Title: **REGULATION AND CONTROL OF SCALD**

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## PROGRESS REPORT

**Abstract**

This year we have expanded our investigation of the effects of 4-methyl cyclopropene (MCP) on apple fruit ripening in general and scald in particular. We used "Granny Smith" and "Red Delicious" apples, both of which are scald-susceptible. We measured the following parameters: ethylene ($C_2H_4$) evolution, levels of α-farnesene and conjugated trienol, and texture. We also compared the effects of MCP on scald to those of 1.5% oxygen ($O_2$) on scald.

**Results**

1. **Ethylene evolution**

Each cultivar was harvested on two dates: "Red Delicious" on 9/14/99 and 9/24/99, and "Granny Smith" on 10/13/99 and 10/21/99. MCP was applied immediately after harvest. In addition, in "Granny Smiths" MCP was applied on several subsequent dates. The fruits were treated with MCP in sealed 10 l. dessicators for 20 h. Immediate application of MCP after harvest suppressed the climacteric rise in $C_2H_4$ evolution in both "Red Delicious" and "Granny Smiths" for about 170 - 200 days (Figs. 1, 2). Subsequent applications of MCP to "Granny Smiths" were not as effective in retarding the onset of the climacteric rise in $C_2H_4$ evolution (Fig. 3). When the fruits were transferred to 17°C after 205 d.. at 1°C, the rate of $C_2H_4$ evolution increased rapidly in both cultivars (Fig. 4), indicating that the physiological ripening processes were not impaired by MCP. After 10 d. at 17°C, the visual and olfactory properties of the MCP-treated fruits did not differ from those of the controls.

We compared the effects of MCP to those of 1.5% $O_2$ on the $C_2H_4$ evolution of climacteric "Granny Smith" fruits. The results presented in Fig. 5 show that MCP may be more effective than 1.5% $O_2$ in inhibiting the rate of $C_2H_4$ evolution. However, with time, in both treatments $C_2H_4$ gradually began to increase.

2. **Changes in α-farnesene**

The results presented in Figs. 6, 7, 8 and 9 show that both α-farnesene and conjugated trienol were present in trace amounts at harvest. α-farnesene increased with time and reached a peak in about 100 days postharvest, followed by a decrease. At the end of this storage the levels of α-farnesene were very low. The level of conjugated trienol continued to increase until 180-200 d. post-harvest (Figs. 6, 7, 8, 9).

MCP strongly inhibited the increase in both α-farnesene and conjugated trienol (Figs. 6, 7, 8, 9). The results presented in Fig. 7 show that after 200 d, α-farnesene began to increase in "Red Delicious" apples harvested on 9/24/99.

3. **Scald Control**

The results presented in Table 1 show that MCP was 100% effective in controlling scald development in "Granny Smith" fruits kept at 1°C for up to 255 d. (see also poster). It also inhibited the development of scald in fruits kept at1°C for 180 d, followed by either 1 week or 6 weeks at 17°C. In addition, MCP treatment was very effective in controlling scald development in "Red Delicious" fruit (Table 2). MCP completely inhibited the development of scald in these apples after storage for 200 d. at 1°C, followed by either 1 or 6 weeks at 17°C (Table 2, see also poster). The data presented in Table 4 show that when the application of MCP was delayed for 21 d.. it controlled scald development for 170 d. of storage at 1°C but it was not effective when the storage period was extended to 255 days (see also poster).

4. **Texture**

The results presented in Table 3A show that MCP prevented softening compared to the controls for both harvest dates. The results also show that delayed application of MCP decreased its ability to preserve texture compared to the immediate application, though the softening was lower than in the controls. MCP also decreased softening in "Red Delicious" (Fig. 3B). The data presented in Fig. 3C show the effect on texture of "Red Delicious" apples which were stored for 49 d. at 1°C then transferred to 17°C and kept in a flow-through system in (a) air (controls), (b) air + MCP, and (c) 1.5% $O_2$. The data show that MCP was as effective as low $O_2$ in decreasing the rate of softening.

In short, application of MCP, preferably immediately after harvest, completely controls scald and extends the storage life of apples as long, or even longer, than does 1.5% $O^2$. It appears to have no adverse effect on the quality of fruits during subsequent storage at room temperature. If it is approved, it will be very beneficial to the apple industry because it has the potential to substitute for CA storage, thereby reducing storage costs and the occasional hazards of CA storage. Fruit can even be treated at room temperature for 24 h, then transferred to regular air refrigeration storage.

**Preliminary Experiments**

Treatment with Inhibitors of Lipoxygenase

In our preliminary investigation we observed that on the scalded areas of the peel, there was a significant increase in manolyldialdehyde (MDA), a product of unsaturated fatty acid peroxidation. We treated fruits in which scalded areas had began to appear with inhibitors of lipoxygenase in order to investigate whether the development of scald symptoms could be reduced during subsequent storage at room temperature. The results were not very encouraging.

Treatment with Mevastatin

We treated a limited number of fruits with mevastatin, an inhibitor of α-farnesene

synthesis, and observed that it decreased the accumulation of α-farnesene. Mevastain produced only a limited curb on scald at the end of storage (Table 5). However, it is not yet clear whether those effects will be long-term or whether the fruits may have to be treated again during storage. Unfortunately the cost of purchasing mevastatin was a prohibiting factor. It should be noted that mevastatin did not inhibit the rise in $C_2H_4$, so it is a good experimental procedure for investigating the role of α-farnesene in scald development.

