

Registration of 1-MCP treatments on Elstar and Tentation apples

Report of experiments storage season 2002-2003, supplement:

Elstar, 8 months storage
Elstar, skin spots extra origins
Elstar, different amounts of product
Tentation, 6 and 8 months storage
Tentation, scald extra origins

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Summary

This report describes results of 1-MCP trials with Elstar and Tentation regarding long-term storage, in addition to trials described in the report 'Registration of 1-MCP treatments on Elstar and Tentation apples. Report of experiments storage season 2002-2003, April 2003'.

Experiments on 1-methylcyclopropene (1-MCP, SmartFresh™) were carried out by ATO for AgroFresh Inc. To test the efficacy of 1-MCP on apples, trials were performed on apple cultivars 'Elstar' and 'Tentation' in the storage season 2002-2003.

Even after 8 months storage of Elstar, 1-MCP prevented firmness loss, both for normal and late harvest. For late harvest, 1-MCP inhibited development of rot during shelf-life. It was shown for late harvest of three origins (main experiment + extra experiment) that 1-MCP caused a higher incidence of skin spots.

The effect of 325 ppb 1-MCP was tested for different amounts of Elstar apples (50 kg/m³, 150 kg/m³ and 300 kg/m³). There were no clear differences between these different treatments.

1-MCP can be advantageous for ULO (CA) storage of Tentation. Treatment with 1-MCP was not necessary for firmness retention as firmness loss of control apples was absent or very small, even during 14 days shelf-life. In many cases, 1-MCP resulted in greener apples and a higher acidity.

1-MCP could be used to replace ULO storage of Tentation during 6 months storage, but only for normal harvest.

Also for (extremely) late harvested Tentation, firmness loss of control apples was not a problem. Application of 1-MCP resulted in apples with often greener colour and higher acidity.

1-MCP prevented development of scald in Tentation apples of normal harvest. 1-MCP could not prevent scald in (extremely) late harvested apples, which was shown for apples of 3 origins (main experiment + extra experiment).

For Tentation both 312 and 625 ppb 1-MCP was tested, but there were no important differences between these concentrations.

1 Introduction

This report describes results of 1-MCP trials with Elstar and Tentation regarding long-term storage in addition to trials described in the report 'Registration of 1-MCP treatments on Elstar and Tentation apples. Report of experiments storage season 2002-2003, April 2003'.

For Elstar, results of 8 months storage are given, for Tentation results of 6 and 8 months storage are given (Table 1).

Also a trial with Elstar is described where the effect of 325 ppb 1-MCP was tested at different amounts of product.

Also results of storage of extra origins Elstar and Tentation (to study skin spots and scald respectively) are given in this report.

Table 1. Assessment dates for Elstar and Tentation directly after storage and after storage plus shelf-life.

Storage duration	Elstar cooling	Elstar ULO	Tentation cooling	Tentation ULO
6 months			April 1 th 2003	April 15 th 2003
6 months + shelf-life			April 1 th 2003	April 15 th 2003
8 months		May 9 th 2003		May 27 th 2003
8 months + shelf-life		May 23 th 2003		June 10 th 2003

2 Results Elstar 8 months storage

The advantage of 1-MCP regarding 8 months ULO storage was shown during shelf-life where 1-MCP prevented firmness loss, both for normal and late harvest (Fig 1A and 1B).

There were no large effects of 1-MCP on colour (Fig. 2), soluble solids content (Fig. 3) or titratable acids (Fig. 4)

For normal harvest, there was no effect of 1-MCP on rot or skin spots. For Late harvest, 1-MCP inhibited development of rot during shelf-life (Fig 5B) but increased the development of skin spots (Fig 6B).

