**South African Avocado Growers' Association Yearbook 1995. 18:102-105**

# Maturity and Storage Temperature Regimes for KwaZulu/Natal Avocados

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## *ABSTRACT*

*Moisture content of avocados is widely used as an indicator of fruit maturity. It is generally accepted that the avocado seasons for KwaZulul/Natal and Transvaal provinces differ with the KwaZulul/Natal season being later. The moisture content of avocados from the two provinces does not reflect this difference in fruit maturity. Moisture content where KwaZulul/Natal avocado fruit ripens at accepted quality norms was determined during the 1990/91 seasons and different temperature regimes were evaluated during 1993/94 to acquire the optimum regime that can be used to export KwaZulul/Natal fruit commercially.*

*The moisture content where fruit ripened acceptably in KwaZulul/Natal was lower than the 'legal' accepted moisture content in Transvaal and temperature regimes that produced the best results in Natal were higher than the regimes used in Transvaal.*

## INTRODUCTION

Moisture content remains the indicator of fruit maturity that is used in selecting avocado export temperature regimes. It is however reported that the 'legal' moisture content (80 %) of Fuerte fruit is not a true reflection of maturity for fruit grown in KwaZulu/Natal and strong indications exist that fruit grown in KwaZulu/Natal differ from fruit grown in warmer conditions like Transvaal as far as the physiology of the fruit is concerned (McOnie & Wolstenholme, 1982; Kaiser *et al.,* 1992).

Voster *et al.* (1990) found that stepped down temperature from warmer to cooler temperatures during transportation on the vessels tended to reduce physiological disorders. Several stepped down temperature regimes are therefore evaluated in this study to determine appropriate regimes whereby KwaZulu/Natal fruit can be exported. Moisture contents where avocado cultivars ripen at acceptable quality standards as established by Van den Dool and Wolstenholme (1983) are also investigated.

At Everdon Estate the cultivar Hass makes up 75 % of the plantings and Fuerte 20 %. It was decided to concentrate on Fuerte as this is the cultivar that presents the most physiological problems.

## MATERIALS AND METHODS

### Fruit Maturity

At Westfalia Estate (Transvaal) and Everdon Estate (KwaZulu/Natal) the moisture content of fruit is determined on a commercial basis in order to select appropriate temperature regimes for exporting. Having found that drought conditions have an influence on the maturity and moisture content relationship, data were consequently selected from the 1989 season for comparative purposes between the two provinces (Table 1).

**Table 1**
Temperature regimes used for cold storage of Fuerte fruit.

| *Regime* | *Temperature (°C)* | | | |
|---|---|---|---|---|
| | *Week 1* | *Week 2* | *Week 3* | *Week 4* |
| 1 | 8.5 | 8.5 | 7.5 | 6.5 |
| 2 | 8.5 | 7.5 | 6.5 | 5.5 |
| 3 | 8.5 | 7.5 | 5.5 | 4.5 |
| 4 | 7.5 | 7.5 | 6.5 | 5.5 |
| 5 | 7.5 | 7.5 | 5.5 | 4.5 |
| 6 | 5.5 | 5.5 | 5.5 | 5.5 |

In the 1990/91 season's fruit was harvested at Everdon Estate on a weekly basis. Five equally sized fruit were sampled from individual trees. Trials were conducted on four different cultivars *viz.,* Fuerte, Edranol, Hass and Ryan. Three fruit of each sample were used to determine the moisture content as described by Swarts (1976) and the remaining two fruit stored at room temperature until ripening. A firmometer was used to determine firmness of the fruit as an indication of ripening where a reading of 30 indicated ripe fruit (Swarts, 1981).

### Temperature regimes

Six treatments or temperature regimes were selected for evaluation (Table 1). Each treatment consisted of 10 cartons (4 kg) of count 14 Fuerte fruit taken weekly from the commercial pack line at Everdon Estate during the 1993/94 seasons.

After cold storage, firmness (Figure 2) of the fruit was determined using a firmometer (Swart 1981). Other disorders that were evaluated were:

- cold damage (black cold and brown cold) (Figure 3),
- pathological disorders (anthracnose and stem-end rot) (Figures 6 & 7),
- (physiological disorders (pulp spot, grey pulp and vascular browning) (Figures 4 & 5).