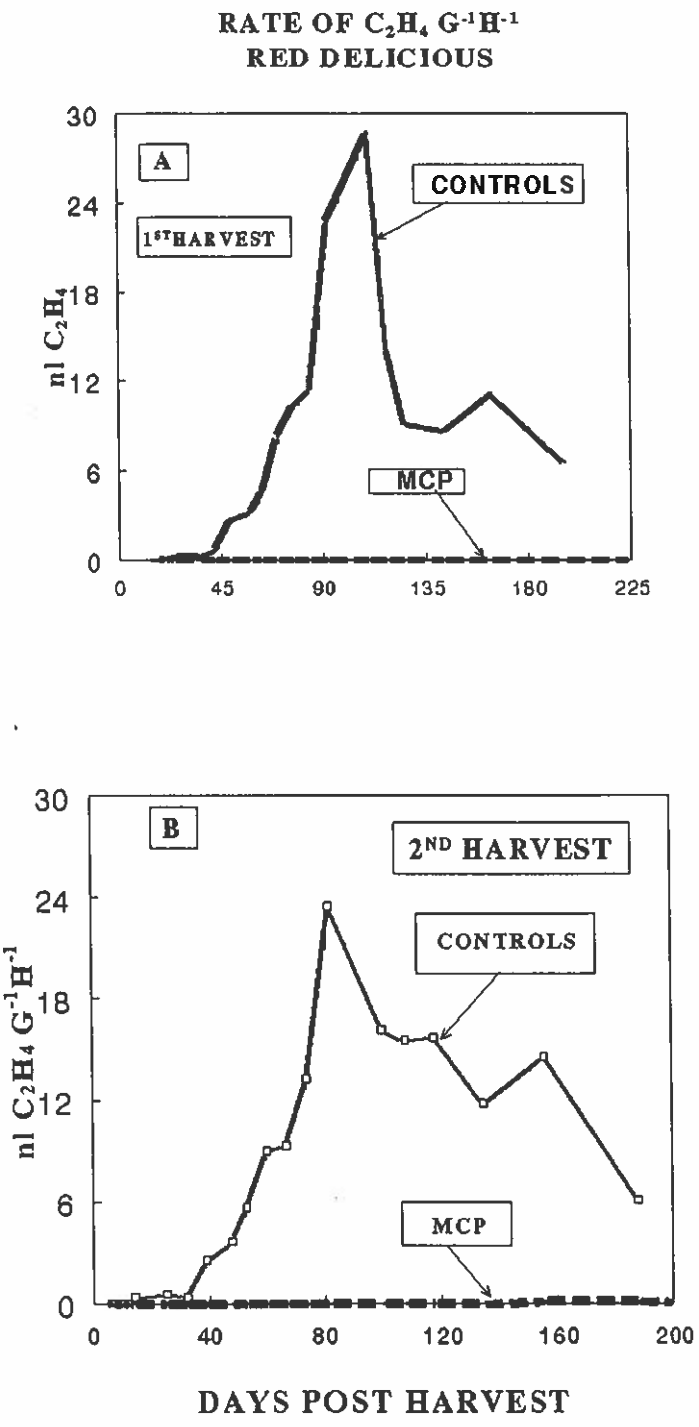
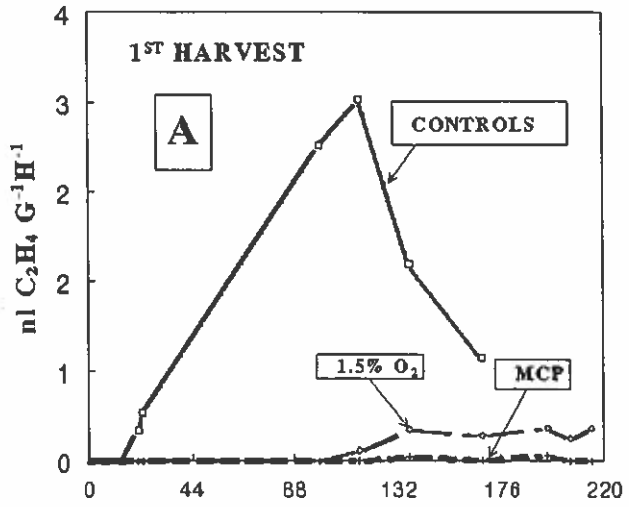

RATE OF $C_2H_4$ $G^{-1}H^{-1}$
RED DELICIOUS
A
1ST HARVEST
CONTROLS
MCP
nl $C_2H_4$
30
24
18
12
6
0
0
45
90
135
180
225
B
2ND HARVEST
CONTROLS
MCP
nl $C_2H_4$ $G^{-1}H^{-1}$
30
24
18
12
6
0
0
40
80
120
160
200
DAYS POST HARVEST

