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FRUIT AGE MANAGEMENT: THE KEY TO SUCCESSFUL LONG DISTANCE EXPORT OF NEW ZEALAND AVOCADOS

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SUMMARY

The New Zealand (NZ) avocado industry has implemented an annual quality assurance programme in the USA in partnership with importers of NZ avocados. Information collected from quality inspections has been used to identify factors that influence fruit quality of exported avocados. The factor with the most influence on fruit quality was fruit age (the number of days from harvest until the fruit are assessed). The relationship between fruit age and fruit quality was non-linear with an appreciable deterioration in quality occurring after 32 days. In a series of controlled experiments the relationship between fruit quality and duration of storage and fruit maturity was investigated. Optimal storage time decreased as fruit maturity increased with 21 days at 4°C maximising fruit quality in September reducing to 7 days in March. Manipulation of fruit age could be used as a management tool to achieve consistent fruit quality in export markets over the harvest season by reducing fruit age on arrival into the market.

Key Words: body rot, maturity, quality, stem end rot

INTRODUCTION

Avocados are recognised as having a short storage life, making it a challenge to maintain fruit quality when exporting avocados long distances. In recent years the NZ avocado industry has been exporting fruit to the USA from August to November. In 1999 there were large losses of avocados exported to the USA due to fruit decaying rapidly after arrival. In response the NZ avocado industry implemented a quality assurance programme for the 2000-2002 export seasons where fruit arriving in the Port of Los Angeles were surveyed for disorders at each importers facility. The information collected was passed back to exporters through the Avocado Industry Council.

One important factor that influences fruit quality in South African avocados exported long distances to Europe is fruit age (the number of days from harvest until assessment) and fruit maturity over the harvest season (Vorster et al, 1990). Avocado fruit quality has been reported to deteriorate with increasing fruit age and maturity (Cutting and Wolstenholme, 1992). At present there is little known about the influence of fruit age on NZ avocado fruit quality. By managing the age of fruit arriving in distant markets it should be possible to deliver fruit of consistent quality despite changing fruit maturity. To determine appropriate postharvest timelines to give desired fruit ages, information is required on fruit quality in relation to fruit age from both the export market and controlled experiments designed to characterise the relationship between fruit quality, maturity and duration of storage. The effect of fruit age on NZ avocado fruit quality was investigated in the USA market via the quality assurance programme in the USA. The effect of storage duration and maturity on fruit quality was examined in a series of experiments on fruit over the export harvest season.

MATERIALS AND METHODS

Quality Assurance Programme

Each year (2000, 2001 and 2002) about 400 boxes of fruit were inspected on arrival into importers facilities in the USA. For the USA export season September-November 2000 one box from each of 10 pallets was assessed each week; a sub-sample of 2 boxes was taken for detailed fruit examination. For the export season September-November 2001 and September-October 2002 one box from up to 24 pallets was assessed two weekly; a sub-sample of 4 boxes was taken for detailed fruit examination. In 2000, 2001 and 2002, 97 boxes of fruit (more than 4600 fruit), 85 boxes of fruit (more than 4000 fruit) and 68 boxes of fruit (more than 3,000 fruit), respectively, were cut for internal examination. In each year, fruit were stored for 5 days at 7°C at the University of California, Riverside then ripened at ambient (20-22°C).

After removal from storage unripe green fruit were inspected for disorders on the surface of the fruit and once eating ripe were assessed for internal disorders. Ripeness was determined by firmometer when the fruit reached a softness reading of 85 using a 300g weight or by hand feel after calibration to a firmometer. Fruit were assessed for disorders according to the Avocado Industry Council Fruit Assessment Manual (2000 and 2001). Disorders were rated by assessing the percentage (scale 0 to 100) of the cut surface of the fruit or skin surface area that was affected by disorders. Green fruit were rated for discrete patches (brown to black sunken lesions with sharp discrete edges), fuzzy patches (brown to black sunken lesions with indistinct edges) and peel damage (skin abrasions). Ripe fruit were rated for visible fungal fruiting bodies then cut longitudinally into quarters where the cut surface of ripe fruit was rated for stem end rot (discoloured flesh from the stem button down), vascular browning, flesh bruising and diffuse flesh discolouration (greying of the flesh with indistinct edges). The under side of the peeled skin was rated for brown patches (body rot as circular brown coloured patches).

