAND AVOCADOS AT OUTTURN IN THE USA FOR THE 2000-2001 AND 2001-2002 SEASONS.

J. DIXON

Avocado Industry Council,
PO Box 16004, Bethlehem, Tauranga

ABSTRACT

Fruit quality at out-turn overall was good from a commercial perspective in both seasons with about 80% of ripe fruit having no defects greater than 5% severity. Fruit age had a major effect on fruit quality, where fruit older than 24 days on arrival had greatest severity and incidence of rots during ripening. Major quality problems were rots (stem-end and body rot), vascular browning and fuzzy spotting on the peel. Minor quality problems were cold peel damage, incomplete ripening, peel damage and cosmetic defects with large amounts of blemish (including leafroller scars) on some lines of fruit. Four different shipping systems were assessed: two controlled atmosphere (CA) container systems (CA1 and CA2), non-CA containers and break bulk Reefer ships. The type of shipping system had a major effect on outturn quality, largely due to differences in fruit age. Best fruit quality was in fruit sent by Reefer break bulk followed by CA2, Non CA and CA1 containers as fruit maintained in CA1 containers had a high incidence and severity of rot. Checkerboarding was common on first shipments. Maturity related disorders were not commercially important. In the 2001-2002 season fruit quality was maintained after storage for several weeks at importers facilities due to market conditions.

INTRODUCTION

Avocado exports from New Zealand to the USA have grown to be about half the volume of avocados exported from New Zealand today. Traditionally the New Zealand avocado export business has been based on shipments to Australia, a market that is relatively close at 3-4 days transport time by ship. The greater distance from New Zealand to the USA compared with Australia results in longer transport times with the fastest shipping times being 14-15 days. A variety of shipping systems for export have been used including 20 and 40 foot refrigerated containers, modified and controlled atmosphere containers and break-bulk reefer ships. Due to the small volumes of fruit sent to the USA initially containers were used to transport fruit but, starting with the 2000-2001 season, reefer shipping has become the transport mode of choice.

The greater distance to travel to the USA and resulting time in storage means that the systems used to successfully transport fruit to Australia are not necessarily suitable for avocados sent to the USA. This was most graphically demonstrated by a severe quality crisis that reached its height in the 1999-2000 export season. This was the infamous disorder ‘measles’, so called because hard green fruit on arrival would rapidly develop patches of rot that seemed to spread from fruit to fruit. The quality crisis demonstrated that the information on quality coming back to New Zealand was inadequate to identify the cause of ‘measles’. In addition the reputation of New Zealand avocado fruit quality was severely downgraded to the extent that New Zealand fruit was discounted compared to fruit from other sources. As the measles problem had been building to crisis point over the past 2 years and seemed unsolvable the

market had delivered an ultimatum to the New Zealand avocado industry: 'one more strike and you are out'.

To solve the 'measles' problem and to improve the reputation of the quality of New Zealand avocados the New Zealand avocado industry employed a "Quality Champion" whose task is to oversee fruit quality issues in New Zealand. An Outturn Monitor was appointed who is based in California during the export season to run a fruit quality survey of New Zealand fruit as they enter the USA importers facility. In order to conduct a comprehensive fruit quality survey a Fruit Quality Assessment manual was written that was commercially relevant, scientifically sound, and that could be used by packshed staff and USA importers. Best practice was defined and changes to handling systems were communicated to growers and packhouses by the Quality Champion. Without a fruit quality survey the impact of these changes could not be measured nor could different shipping systems be evaluated. In addition the exporters needed to have a system in place that allows them to react as quickly as possible to quality problems so that problems could be resolved in as close to real time as possible.

Hence the quality assurance programme has the following objective: To provide industry participants with real time evaluation of fruit quality after shipment to the USA using a comparative and consistent evaluation format.

This report describes the findings from the fruit quality survey over the 2000-2001 and 2001-2002 USA export seasons.

MATERIALS AND METHODS

Fruit quality was surveyed for New Zealand avocados arriving into importer facilities in California. The fruit were sampled as soon as was practicable after arrival into the importers facility which was between 1 to 5 days after fruit were unloaded off the ship and the fruit had passed through plant pest and quarantine inspections. USDA grade inspections were carried out in the importers facilities. In 2001-2002 shipments arrived once every 2 weeks and the fruit from 2 importers were re-sampled after an additional week in coolstorage at the importers facility.