FIG 1

RATE OF $C_2H_4$ IN GRANNY SMITH




RATE OF $C_2H_4$ EVOLUTION
GRNNY SMITH SECOND HARVEST

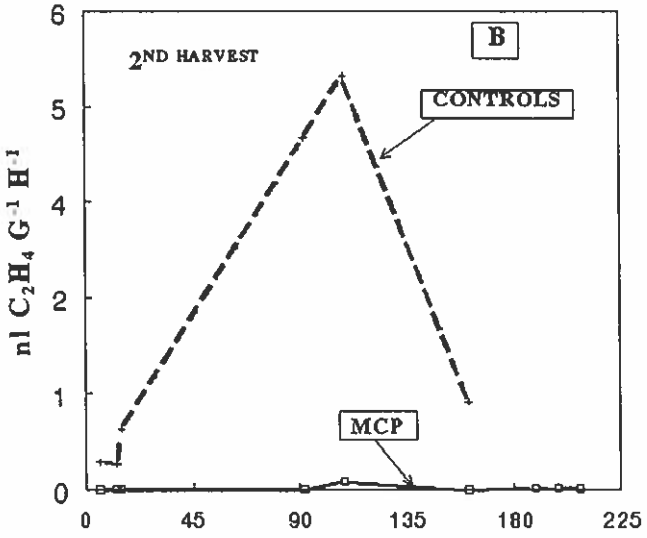



FIG 2

# Rate of ethylene production in late MCP treated Granny Smith apples

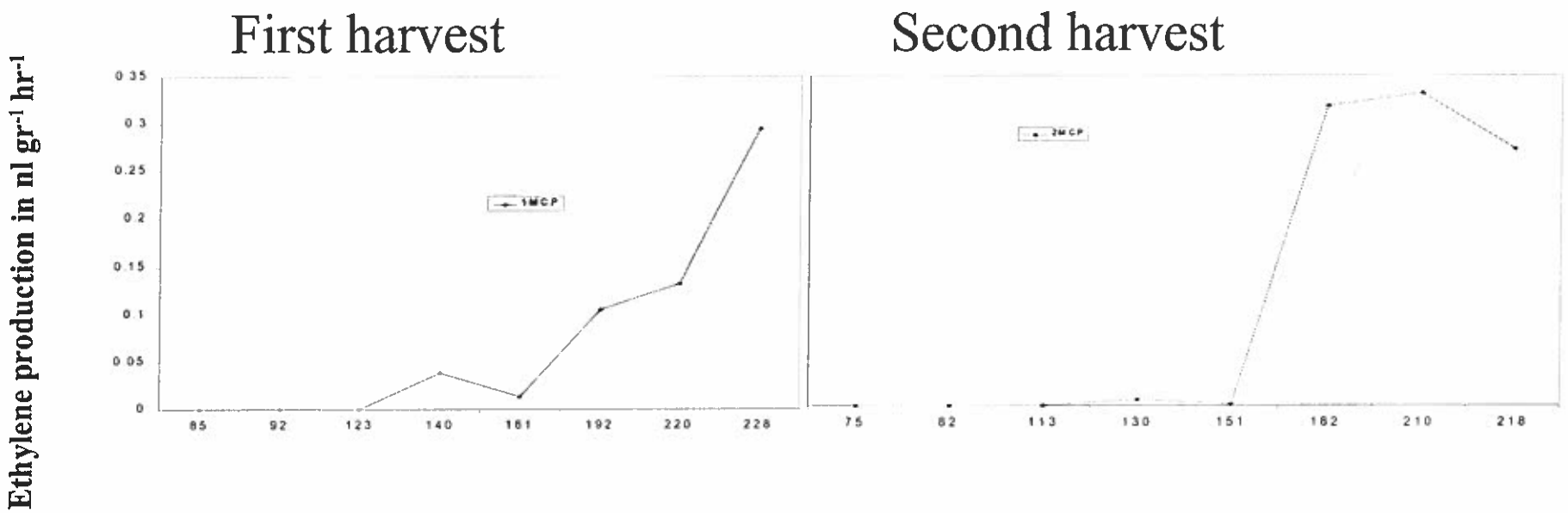



FIG 3