All the above mentioned disorders were rated on a scale from zero to ten according to the severity of the symptoms, zero being healthy and ten indicating totally affected fruit. The average ratings of the different pathological and physiological disorders respectively were added (totalled).

Statistical analysis was done using Duncan's multiple range test (P = 0.05).

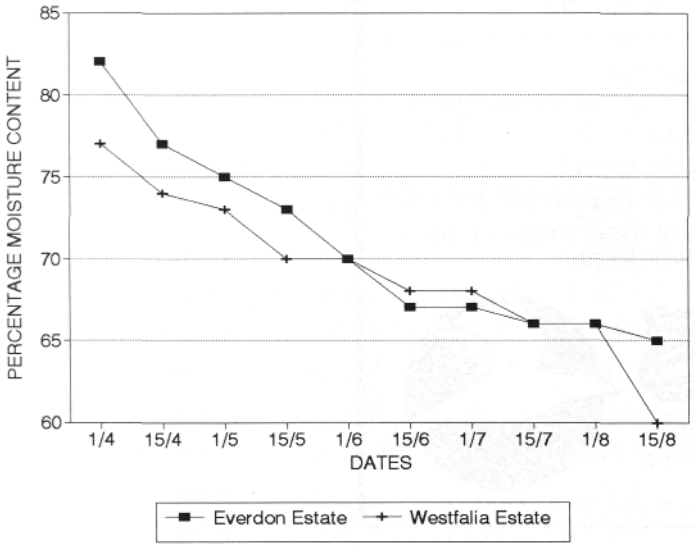


**Figure 1**
Moisture content of Fuerte fruit in KwaZulul/Natal (Everdon Estate) and Transvaal (Westfalia Estate) for different weeks

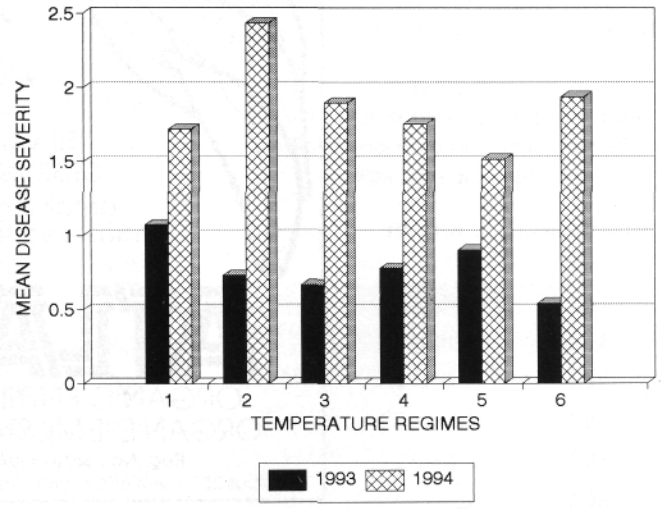


**Figure 2**
Mean firmometer readings for different temperature regimes tested during the 1993 and 1994 seasons for all the different dates.