Fruit inspections were carried out during 2000-2001 and 2001-2002 export seasons. In the 2000-2001 season fruit arrived each week alternating between container and reefer ships. In the 2001-2002 season fruit arrived every 2 weeks by reefer shipment. Fruit were inspected at each of the importers facility after USDA grade inspection and before distribution to retailers. In each season there were three tiers of fruit quality assessment: an inspection of one box from 12 to 24 pallets, a detailed green fruit external examination from a sub-sample of the fruit removed from each pallet, and a ripe fruit internal and external examination after a standard ripening protocol of 5 days at 7°C then removal to 20°C until the fruit reached a firmness of at least 85 as determined by a firmometer with a 300g weight. Ripeness was assessed by hand after calibration against the firmometer. At each visit in 2000-2001 2 boxes were sub-sampled for detailed green fruit assessment and subsequent ripe fruit assessment, while in 2001-2002 4 boxes were sub-sampled for detailed fruit assessment as in 2000-2001. The same fruit that were examined in the green fruit assessment were ripened for the ripe fruit assessment.

Fruit for detailed assessment were selected according to the following criteria: count 48 when possible, as many different growers as possible, cover the range of pickdates as stamped on the boxes, and be proportional to the packhouses represented in store. Although count 48 fruit

were the targeted size for sub samples a significant number of fruit of other count sizes were also inspected. The top tray of fruit within a sub-sampled box was photographed using a digital camera. This photograph along with the fruit quality report was e-mailed to the AIC office where the results were collated and passed onto the exporter whose fruit had been inspected.

Disorders and defects in the fruit were rated by the percentage of a fruit affected by a disorder (severity) or numbers of fruit within a box that had a particular disorder (incidence). Checker boarding was rated on a scale of 0-10 depending on the proportion of fruit that were coloured compared to the number of fruit that were green. The disorders were rated on a scale of 0-100 for each individual fruit. Fruit assessed at the importers facility were rated for external disorders only while ripe fruit were cut open and the skin peeled off to rate the fruit internal disorders. The disorders and a detailed description of the system used to assess fruit quality is described in the AIC fruit quality assessment manual. The manual contains a large number of full colour photographs illustrating each disorder considered to be commercially important and the manual explains how the fruit are to be examined and cut for inspection.

Results are reported as a percentage of fruit affected (incidence) and the average area of a fruit affected by a disorder (severity). The overall quality was given a rating as the percentage of sound fruit by rejecting a fruit once the disorders: external rot, stem-end rot, vascular browning, brown patches, flesh bruising and flesh discolouration exceeded a minimum threshold level and peel damage in excess of 20% severity. The average severity and incidence of disorders have been tabulated and graphed for this report.

RESULTS AND DISCUSSION

In 2000-2001 there was a total of 43 fruit inspections at importers, fruit from 425 pallets were inspected and 97 boxes were taken for detailed green and ripe fruit assessment. In 2001-2002 there was a total of 27 fruit inspections at importers, fruit from 409 pallets were inspected and 85 boxes were taken for detailed green and ripe fruit assessment.

The major disorders found in both seasons were rots: visible fungal bodies on the outside of the fruit, fuzzy patches of undeveloped rots, stem-end rot and vascular browning. Minor disorders were physiological and mechanical disorders: incomplete ripening, cold peel damage, bruising, and peel damage. Cosmetic problems were apparent at very low incidences that included out of grade leafroller damage, misshapen fruit and ridging. The incidence and severity of the major disorders is presented in Tables 1 and 2. Ripe fruit had similar numbers of sound fruit in each season but the green fruit had fewer disorders in 2001-2002 than 2000-2001 (Table 3).

Table 1. Average incidence of disorders for all fruit evaluated in the USA Outturn Monitoring programme. Total number of individual fruit examined was 4,410 in 2000-2001 and 4,092 in 2001-2002.

Green fruit Disorder	Incidence (%) 2000-2001	2001-2002	Ripe fruit Disorder	Incidence (%) 2000-2001	2001-2002
Checkerboarding*		**26.5**	External rot	**3.2**	**0.4**
Discrete patches	**2.7**	**0.6**	Stem-end rot	**56.0**	**21.3**
Fuzzy Patches	**26.8**	**4.4**	Vascular Browning	**19.8**	**10.8**
Peel Damage	**89.4**	**83.6**	Brown Patches	**49.8**	**55.5**
External Rot	**0.0**	**0.0**	Flesh adhesion	**15.6**	**5.8**

*checker boarding is rated on a scale from 0 – 10.