# RATE OF $C_2 H_4$ EVOLUTION OF MCP TREATED APPLES AT 17 C

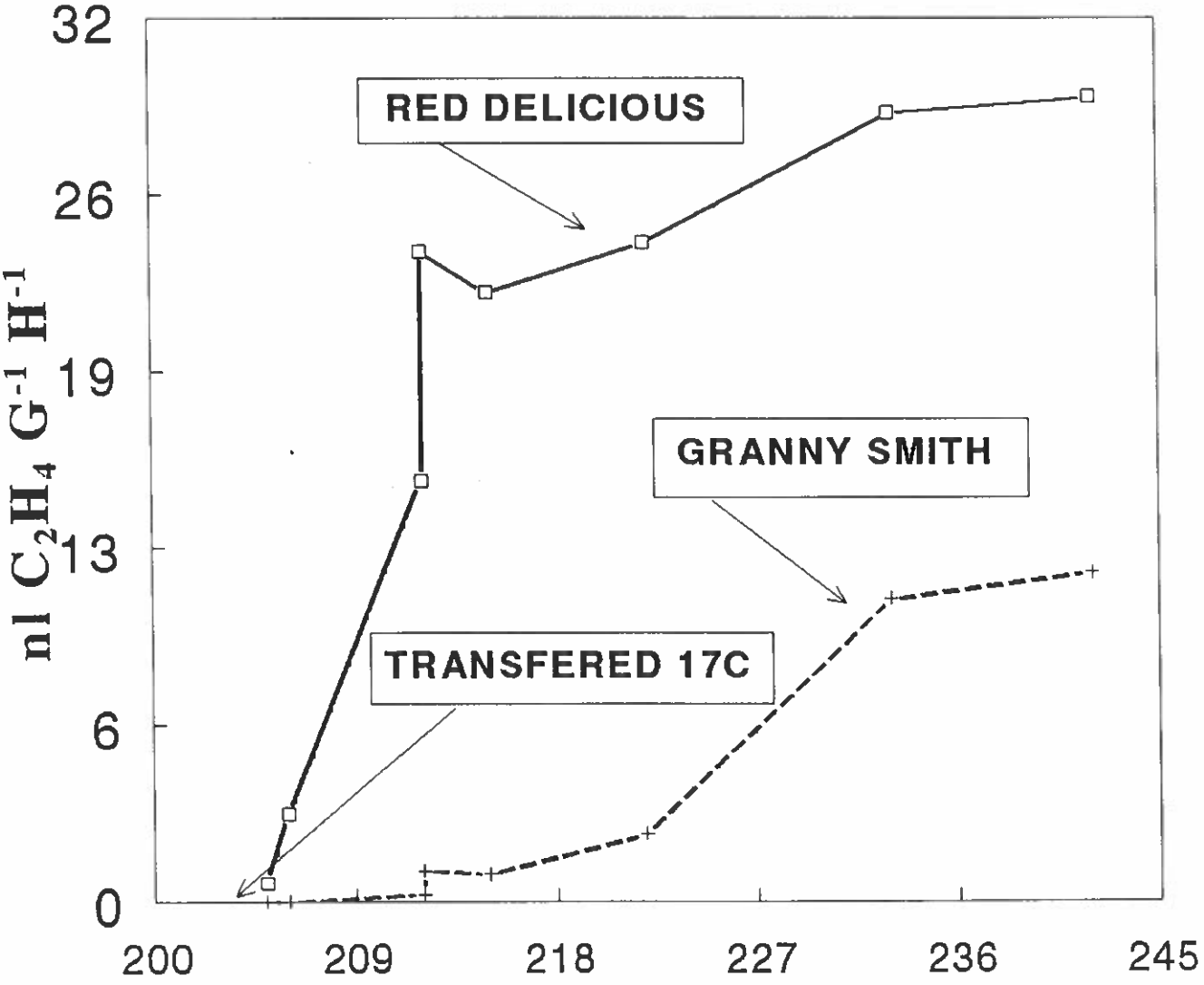



FIG 4

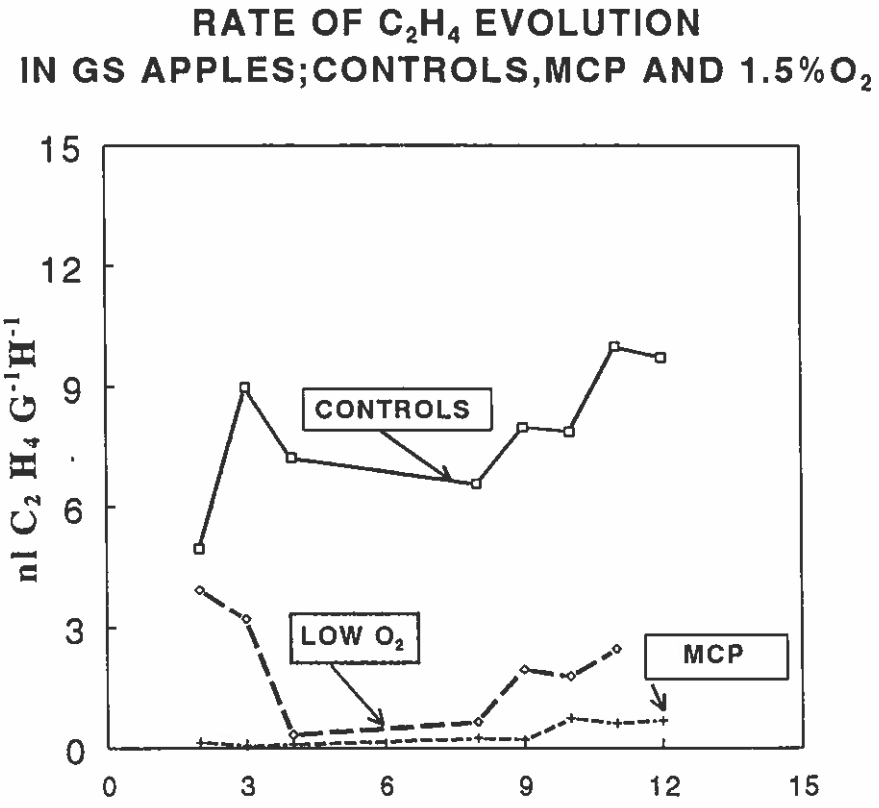
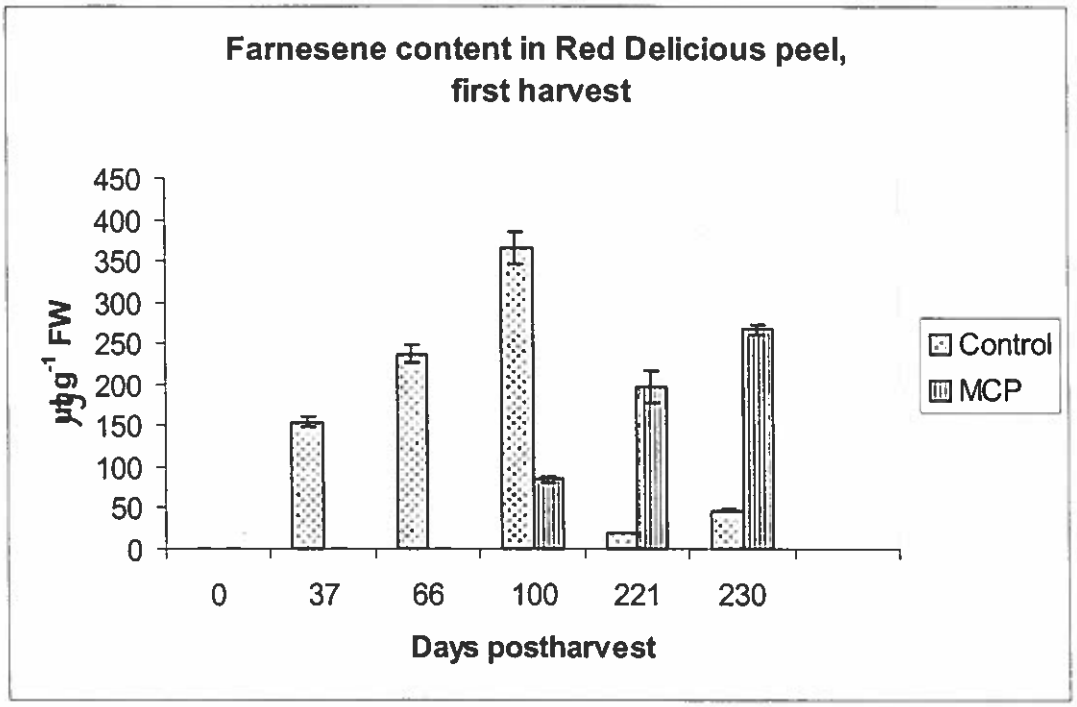

RATE OF $C_2H_4$ EVOLUTION
IN GS APPLES;CONTROLS,MCP AND 1.5%$O_2$
15
12
9
6
3
0
nl $C_2$ $H_4$ $G^{-1}H^{-1}$
CONTROLS
LOW $O_2$
MCP
0
3
6
9
12
15
DAYS IN TREATMENT