Fruit age experiment

Avocado fruit (cv. 'Hass') were harvested from three commercial orchards in the Bay of Plenty region (37°S, 176°E), North Island of NZ. There were four harvests: 4/9/2002 (harvest 1), 31/10/2002 (harvest 2), 7/1/2003 (harvest 3) and 6/3/2003 (harvest 4). Within 4 hours of harvest fruit were packed into trays and placed into a commercial coolstore at 4°C, 85% RH. A sample of 100 fruit per orchard per harvest was removed from storage every seven days for up to 42 days to 20°C for ripening. A non-stored control sample of 100 fruit per orchard per harvest was ripened at 20°C, 60% RH, immediately after harvest. A 20 fruit sample from each harvest from each orchard was assessed for percentage dry matter by drying flesh peelings from the inside face of one quarter of each fruit after the seed, seed coat and skin were removed. After removal from

storage unripe green fruit and eating ripe fruit were assessed for disorders as in the quality assurance survey.

The fruit age experiment was analysed as a repeated measures trial with harvests nested within orchards. Binary logistic regression analysis (MINITAB) was used to determine differences in incidences.

RESULTS AND DISCUSSION

Quality Assurance Programme

New Zealand avocados exported to the USA were 23 to 44 days from harvest when the fruit reached eating ripeness (Figure 1). The lower the fruit age the lower the incidence of unsound fruit at a disorder severity threshold of 5% (Figure 1). There was a non-linear increase in unsound fruit as fruit age increased with an appreciable deterioration in quality after 32 days from harvest. The relationship between fruit age and unsound fruit was described by the power function $y = -7.56 + 0.0075*x^3$ ($r^2 = 0.733$, $p<0.001$, Figure 1). These results suggest that if fruit age can be maintained below 30 days then the incidence of unsound fruit will, on average, be below 10%.

The current timeline for postharvest handling of NZ avocados exported to the USA is: 1-2 days for harvest, grading and packing, 9-10 days for onshore consolidation, 15 days for transit on reefer vessel, 9-12 days for unloading, distribution and sale and 3-5 days for ripening. Within this timeline the only opportunity for the New Zealand avocado industry to manipulate fruit age is to change the onshore consolidation time. However, the degree to which onshore consolidation times should be reduced and the timing during the harvest season of changes to consolidation times cannot be determined from the quality assurance programme data.

Fruit age experiment

Fruit dry matter increased from harvest 1 to harvest 3 and was the same for harvest 3 and harvest 4 (Table 1). The time to ripen decreased with each harvest ($p<0.001$) and storage duration ($p<0.001$). In general, non-stored fruit from harvests 1 to 3 had higher incidences and severity of stem end rot and body rot than fruit cool stored 7 to 21 days. Fruit stored longer than 21 days had levels of rots that increased exponentially with time in storage, up to 42 days, eventually exceeding the levels of rots found in non-stored fruit. The incidence of unsound fruit with disorders less than 5% severity increased significantly after 28 days storage (Table 1). A short period of cool storage (7 to 14 days) was beneficial in reducing the incidence and severity of rots over that of non-stored fruit for all harvests (Table 1). Harvest 1 fruit stored for 21 days had the least incidence of unsound fruit but by harvest 4 it was fruit stored 7 days that had the least incidence of unsound fruit (Table 1). With each successive harvest the incidence and severity of rots was greater with less time in storage. Plotting this data as a response surface (Figure 2) shows that the pattern of unsound fruit incidence was similar over the harvests but the rate at which the incidence of unsound fruit increased was greater in harvests 3 and 4. The changing surface topography in Figure 2 suggests that the range of storage times when the fruit quality was optimal narrowed with each successive harvest. Outside the optimal storage times quality deteriorated faster and to a greater incidence of unsound fruit with successive harvests. To maintain the same incidence of unsound fruit at each harvest would require reducing the duration of storage from a range of 7 to 21 days for harvest 1 to 7 days for harvest 4. This suggests that fruit age in the market could be progressively reduced to maintain fruit quality at the same level. However, changes in the onshore consolidation time needs to take into account what is practicable with respect to the logistics of harvesting and loading of shipping vessels to meet market requirements.