Table 2. Average severity of disorders for all fruit evaluated in the USA Outturn Monitoring programme. Total number of individual fruit examined was 4,410 in 2000-2001 and 4,092 in 2001-2002.

Green fruit Disorder	Incidence (%) 2000-2001	2001-2002	Ripe fruit Disorder	Incidence (%) 2000-2001	2001-2002
Checkerboarding*		**0.5**	External rot	**0.5**	**0.1**
Discrete patches	**0.2**	**0.1**	Stem-end rot	**1.7**	**0.5**
Fuzzy Patches	**0.7**	**0.4**	Vascular Browning	**7.5**	**3.1**
Peel Damage	**10.1**	**16.2**	Brown Patches	**3.4**	**3.3**
External Rot	**0.0**	**0.0**	Flesh adhesion	**NA**	**NA**

*checker boarding is rated on a scale from 0 – 10.

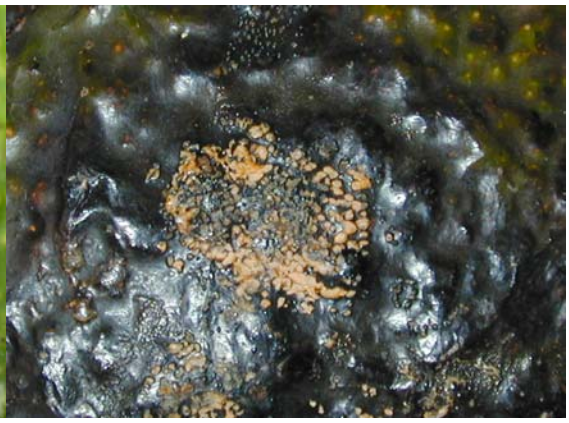
Table 3. Incidence of avocados with quality defects in 2000-2001 and 2001-2002 counting peel damage as a defect when greater than 20% of fruit surface was affected. Other defects were counted once their severity exceeded the threshold value listed in the table.

Green Fruit	Threshold value	Sound fruit (%)	
		2000-2001	**2001-2002**
	0%	**62.6**	**85.0**
	1%	**75.3**	**87.4**
	5%	**86.3**	**88.6**
	10%	**87.0**	**88.6**
Ripe Fruit	Threshold value	Fruit without defects (%)	
		2000-2001	**2001-2002**
	0%	**26.2**	**37.1**
	1%	**64.1**	**63.5**
	5%	**80.3**	**81.1**
	10%	**86.5**	**88.6**

Major disorders:

Fuzzy patches

External rot



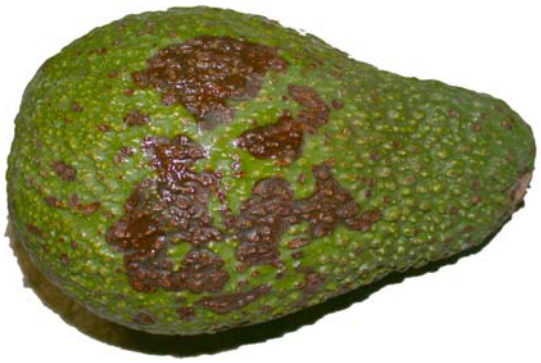
Stem-end rot

Vascular Browning

Brown patches (body rots)

Minor disorders:

Discrete patches



Peel damage

Flesh adhesion

Leafroller chew

Out of grade

Ridging

Checkerboarding

Blemish

Fruit age

Fruit age had a major influence on fruit quality, with incidence of stem-end rot and body rots increasing steadily after arrival in the USA until about 34 days after picking when rot severity and incidence increased exponentially (Figure 1). The same pattern in rot development with fruit age was seen each year. The exception was body rots that had a higher initial incidence in the 2001-2002 season compared to the 2000-2001 season.