FIG 5



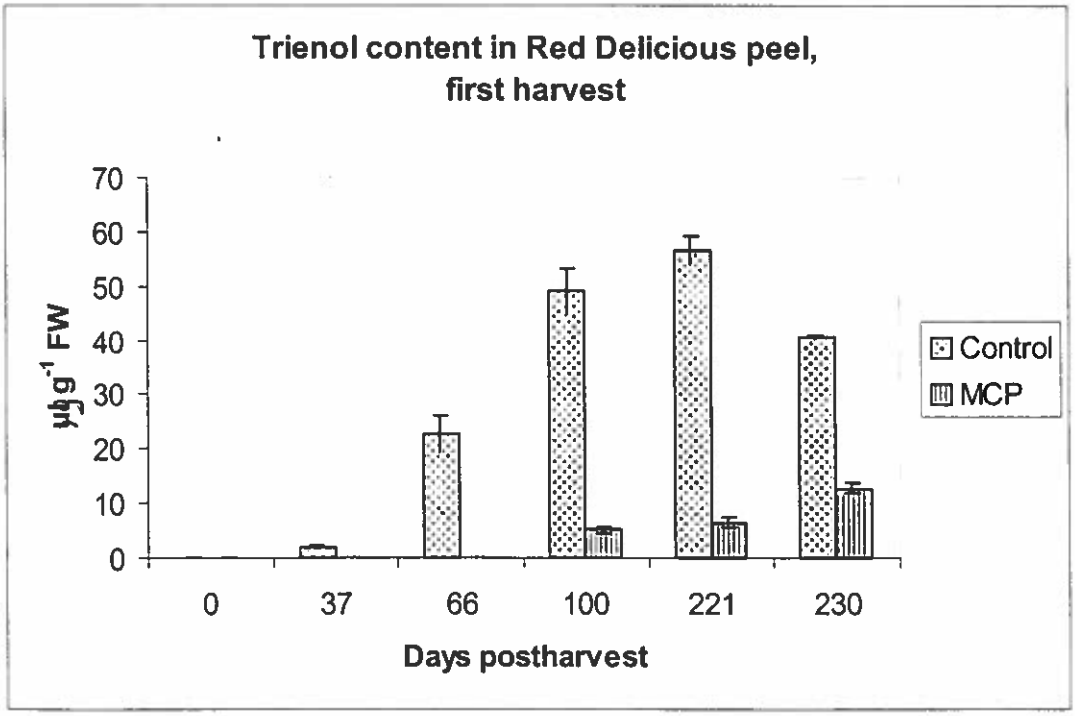




Fig 6: Farnesene and Trienol content in Red Delicious