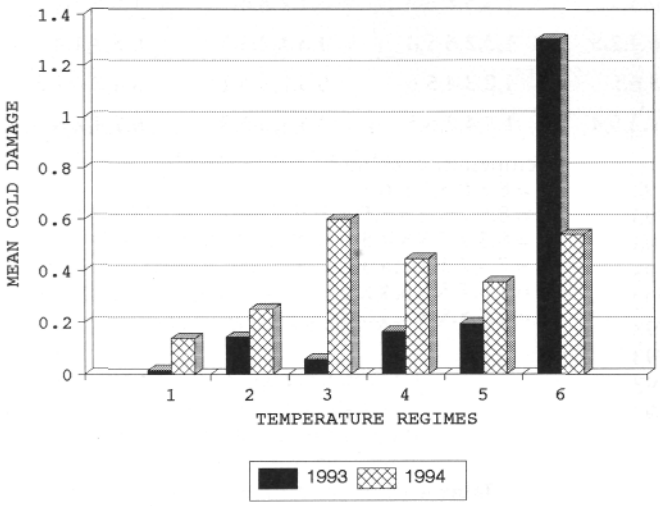


**Figure 3**
Effect of temperature regimes on cold damage during the 1993 and 1994 seasons.

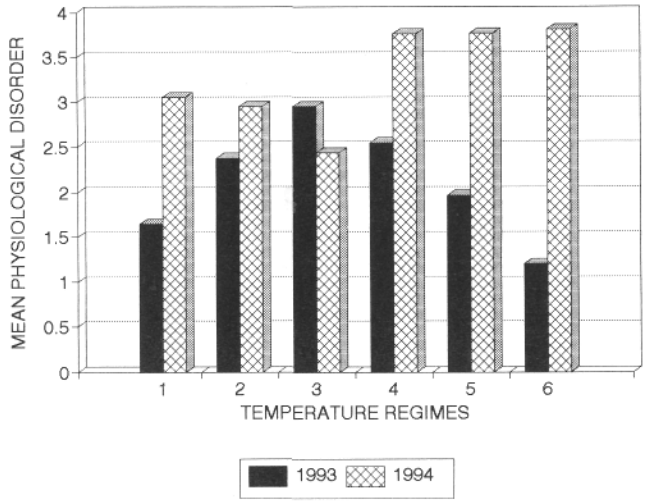


**Figure 4**
Effect of temperature regimes on physiological disorders during the 1993 and 1994 seasons.

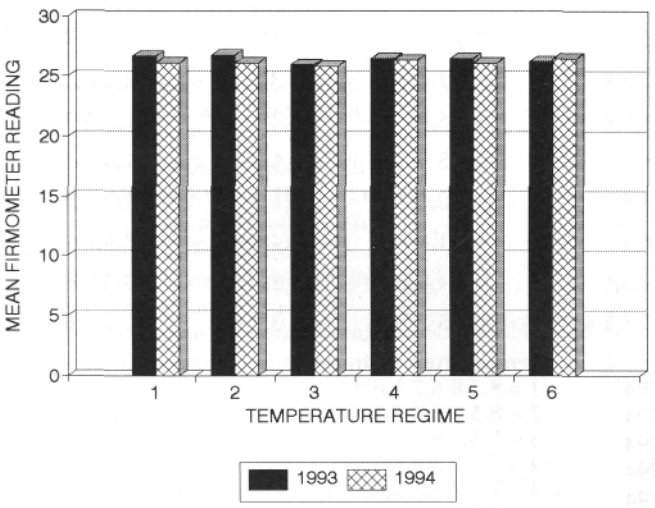


**Figure 5**
Seasonal trends in physiological disorders for 1993 & 1994 seasons.

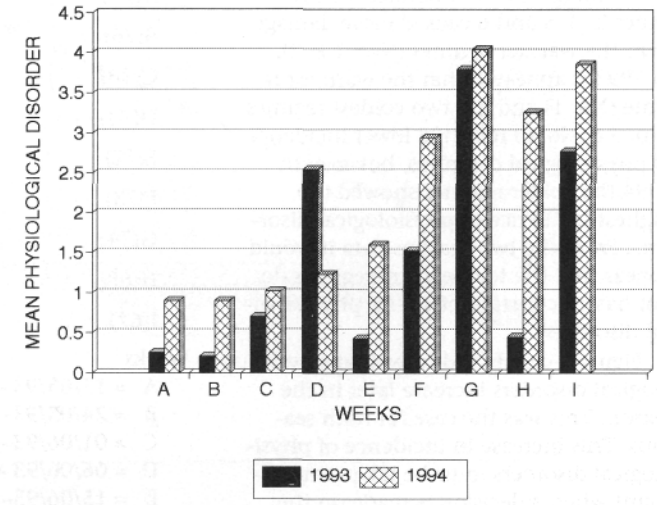


**Figure 6**
Effect of temperature regime on pathological disorders during the 1993 and 1994 seasons.

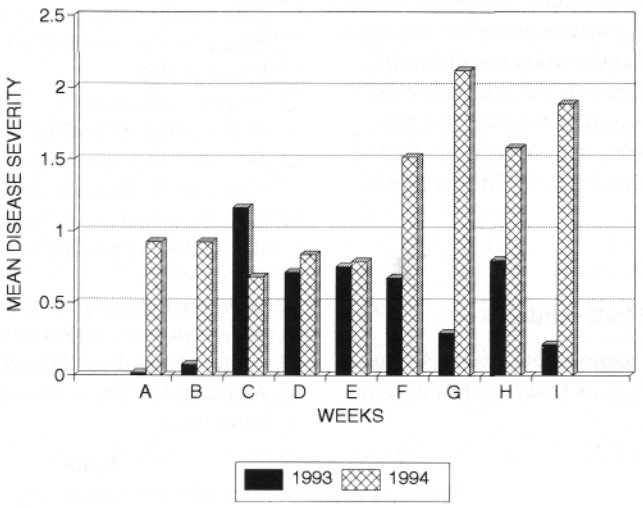


**Figure 7**
Seasonal trends in pathological disorders during the 1993 and 1994 seasons.

## RESULTS AND DISCUSSION

### Fruit maturity

It is generally accepted that fruit in KwaZulu/Natal mature later than in the Transvaal. As there is a correlation between fruit maturity and moisture content, a difference in moisture content would be expected. From Figure 1 it can be seen that in the beginning of the season the moisture content of fruit in KwaZulu/Natal is higher than that of the Transvaal (10-15 days difference in maturity). No difference can be observed later in the season.

In the 1990 and 1991 season Fuerte fruit was picked, the moisture content were determined and some fruit was held back to determine quality on ripening. The most common symptoms found with immature fruit were

- Shrinking — found with Hass and especially with Edranol.
- Uneven ripening — where the distal end of the fruit turned soft while the rest remained hard. Fuerte often shows this symptom.
- Rubbery ripening — especially Ryan.

With two season's data, moisture content with acceptable fruit quality on ripening has been established as shown in table 2.

**Table 2**
Moisture content of different cultivars where KwaZulu/Natal fruit ripened acceptably.

| *Cultivar* | *Moisture content %* |
|---|---|
| Fuerte | 75 |
| Edranol | 70 |
| Hass | 75 |
| Ryan | 69 |

The results clearly indicate that KwaZulu/Natal fruit reaches proper maturity at moisture contents lower than the "legal" limit for Transvaal fruit.