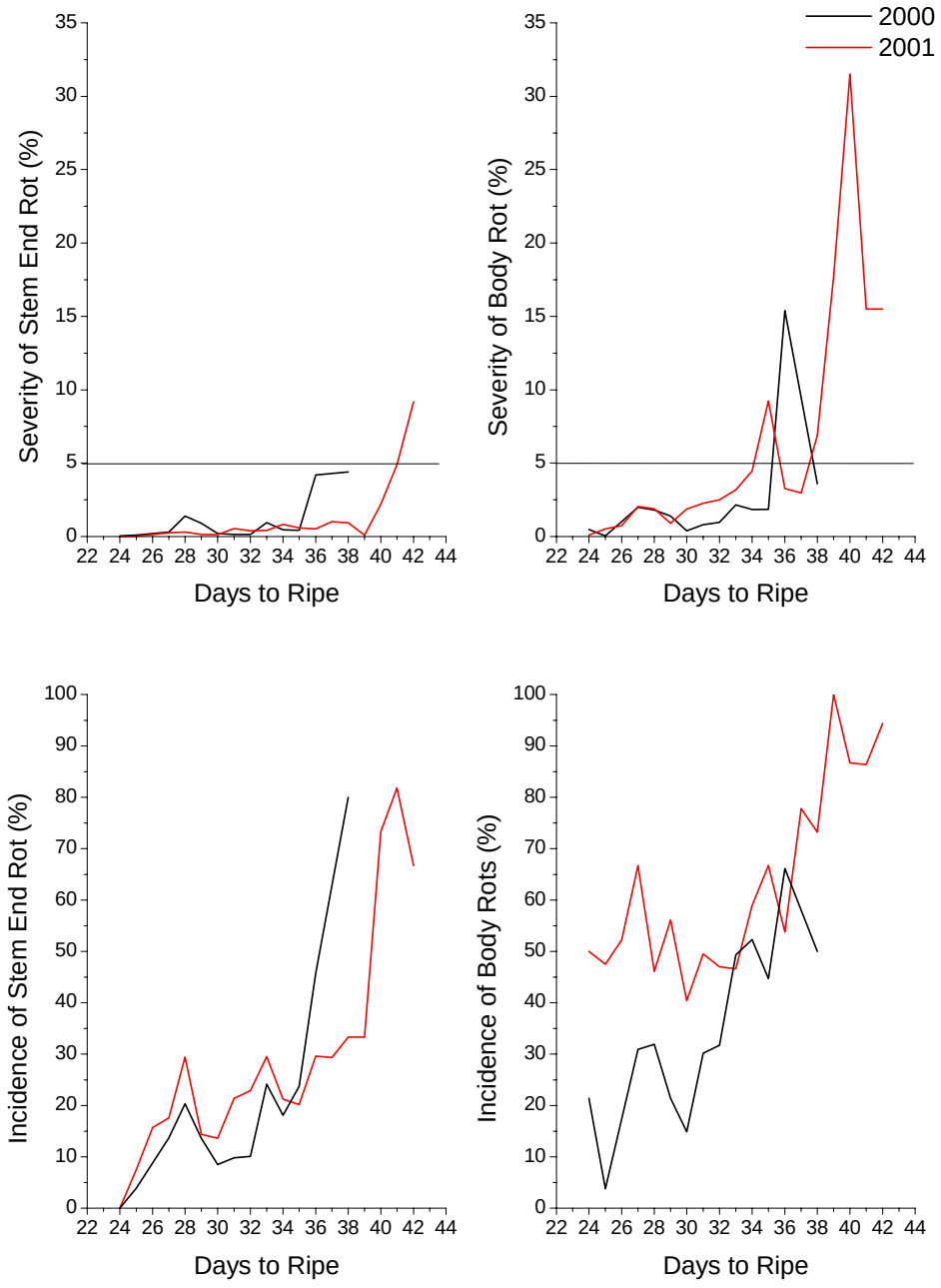


Figure 1. Average incidence and severity of stem-end rot and body rot in avocados of different fruit ages. Fruit age was calculated as the number of days from picking to cutting the fruit for ripe assessment.

Shipping system

Fruit quality varied according to shipping system with fruit sent by reefer ships being the best with about 90% sound fruit when ripe and one of the CA systems the worst quality with about 65% sound fruit (Table 4). The fruit sent by reefer ship were of better quality as they had fewer rots than container fruit (Table 5). This may be due to the shorter shipping times for reefer ships (15 days) compared to container ships (*ca* 20 days).

Table 4. Overall percentage of sound fruit in 2000-2001 by shipping system, counting peel damage as a defect when greater than 20% severity, for all fruit evaluated in the outturn monitoring program. Other defects were counted once their severity exceeded the threshold value listed in the table.

