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Distal-end Browning ('Bolverkleuring') of Fuerte Fruit in the Kwazulu/Natal Midlands

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INTRODUCTION

Distal-end browning otherwise known as 'Bolverkleuring', 'Bulb-discolouration' or 'Dusky cold' is well known in the industry. However, little has been published on this disorder. Leclercq (1989) described the skin discolouration as an ill-defined light to hazy brown colour which usually affects the distal portion of the fruit. The symptoms were poorly developed at storage temperatures but manifested clearly after several hours at ambient temperatures. In that year, Edranol and Fuerte were particularly susceptible to the disorder and the tolerance level for skin discolouration was set at 2.5 %. In addition the incidence of the disorder on Fuerte fruit decreased as the season progressed and it was suggested that moisture loss may have been responsible for the disorder.

The incidence of the disorder has declined markedly in the Transvaal since 1989. However, in the last 3 years it has become a major problem in the KwaZulu/Natal midlands where the incidence was high in 1992 and 1994, when the crop loads were relatively low and the vegetative vigour high. In 1993 when the crop load in KwaZulu/Natal was large and thus had reduced vegetative vigour, the incidence of the disorder was low. During the 1994 season in KwaZulu/Natal, if fruit with the disorder were left to ripen fully, the distal-end of the fruit became a dark brown colour and was associated with mesocarp discolouration (Figure 1).

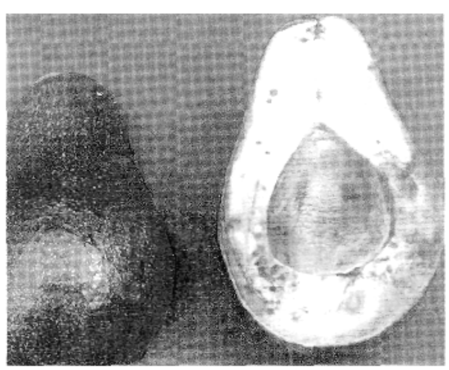

Figure 1
Fuerte fruit showing symptoms of
distal-end browning (Trial 2, Harv. 2/6/93)

Several aspects ranging from pathological to physiological which may have been implicated were examined during the 1994 season in an effort to understand and control the disorder. These are reported on in an informal manner in this paper where the results and discussions will be dealt with under the relevant topics.

PATHOLOGICAL FACTORS

Fruit harvested at weekly intervals between 17/05/94 and 26/07/94 were cold stored at 5.5°C for 28 days, allowed to ripen, and evaluated for distal-end browning, anthracnose and stem-end rot (Figure 2). Evaluations were performed on a scale of 0 to 10, where 0 = healthy and 10 = completely affected fruit. Distal-end browning was first noticed on 14/06/94 and peaked on 21/07/94 after which time the incidence declined.