CONCLUSIONS

Maturity and duration of storage affected the incidence and severity of rots in ripe avocado fruit. The age of fruit in the market is related to avocado fruit quality. Fruit quality in distant markets has the potential to be managed by manipulating fruit age. One such method could be to progressively reduce the onshore consolidation time throughout the export harvest season.

Acknowledgements

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Table 1 The effect of time at 4°C, time to ripen at 20°C and quality of avocados ripened at 20°C.

Harvest	Dry matter %	Storage time days	Time to ripen days	Stem end rot		Body rot		Unsound fruit[c] %
				Inc[a]	Sev[b]	Inc	Sev	
1	24.2	0	16.5	25.3	1.3	25.0	2.4	19.3
		7	13.9	10.3	0.5	18.7	0.9	5.7
		14	9.6	11.3	0.3	12.0	0.5	6.0
		21	7.0	14.0	0.2	8.7	0.3	3.0
		28	6.3	21.0	0.4	17.0	0.4	7.0
		35	6.3	19.7	0.5	20.3	1.1	11.0
		42	5.9	23.3	1.3	30.0	2.5	28.3
2	28.3	0	12.9	7.3	0.3	21.3	0.6	6.0
		7	8.5	1.7	0.0	13.3	0.3	1.7
		14	6.1	1.7	0.0	12.0	0.4	2.3
		21	5.6	7.0	0.1	8.3	0.1	2.3
		28	5.4	11.7	0.2	21.3	0.8	4.0
		35	5.3	24.0	0.5	21.0	1.6	19.3
		42	6.4	63.3	2.4	59.0	20.4	59.3
3	33.1	0	12.3	14.7	1.1	39.7	1.9	13.0
		7	6.6	2.3	0.1	12.3	0.3	1.3
		14	4.9	0.7	0.0	15.0	0.3	0.3
		21	3.3	3.3	0.1	16.0	0.4	2.0
		28	4.7	8.3	0.5	33.7	2.3	11.3
		35	4.4	7.7	0.4	41.7	3.5	15.7
		42	4.2	18.0	0.7	62.3	5.6	60.0
4	33.2	0	5.5	2.0	0.0	35.7	0.8	4.3
		7	3.7	0.0	0.0	23.0	0.5	1.3
		14	4.1	2.3	0.0	32.3	0.7	3.0
		21	3.2	3.7	0.1	42.0	1.8	9.0
		28	2.4	8.3	0.2	51.3	2.4	16.7
		35	3.1	20.7	0.7	64.0	4.7	27.0
		42	3.2	42.3	1.4	90.3	9.1	64.3
ANOVA		Harvest	p<0.001	p<0.001	p<0.001	p<0.001	p<0.001	p<0.001
		Time	p<0.001	p<0.001	p<0.001	p<0.001	p<0.001	p<0.001

[a] Percentage of fruit, significance levels estimated using binary logistic regression analysis; [b] Percentage of the cut surface of a fruit with stem end rot of the percentage of the inside skin with lesion for body rot; [c] The incidence of ripe fruit with disorders greater than 5% severity