Disorder Threshold	Shipping Type	Green Sound Fruit (%)	Ripe Sound Fruit (%)
0%	Reefer	**67.1**	**29.2**
	CA1	**57.7**	**16.8**
	CA2	**63.4**	**28.1**
	Non CA	**57.5**	**29.8**
5%	Reefer	**86.7**	**88.9**
	CA1	**81.9**	**65.0**
	CA2	**92.1**	**81.2**
	Non CA	**85.9**	**79.0**

Table 5. Average incidence and severity of disorders in fruit in 2000-2001 by shipping system transported by different shipping systems to the USA. Total number of individual fruit examined was 4,410 in 2000-2001 and 4,092 in 2001-2002.

Green fruit Disorder	Incidence (%) Reefer	CA1	CA2	NonCA	Ripe fruit Disorder	Incidence (%) Reefer	CA1	CA2	Non CA
					External rot	**0.6**	**8.5**	**3.1**	**3.0**
Discrete patches	**0.5**	**9.4**	**1.3**	**0.5**	Stem-end rot	**53.4**	**69.0**	**48.3**	**52.1**
Fuzzy Patches	**22.9**	**26.2**	**29.8**	**32.6**	Vascular browning	**8.3**	**38.1**	**21.6**	**21.3**
Peel Damage	**89.4**	**93.1**	**83.5**	**89.7**	Brown patches	**42.8**	**60.9**	**54.8**	**47.0**
External Rot	**0.0**	**0.0**	**0.0**	**0.0**	Flesh adhesion	**19.2**	**8.8**	**13.1**	**18.0**

Green fruit Disorder	Severity (%) Reefer	CA1	CA2	NonCA	Ripe fruit Disorder	Severity (%) Reefer	CA1	CA2	NonCA
					External rot	**0.2**	**1.4**	**0.3**	**0.3**
Discrete patches	**0.0**	**0.8**	**0.1**	**0.0**	Stem-end rot	**0.7**	**4.3**	**1.1**	**1.5**
Fuzzy Patches	**0.6**	**0.8**	**0.8**	**1.0**	Vascular browning	**1.5**	**19.0**	**5.8**	**8.1**
Peel Damage	**10.1**	**12.2**	**7.1**	**10.4**	Brown patches	**1.9**	**6.9**	**2.4**	**3.5**
External Rot	**0.0**	**0.0**	**0.0**	**0.0**	Flesh adhesion	**NA**	**NA**	**NA**	**NA**

Fruit maturity

Incomplete ripening (flesh adhesion) is an indirect measure of physiological fruit maturity and is a good indication of how well the maturity clearance programme is working. There was a high incidence of flesh adhesion in 2000-2001 until early November but in 2001-2002 was only high until mid October (Figure 2).

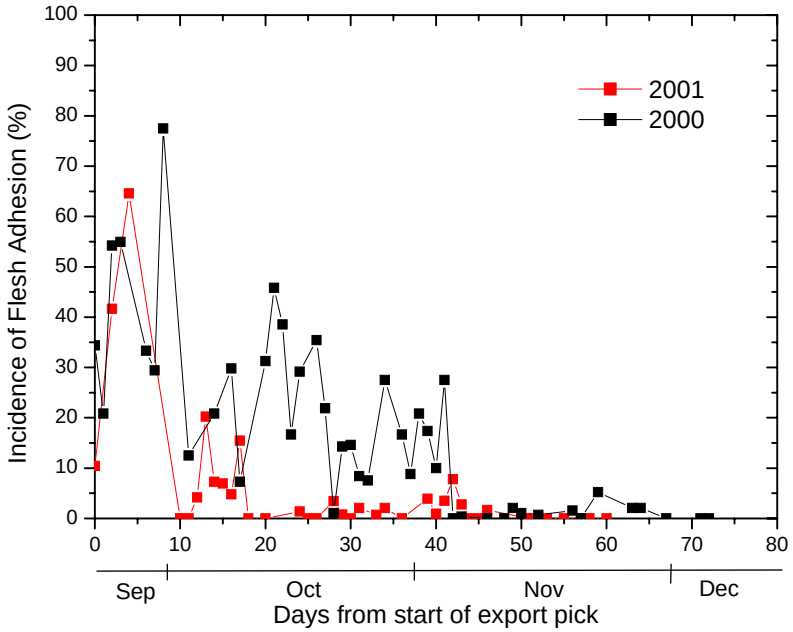


Figure 2. Incidence of flesh adhesion in fruit harvested in September through to December and exported to the USA in 2000 and 2001.