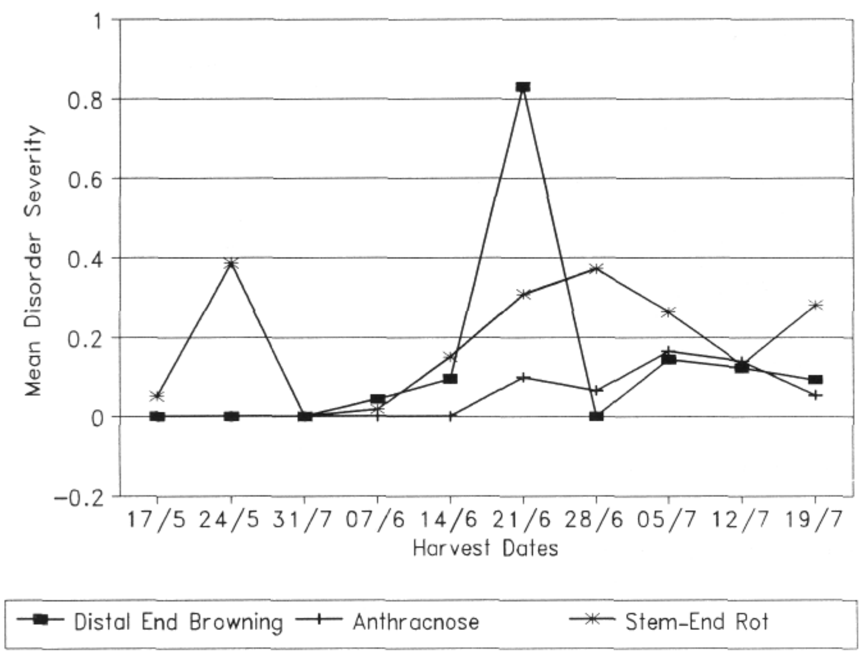

Figure 2
Incidence of distal-end browning, anthracnose and stem-end rot of Fuerte fruit harvested on Everdon Estate (Howick) between 17/05/94 and 26/07/94.

The severity of the pathological disorders anthracnose and stem-end rot followed a similar trend. This increased susceptibility may best be explained by the physiological degradation of the fruit, probably brought on by the distal-end browning disorder.

Isolations were made from the borders of the mesocarp tissue displaying discolouration to determine whether any pathogens could be identified. A total of 50 isolations were made on potato dextrose agar and incubated at 25 °C for 7 days. Total counts of fungi and bacteria were recorded (Table 1). The majority of isolates did not have any fungal or bacterial growth and those which did were most likely incidental. Clearly, pathogens are not implicated in distal-end browning.

Table 1
Percentages for presence or absence of fungal or bacterial growth from isolations made from fruit displaying distal-end browning symptoms.

	Isolations	*% occurence*
1	None	64 %
2	Fungal growth	6 %
3	Bacterial growth	30 %

PHYSIOLOGICAL FACTORS

During the 1994 season when the crop load was relatively low, the incidence of distal-end browning was relatively high. Although the disorder was also observed in the early part of the season, it peaked after the 21st June 1994. Donkin *et al.* (1995) found that the same was true for vascular browning and grey pulp. Consequently, fruit maturity is implicated and Kaiser *et al.* (1995) showed that the fruit picked after the 21st June 1995 were more prone to softening while in cold storage and suggested a tentative value of approximately 15 % lipids on a dry mass basis (or approximately 56 % lipids on a fresh mass basis) as a maximum maturity standard for fruit in the KwaZulu/Natal midlands. It should be borne in mind that the maximum maturity standard will vary according to the crop load and will not necessarily remain constant between years of low crops. More work is definitely implicated.

Before the maturity standards were implicated, it was suggested by Kotzé (pers. comm.*) that the disorder may be related to water stress in the orchard during fruit growth. Consequently, the irrigation records for orchards on Everdon Estate with a particularly high incidence of the disorder were examined for the six months preceding harvest during the years 1991 to 1994, inclusive. It was found that none of these orchards were water stressed during these periods since all were irrigated regularly at a tensiometer reading of -55 kPa. Water stress during the six months preceding harvest is thus not a factor affecting the disorder.

Trial 1

Towards the end of the Fuerte season (late June 1995) two boxes of count 14 Fuerte fruit were stored for 28 days at 5.5°C and then allowed to ripen, while two similar boxes were held at room temperature and allowed to ripen over 14 days. Fruit in all the cartons developed distal-end browning. However, the disorder on cold stored fruit only appeared when the fruit were ripe. Consequently, distal-end browning was not induced by cold storage conditions. In addition, since the fruit allowed to ripen at room temperature were not containerized, changes in gaseous concentrations may also be eliminated from the equation.

Trial 2

Mineral analysis of calcium, magnesium and potassium of twelve clean and twelve discoloured fruit was undertaken and the results are shown in Table 2. Clearly, there were no significant differences between the means of any of these elements in the clean versus discoloured fruits.

Table 2
Calcium, magnesium and potassium concentrations ($mgkg^{-1}$) for clean and discoloured Fuerte fruit.