apples, first harvest

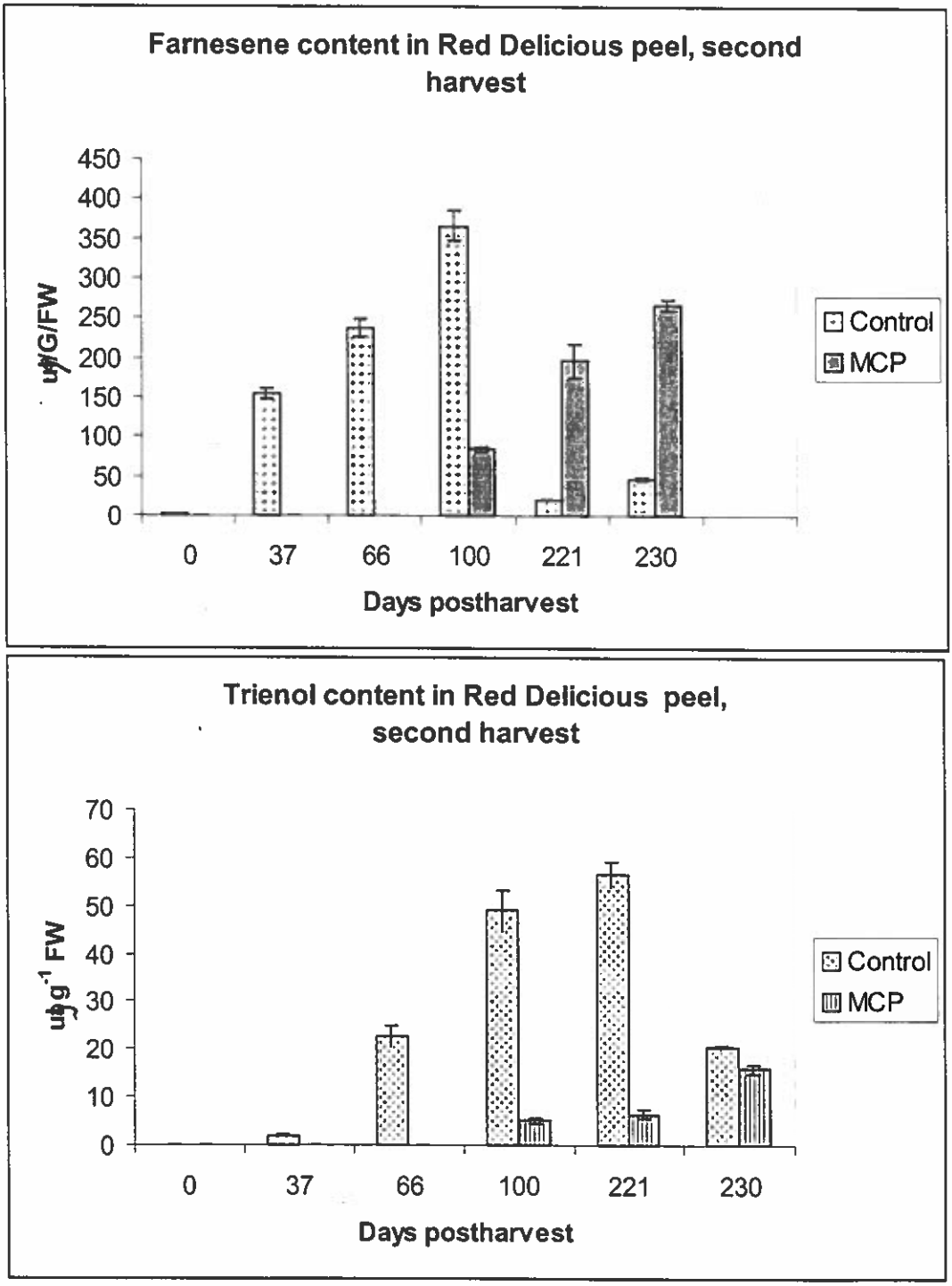
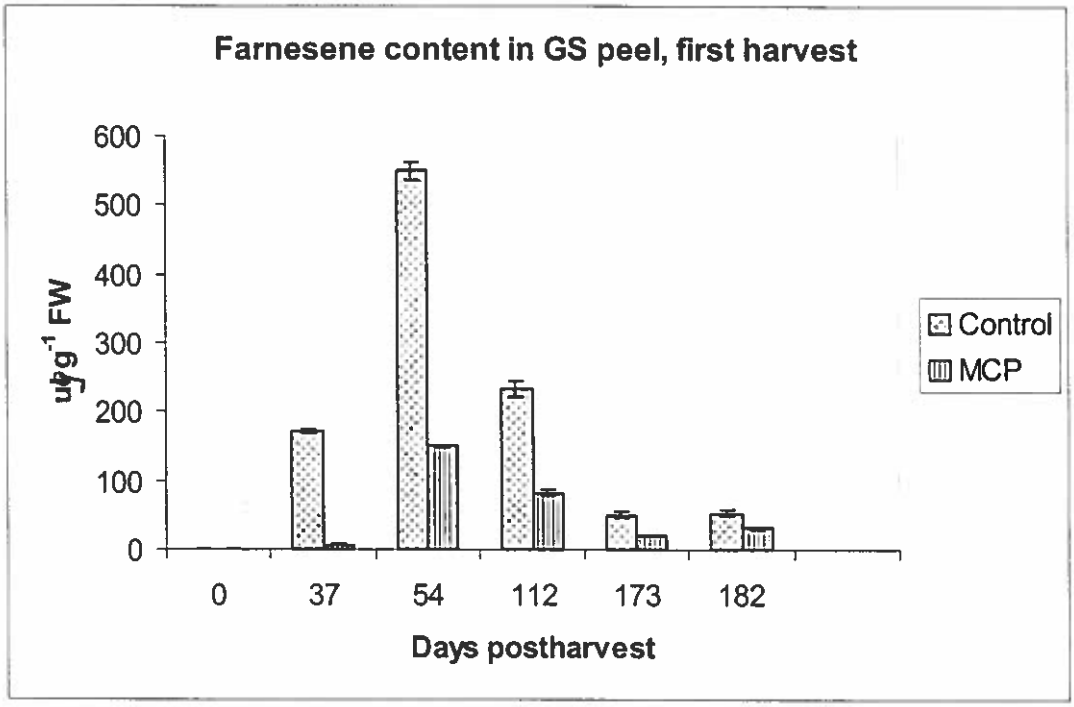