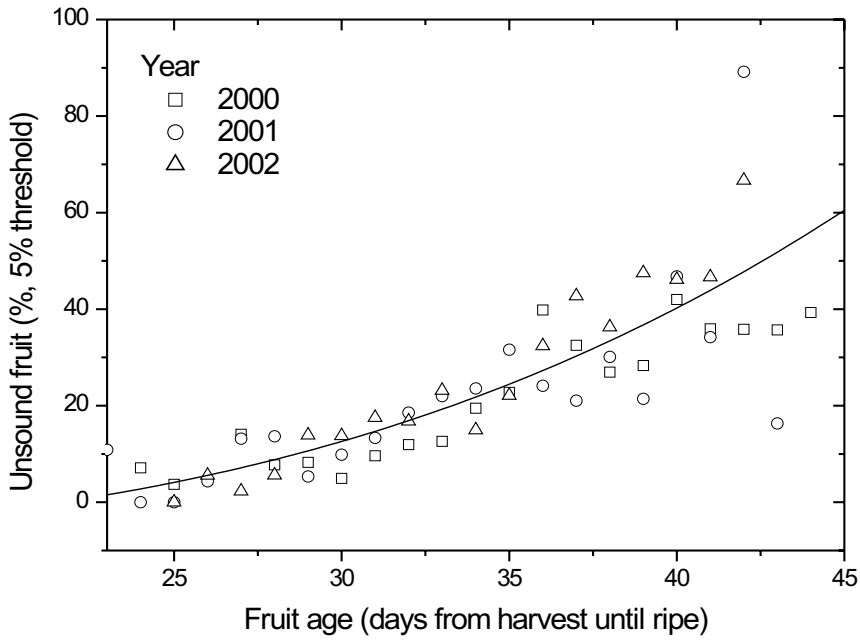

Figure 1 Relationship between fruit age and incidence of unsound fruit (using a 5% threshold of disorder severity) for avocados exported to the USA from 2000 to 2002. Each point represents the average incidence of unsound fruit that ripened at each fruit age.

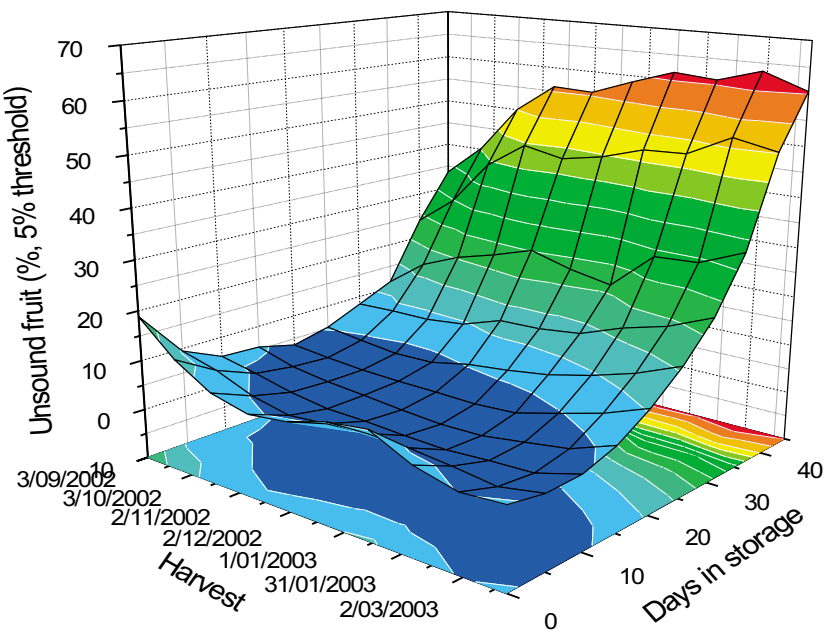

Figure 2 Surface plot of incidence of unsound fruit (using a 5% threshold of disorder severity) for fruit harvested over the New Zealand export harvest season and removed weekly from 4°C storage.