	Clean Fruit			*Discoloured Fruit*		
Number	*Ca*	*Mg*	*K*	*Ca*	*Mg*	*K*
1	0.017	0.06	1.02	0.031	0.12	1.70
2	0.031	0.08	1.24	0.028	0.13	2.00
3	0.026	0.08	1.21	0.022	0.09	1.95
4	0.019	0.09	1.00	0.015	0.08	1.17
5	0.039	0.09	1.17	0.016	0.11	1.85
6	0.026	0.08	1.30	0.021	0.10	1.24
7	0.019	0.09	1.45	0.020	0.12	1.60
8	0.022	0.07	1.44	0.015	0.10	2.02
9	0.034	0.09	1.28	0.013	0.09	1.89
10	0.035	0.10	1.25	0.021	0.09	1.35
11	0.023	0.09	1.14	0.017	0.10	2.19
12	0.031	0.09	1.22	0.022	0.10	1.77
Average	0.027	0.08	1.23	0.020	0.10	1.73
S.E.	0.007	0.011	0.14	0.005	0.015	0.327

Trial 3

Preliminary investigations of phenolic concentrations were undertaken. Phenolics are usually concentrated in the seed as anti-herbivory agents (Kaiser, 1993) and are the substrate for browning reactions observed in avocado fruit (Golan *et al.* 1977). Phenolic concentrations were monitored in the distal and proximal ends of fruit which had distal-end browning (Table 3), using a technique modified from Torres *et al.* (1987). Phenolic concentrations were almost double in the distal end of three of the four fruit. Phenolic concentrations at both ends of the fourth fruit were similar but sampling error should not be ruled out. In any event, phenolic concentrations appear to have a definite role in distal-end browning. In a particular season, one would expect the leaves to produce a certain fixed amount of phenolics and these will be allocated to the total number of fruit on the tree. Should the crop be small in a particular year, one would expect more phenolics to be allocated to each fruit than in a year when there is a heavy crop. This being the case one would expect phenolic concentrations to be higher towards the end of a season with a low crop but Donkin *et al.* (1995) showed that this was not true as phenolic concentrations remained fairly constant over the 1995 season. It is however, possible that the sample size being only 8 fruit was not large enough to incorporate those fruit with distal-end browning.

Table 3
Phenolic concentrations ($\mu g g^{-1}$) of distal and proximal ends of Fuerte fruit with distal-end browning

Number	*Position*	*Concentration* ($\mu g\ g^{-1}$)
1	Distal	4.40
	Proximal	2.11
2	Distal	4.99
	Proximal	2.85
3	Distal	3.71
	Proximal	2.96
4	Distal	2.33
	Proximal	2.80

CONCLUSIONS

The high incidence of distal-end browning and the associated mesocarp discolouration in Fuerte fruit from the KwaZulu/Natal midlands during the 1995 season are cause for concern. Clearly, pathological disorders; water stress in the orchard from 6 months before harvest, cold storage conditions, and calcium, magnesium and potassium levels are not implicated as causal factors.

Although some of the fruit harvested before 21st June 1995 developed the symptoms, a peak occurred after this date. This was also true for the vascular browning and pulp spot disorders, and fruit were also more prone to softening while in cold storage after this date. Consequently, a maximum maturity standard of 15 % lipids (on a dry mass basis) or 56 % lipids (fresh mass basis) was suggested. It should however, be remembered that these figures may not be valid every year as the crop load is a determining factor. Where a heavy crop is set, the maturity levels may be higher or simply take longer to be reached if reserves are being allocated to many more fruit. Phenolic concentrations varied greatly between the distal and proximal ends of affected fruit and a future study incorporating crop load is implicated. Although one would expect a lower incidence of distal-end browning in 1995 as a large crop was predicted, hail has caused a severe reduction in the total crop at Everdon Estate. Consequently, this will provide an excellent opportunity of testing the theory.

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