Fruit quality changes during the export season

At present New Zealand avocados are exported to the USA in September, October and November. With an increasing national crop the export season to the USA can be expected to extend into December and possibly January. Seasonal changes in fruit quality will become more important in helping to determine at which stage in the export season quality problems may start to get worse. Severity of body rots increased in November in 2001-2002 compared to September and October reducing the percentage of sound fruit by about 10% (Table 6).

Table 6. Trends in rot incidence and severity by month of export in the 2001-2002 export season.

Disorder	Month		
	1	2	3
		(%)	
Incidence Stem-end Rot	**19.6**	**21.0**	**29.7**
Incidence Vascular Browning	**11.2**	**9.3**	**14.9**
Incidence Brown Patches	**67.3**	**47.7**	**73.4**
Severity Stem-end Rot	**0.9**	**0.4**	**0.9**
Severity Vascular Browning	**3.7**	**2.6**	**3.1**
Severity Brown Patches	**3.3**	**3.3**	**5.8**
% Sound fruit (5% threshold)	**80.1**	**82.6**	**69.3**

Comparison of exporters

Sufficient data has been collected to allow the fruit quality from different exporters to be compared but not enough boxes have been sampled to allow a comparison of packhouses or

growers fruit quality. Care should be taken in interpretation of Table 7 as some of the exporter averages are based on fewer than 5 boxes of fruit. Table 7 indicates that there are differences in fruit quality due to the slightly different ways the fruit are handled by packhouses and USA importers. The industry average of fruit quality has been similar over the past 2 export seasons.

Table 7. Percentage of sound avocado fruit listed by exporter for fruit in 2000-2001 and 2001-2002. Sound fruit were the number of fruit with less than 20% peel damage; other defects were counted once their severity exceeded a threshold value of 5%.

Exporter	2000-2001	2001-2002
A	99.3	-
B	79.8	72.6
C	75.9	71.0
D	75.0	-
E	91.3	84.5
F	78.4	83.8
G	81.9	92.1
H	86.8	93.3
Industry Average	83.6	80.5

SUMMARY

The fruit quality survey has been successful in allowing the New Zealand avocado industry to evaluate the success of the changes in harvest and postharvest practice introduced to solve the fruit quality crisis of the 1999-2000 export season. The major quality issue for avocados from New Zealand is rots with physiological disorders inducing only minor problems. Fruit age has been identified as a key issue for avocados transported long distance to market. The out-turn results have demonstrated that using a shipping system such as break bulk reefers not only minimises fruit age at a reasonable cost but also allows fruit quality to be maintained even through different export seasons.

The fruit quality survey has given some important insights to what avocado fruit quality is like in the USA. One new finding was that stem-end rots are more important than previously thought and require more research to understand how the incidence of stem-end rot may be reduced. Body rots vary from season to season but remain a very large proportion of the disorders that cause fruit to be rejected as unsound. While this is important information the numbers of boxes sampled in the fruit quality survey are low and are insufficient to allow a comparison of packhouses and growers fruit. The best fruit quality information for packhouses and growers is from the shed library tray programme. In addition it remains unknown how long New Zealand fruit keep their quality as the season progresses.

There have been intangible benefits to the New Zealand avocado industry beyond reporting disorders and fruit quality problems back to exporters. There has been a boost to the reputation of New Zealand avocados restoring much of the lost ground after the quality crisis. The flow of information about fruit quality has allowed exporters to make timely key decisions about what is best to do when a quality problem arises or the market conditions are not ideal. An example of this was the severe downturn in the USA market in September 2001 that meant a lot of fruit was stored at the importers facilities for several weeks after arrival in

the USA. New Zealand avocados held their quality in storage well but it is doubtful that without the fruit quality survey and its findings the USA importers would have had the confidence that avocados from New Zealand would last in storage.

Quality problems in the USA were identified as early as possible allowing suitable remedial action to be taken in the USA by the New Zealand exporters that helped to isolate causes of disorders. There has been continuous feedback to the AIC and New Zealand exporters about New Zealand avocado quality in the USA market and allow problem solving in as close to real time as possible. That avocado fruit quality has been similar in the past 2 seasons suggests that the New Zealand avocado industry has been successful in managing fruit quality but the inherent tendency of the fruit to rot and develop disorders has not changed from the 1999-2000 export season. Should there be any easing up on the quality effort severe quality problems, such as measles, could reoccur.