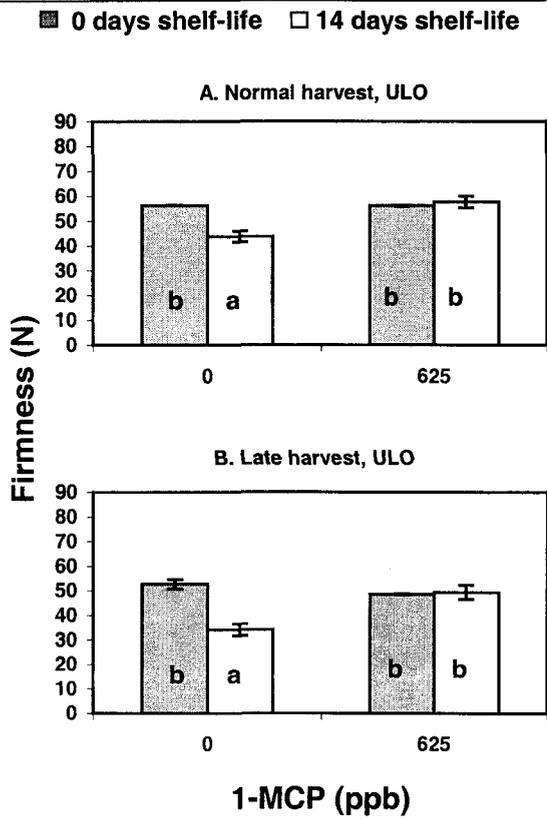


Fig. 1. Firmness of Elstar after 8 months of storage. Vertical bars indicate \pm std of the mean of two replicates. Columns within a chart marked with a same letter are not statistically different ($P=0.05$).

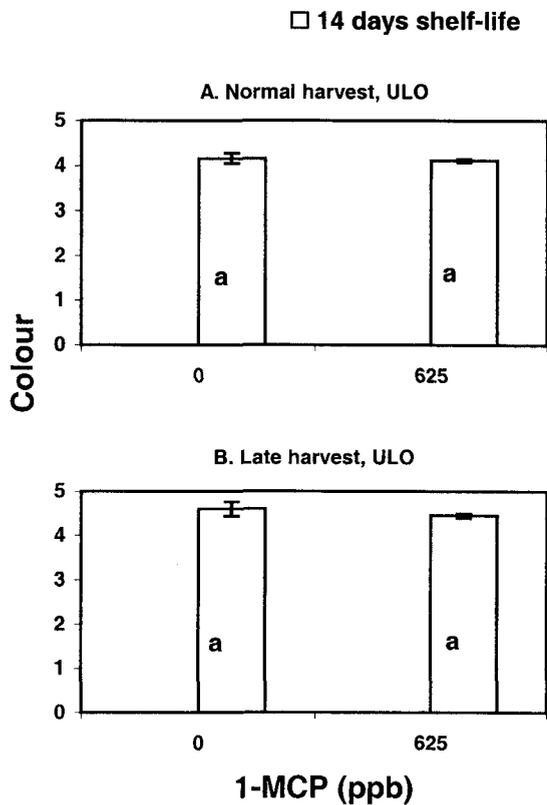


Fig. 2. Colour of Elstar after 8 months of storage. Vertical bars indicate \pm std of the mean of two replicates. Columns within a chart marked with a same letter are not statistically different ($P=0.05$).