**Temperature regime**

Different factors influence fruit quality of avocados. The purpose of a temperature regime is to ensure that fruit reaches the overseas markets free of quality problems. Four quality aspects namely cold damage, firmness, pathological disorders and physiological disorders were evaluated. Results are displayed in figures 2 to 7.

Results (Figure 2) suggest that the different temperature regimes had no effect on the firmness of the fruit. It is important to note that the warmest regime (No. 1) produced acceptably hard fruit. There is a clear trend for the colder regimes to show more symptoms of cold damage. In 1993, regime 6 being 5.5°C (4 weeks) showed substantially more cold damage. In 1994 temperature regimes 3, 4, 5 and 6 caused more damage than the warmer regimes (No's 1 & 2). In 1993 it appeared that the warmest regime (No. 1) and the two coldest regimes (No. 5 & No. 6) reflected lower incidence of physiological disorders; however in 1994 the colder regimes showed the highest incidence of physiological disorders. From the two seasons data it would appear that the temperature regimes do not have a constant effect on physiological disorders.

Figure 5 clearly indicates that physiological disorders increase later in the season. This was the case for both seasons. This increase in incidence of physiological disorders must be taken into account when a decision is made on the length of the Fuerte harvesting season. The incidence of pathological disorders was clearly less in 1993 than in 1994. No definite trend could be established for different regimes on the incidence of pathological disorders.

In 1993 the first two weeks displayed very little pathological disorders but increased in the third week and then decreased for the rest of the season. Contrary to the 1993 season, the pathological disorders in the 1994 season increased towards the end of the season.

There is clearly no consistent trend between the two seasons.