Fig 7: Farnesene and Trienol content in Red Delicious apples, second harvest



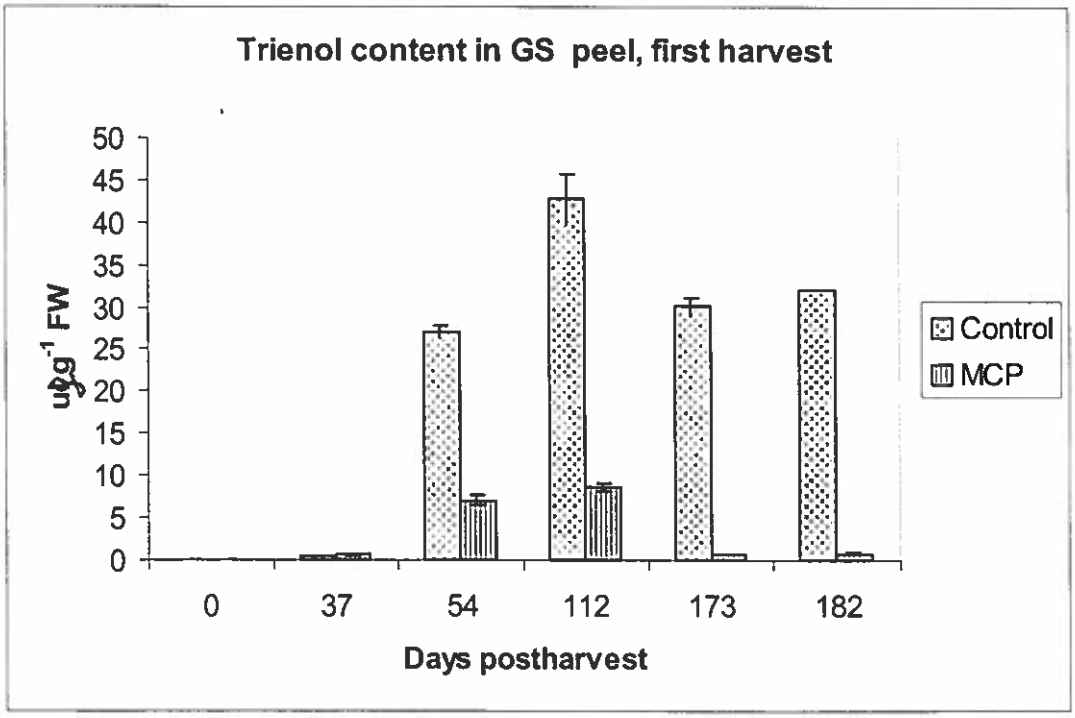




Fig 8: Farnesene and Trienol content in Granny Smith apples , first harvest

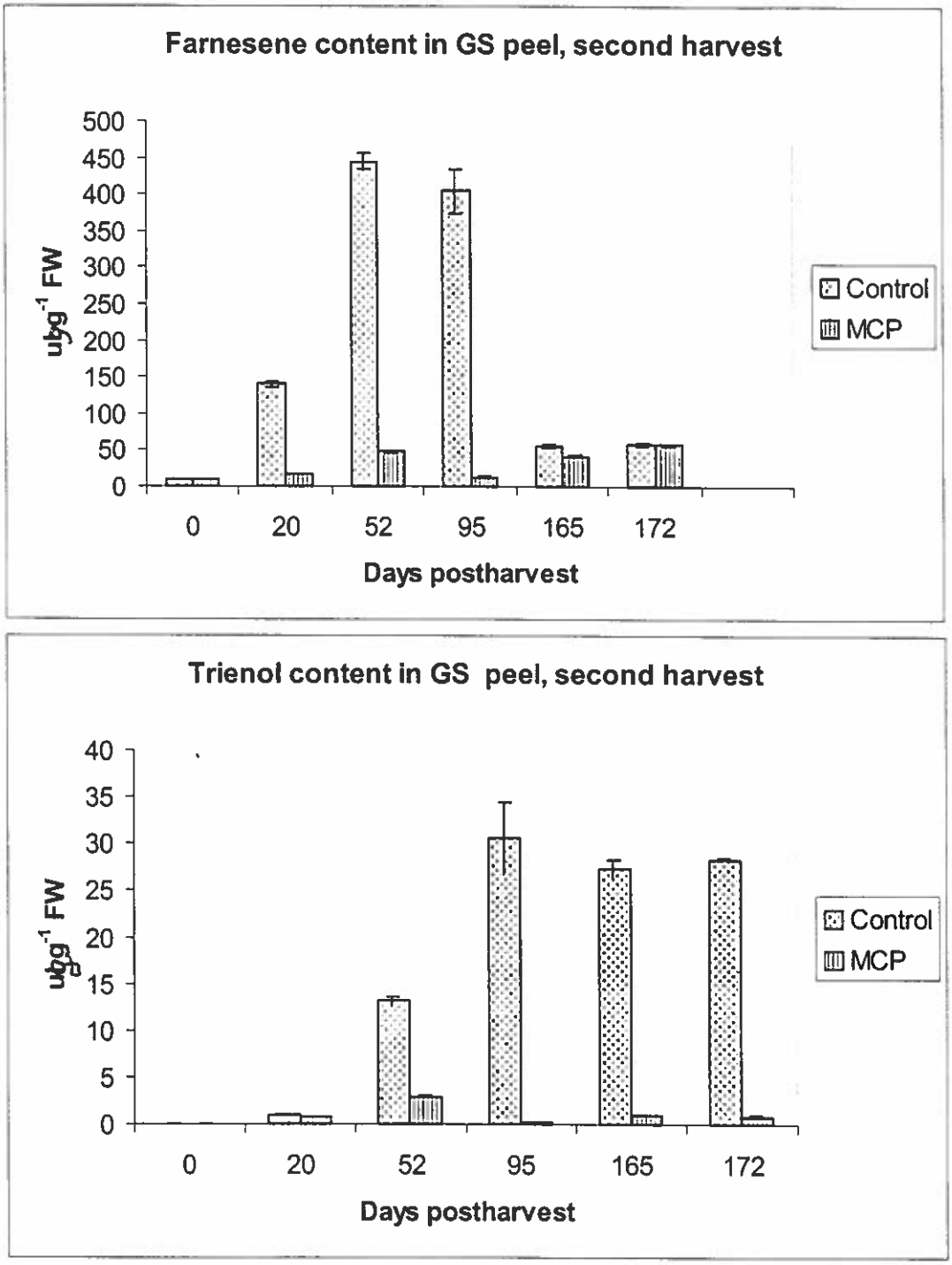



Fig 9: Farnesene and Trienol content in Granny Smith apples, second harvest

TABLE 1: EFFECTS OF MCP ON SCALD FORMATION IN GRANNY SMITH APPLES

| DAYS APROX | TEMP | SCALD SCORE* | FIRST HARVEST ( % OF SCALD SCORE) CONTROL | MCP | SECOND HARVEST (% OF SCALD SCORE) CONTROL | MCP |
|---|---|---|---|---|---|---|
| 120 | 1 C | 1 | 80 | 100 | 70 | 100 |
| 120 | 1 C | 2 | 20 | 0 | 30 | 0 |
| 120 | 1 C | 3 | 0 | 0 | 0 | 0 |
| 120 | 1 C | 4 | 0 | 0 | 0 | 0 |
| 170 | 1 C | 1 | 0 | 100 | 0 | 100 |
| 170 | 1 C | 2 | 20 | 0 | 20 | 0 |
| 170 | 1 C | 3 | 30 | 0 | 40 | 0 |
| 170 | 1 C | 4 | 50 | 0 | 40 | 0 |
| 180 | 1 C+ 1 W@17 C | 1 | 0 | 100 | 0 | 100 |
| 180 | 1 C+ 1 W@17 C | 2 | 0 | 0 | 0 | 0 |
| 180 | 1 C+ 1 W@17 C | 3 | 0 | 0 | 0 | 0 |
| 180 | 1 C+ 1 W@17 C | 4 | 100 | 0 | 100 | 0 |
| 225 | 1 C+ 6 W@17 C | 1 | SPOILED | 100 | SPOILED | 100 |
| 225 | 1 C+ 6 W@17 C | 2 | SPOILED | 0 | SPOILED | 0 |
| 225 | 1 C+ 6 W@17 C | 3 | SPOILED | 0 | SPOILED | 0 |
| 225 | 1 C+ 6 W@17 C | 4 | SPOILED | 0 | SPOILED | 0 |
| 255 | 1 C | 1 | SPOILED | 100 | SPOILED | 100 |
| 255 | 1 C | 2 | SPOILED | 0 | SPOILED | 0 |
| 255 | 1 C | 3 | SPOILED | 0 | SPOILED | 0 |
| 255 | 1 C | 4 | SPOILED | 0 | SPOILED | 0 |

* SCALD SCORES: 1 (NO SYMPTOMS); 2 (LESS THAN 1/3 OF SURFACE SCALDED) ; 3 (MORE THAN 1/3); 4 (ALL SCALD)

TABLE 2: EFFECT OF MCP ON SCALD FORMATION IN RED DELICIOUS APPLES

| DAYS (APROX) | TEMP | SCALD SCORE* | FIRST HARVEST ( % OF SCALD SCORE) CONTROL | MCP | SECOND HARVEST (% OF SCALD SCORE) CONTROL | MCP |
|---|---|---|---|---|---|---|
| 200 | 1 C | 1 | 0 | 100 | 0 | 100 |
| 200 | 1 C | 2 | 0 | 0 | 10 | 0 |
| 200 | 1 C | 3 | 20 | 0 | 10 | 0 |
| 200 | 1 C | 4 | 80 | 0 | 80 | 0 |
| 210 | 1 C+ 1 W@17 C | 1 | 0 | 100 | 0 | 100 |
| 210 | 1 C+ 1 W@17 C | 2 | 0 | 0 | 0 | 0 |
| 210 | 1 C+ 1 W@17 C | 3 | 0 | 0 | 0 | 0 |
| 210 | 1 C+ 1 W@17 C | 4 | 100 | 0 | 100 | 0 |
| 255 | 1 C+ 6 W@17 C | 1 | SPOILED | 100 | SPOILED | 100 |
| 255 | 1 C+ 6 W@17 C | 2 | SPOILED | 0 | SPOILED | 0 |
| 255 | 1 C+ 6 W@17 C | 3 | SPOILED | 0 | SPOILED | 0 |
| 255 | 1 C+ 6 W@17 C | 4 | SPOILED | 0 | SPOILED | 0 |
| 280 | 1 C | 1 | SPOILED | 100 | SPOILED | 100 |
| 280 | 1 C | 2 | SPOILED | 0 | SPOILED | 0 |
| 280 | 1 C | 3 | SPOILED | 0 | SPOILED | 0 |
| 280 | 1 C | 4 | SPOILED | 0 | SPOILED | 0 |

* SCALD SCORES: 1 (NO SYMPTOMS); 2 (LESS THAN 1/3 OF SURFACE SCALDED) ; 3 (MORE THAN 1/3); 4 (ALL SCALD)

**TABLE 3**

**A:EFFECT OF MCP ON THE TEXTURE OF GRANNY SMITH APPLES KEPT AT 1 DEGREE C**

| DAYS POST HARVEST | FIRST HARVEST (PRESSURE IN PSI) CONTROL | MCP | LATE MCP | SECOND HARVEST (PRESSURE IN PSI) CONTROL | MCP |
|---|---|---|---|---|---|
| 0 | 23.06 (0.51) | | | 20.84 (1.51)170 | |
| 250 | 15.71 (1.40) | 21.58 (1.15) | 17.9 (1.81) | 13.52 (1.02) | 18.84 (1.25) |

**B:EFFECT OF MCP ON THE TEXTURE OF RED DELICIOUS APPLES KEPT AT 1 DEGREE C**

| DAYS POST HARVEST | FIRST HARVEST (PRESSURE IN PSI) CONTROL | MCP | SECOND HARVEST (PRESSURE IN PSI) CONTROL | MCP |
|---|---|---|---|---|
| | 23.50 (1.72) | | 22.23 (0.71) | |
| 275 | 17.55 (1.19) | 21.2 (1.37) | 17.02 (1.08) | 20.22(1.24) |

**C: EFFECT OF MCP AND LOW OXYGEN CONCENTRATIONS ON THE TEXTURE OF RED DELICIOUS APPLES KEPT AT 17 DEGREE C**

| DAYS POST HARVEST | DATS AT 17 C | PRESSURE IN PSI CONTROL | MCP | 1,5% OXYGEN |
|---|---|---|---|---|
| 119 | 60 | 18.22 (0.22) | 21.03 (1.23) | 19.98 (1.05) |

# TABLE 4: EFFECTS OF MCP ON SCALD FORMATION IN LATE MCP TREATED GRANNY SMITH APPLES

| DAYS IN 1 C | SCALD* SCORE | CONTROLS % OF SCALD SCORE | LATE MCP % OF SCALD SCORE | EARLY MCP % OF SCALD SCORE |
|---|---|---|---|---|
| 170 | 1 | 0 | 100 | 100 |
| 170 | 2 | 20 | 0 | 0 |
| 170 | 3 | 30 | 0 | 0 |
| 170 | 4 | 50 | 0 | 0 |
| 255 | 1 | SPOILED | 75 | 100 |
| 255 | 2 | SPOILED | 16.66 | 0 |
| 255 | 3 | SPOILED | 8.33 | 0 |
| 255 | 4 | SPOILED | 0 | 0 |

*SCALD SCORE: 1=(NO SYMPTOMS);2 =(LESS THAN 1/3 OF SURFACE SCLODED)
3=(MORE THAN 1/3 OF SURFACE SCALDED; 4=(ALL SURFACE SCALDED)

**TABLE 6: EFFECTS OF MEVASTATIN ON SCALD FORMATION IN GRANNY SMITH APPLES**

| DAYS AT $1^0$ C | SCALD SCORE * | CONTROLS % SCALD SCORE | MEVASTATIN % SCALD SCORE |
|---|---|---|---|
| 255 | 1 | SPOILED | 50 |
| 255 | 2 | SPOILED | 10 |
| 255 | 3 | SPOILED | 20 |
| 255 | 4 | SPOILED | 20 |

* SCALD SCORES: 1 (NO SYMPTOMS); 2 (LESS THAN 1/3 OF SURFACE SCALDED) ; 3 (MORE THAN 1/3); 4 (ALL SCALD)