Summarised results of the individual weeks for the 1993 Fuerte season are reflected in Table 3 and for 1994 in Table 4. The treatments (regimes) which produced the worst results ($p = 0.05$) are not included. The data for week C in 1994 is unreliable as a result

of an interruption in the electricity supply during storage.

**Table 3**

Effect of temperature regimes (arranged from best to worst) on firmness, cold damage, pathological and physiological disorders observed in the 1993 season.

| *Week & Moisture Content* | *Firmometer* | *Cold Damage* | *Pathological disorders* | *Physiological disorders* |
|---|---|---|---|---|
| A 77 % | 6,2,1 | 1,2,3,4,5,6 | 1,2,3,4,6,5 | 2,6,4,5,1,3 |
| B 74 % | 4,5,3 | 1,2,3,4,5 | 2,4,6,3,1,5 | 2,5,3,6,1,4 |
| C 74 % | 5,2,6,3,4,1 | 1,3,4,5,6,2 | 4,3,6,2,5,1 | 4,5,3,1,6 |
| D 74 % | 5,6,1,4 | 1,2,3,4,5,6 | 6,4,2,5,1 | 6,1,5,2 |
| E 73 % | 3,2,6,4,1,5 | 1,2,3,4,5,6 | 4,2,5,3,6,1 | 4,1,6,3,5,2 |
| F 70 % | 1,4,6,3 | 1,2,5,6,3,4 | 5,1,2,3,6 | 1,6,5,3,2 |
| G 69 % | 3,1,6,4,2,5 | 1,3,2,6,5,4 | 4,6,1,2,3,5 | 6,5,3,1,4 |
| H 65 % | 2,4,3,6,5 | 1,2,3,4,5,6 | 6,3,2,5,4,1 | 3,4,2,6,1,5 |
| I 65 % | 3,6,1,2,5,4 | 1,3,4,2,6,5 | 3,4,1,6,2,5 | 6,1,4,2,5 |

Weeks

A = 19/05/93–16/06/93
B = 26/05/93–23/06/93
C = 02/06/93–30/06/93
D = 09/06/93–07/07/93
E = 16/06/93–14/07/93
F = 23/06/93–21/07/93
G = 30/06/93–28/07/93
H = 08/07/93–04/08/93
I = 15/07/93–11/08/93

Temperature regimes

1 = 8.5,8.5,7.5,6.5.
2 = 8.5,7.5,6.5,5.5.
3 = 8.5,7.5,5.5,4.5.
4 = 7.5,7.5,6.5,5.5.
5 = 7.5,7.5,5.5,4.5.
6 = 5.5,5.5,5.5,5.5.

**Table 4**

Effect of temperature regimes (arranged from best to worst) on firmness, cold damage, pathological and physiological disorders observed in the 1994 season.

| *Week & Moisture content* | *Firmometer* | *Cold damage* | *Pathological disorders* | *Physiological disorders* |
|---|---|---|---|---|
| A(78) | 3,1,5,4 | 1,2,4,5 | 2,3,1,5 | 1,5,6,3,4 |
| B(76) | 3,1,5,4 | 1,2,4,5 | 2,3,1,5 | 1,5,6,3,4 |
| C(76) | 2,5,1,3,4 | 5,3,2,1,4 | 4,5,3,2,1 | 3,4,2,5,1 |
| D(74) | 3,2,1,5,4 | 1,2,3,5,4 | 1,4,2 | 1,3,5,2 |
| E(72) | 2,4,5 | 1,2,4,5 | 4,5,1,3 | 1,3,5,2 |
| F(73) | 2,3,5,4 | 1,3,4,2,5 | 4,2,1,3 | 1,2,3,5 |
| G(74) | 2,1,6,4 | 2,3,5,1,4 | 3,2,4,5,6 | 3,5,2,1,4 |
| H(68) | 3,5,1,2,6 | 1,6,3,4,5,2 | 4,3,2,1,5,6 | 3,2,1,4,5,6 |
| I(67) | 2,6,5,3,1,4 | 3,1,2,5 | 1,5,3,2,6 | 3,2,4,6 |

Weeks
A = 17/05/93–14/06/94
B = 24/05/93–21/06/94
C = 01/06/93–29/06/94
D = 06/06/93–05/07/94
E = 15/06/93–13/07/94
F = 21/06/93–19/07/94
G = 29/06/93–27/07/94
H = 06/07/93–03/08/94
I = 12/07/93–09/08/94

Temperature regimes
1 = 8.5,8.5,7.5,6.5.
2 = 8.5,7.5,6.5,5.5.
3 = 8.5,7.5,5.5,4.5.
4 = 7.5,7.5,6.5,5.5.
5 = 7.5,7.5,5.5,4.5.
6 = 5.5,5.5,5.5,5.5.

The moisture content of the fruit is given in brackets next to the week number.

There is no statistical difference between the temperature regimes listed in Tables 3 and Table 4. The treatments for a specific aspect have been arranged according to trends from the best to the worst.

From the trends in Figures 2 and 3 it can be seen in the case of cold damage that the warmer regimes were better and also had good firmometer levels. The warmer temperature regimes would thus have less cold damage and still be hard. It was thus decided to take the three treatments with the lowest incidence of cold damage and establish which of these occurred in the better treatments for the other factors (Firmometer, Pathology and Physiology).

From Table 5 it can be observed that there is a tendency for the warmest regimes to be better at the beginning of the season and the cooler regimes to be better at the end of the season. The temperature regimes, even at the end of the Fuerte season are much warmer than those used in the Transvaal.

From Table 5 the following temperature regimes for Fuerte grown in KwaZulu/Natal can be recommended for the different moisture contents.

**Table 5**
The best temperature regimes for specific moisture contents for Fuerte

| *Moisture content %* | *Week No. 1993* | *Week No.1994* | *Best regimes* |
|---|---|---|---|
| 78 | | A | 1 |
| 77 | A | | 1,2 |
| 76 | | B | 1 |
| 75 | | | |
| 74 | B,C,D | D,G | 1,2,3,4 |
| 73 | E | F | 2,3,4 |
| 72 | | E | 2,4 |
| 71 | | | |
| 70 | F | | |
| 69 | G | | 3 |
| 68 | | H | 3,6 |
| 67 | | I | |
| 66 | H | | 3 |
| 65 | I | | 4 |

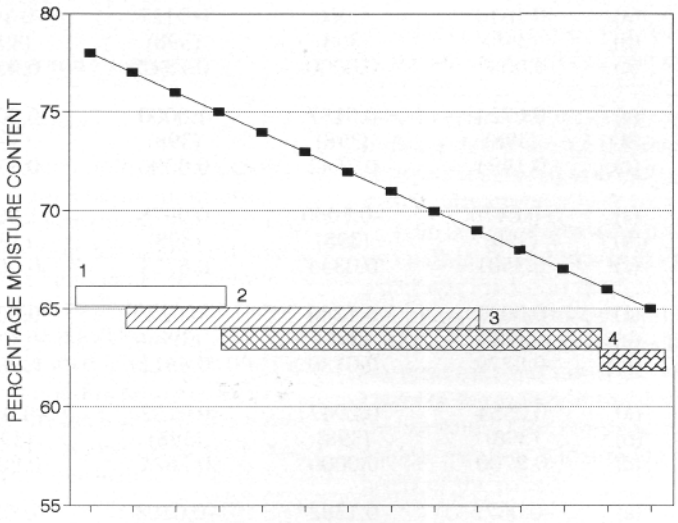


**Figure 8**
Recommended temperature regimes for Fuerte at different moisture contents
Temperature regimes:
1. 8.5–8.5–7.5–6.5 2. 8.5–7.5–6.5–5.5 3. 8.5–7.5–5.5–4.5 4. 7.5–7.5–6.5–5.

## CONCLUSION

The moisture content where avocado fruit will ripen acceptably differs from that in the Transvaal. Because of the drought in the Transvaal the "legal" moisture content has been lowered by two percentage points. Should a drought situation be experienced in KwaZulu/Natal the recommended moisture content will also have to be lowered.

The higher temperature regimes give the best results at the beginning of the season; as the fruit matured the cooler temperature regimes gave the better results. All the temperature regimes that gave the better results are higher than the regimes used in the Transvaal.

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