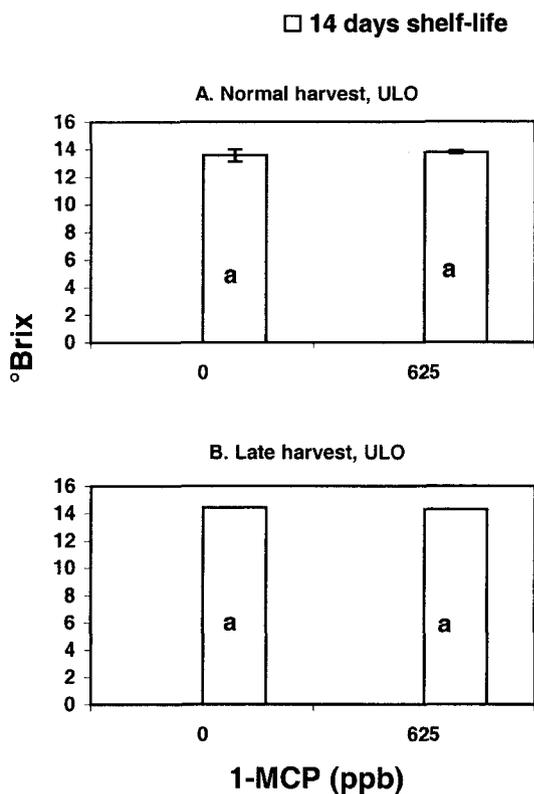


Fig. 3. Soluble solids content of Elstar after 8 months storage. Vertical bars indicate \pm std of the mean of 2 replicates. Columns within a chart marked with a same letter are not stat. diff. ($P=0.05$).

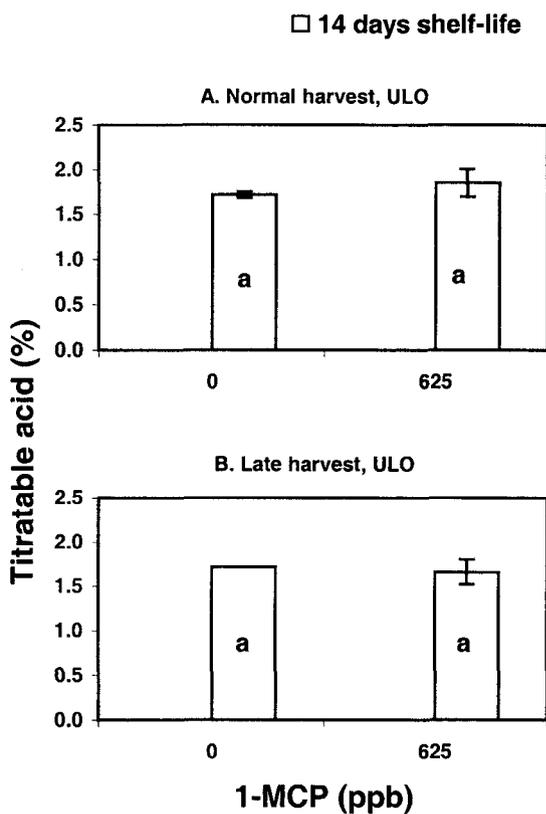


Fig. 4. Titratable acidity of Elstar after 8 months storage. Vertical bars indicate \pm std of the mean of 2 replicates. Columns within a chart marked with a same letter are not statistically different ($P=0.05$).

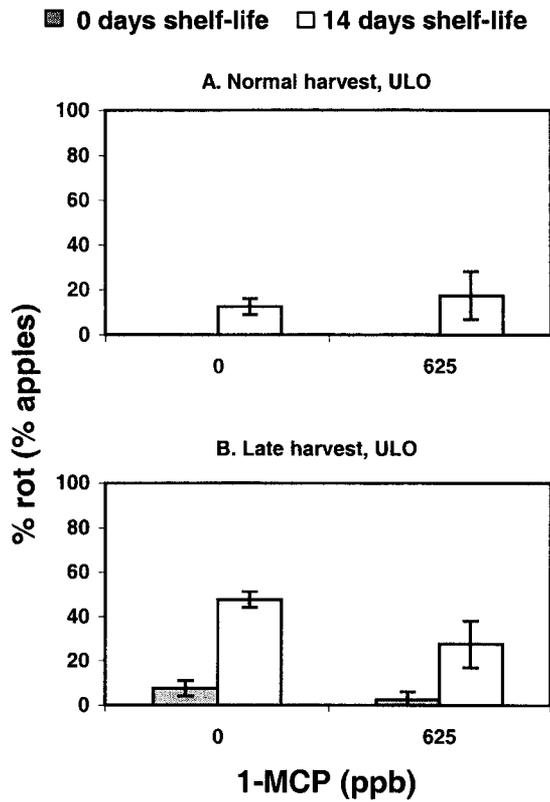


Fig. 5. % apples with rot of Elstar after 8 months storage. Vertical bars indicate \pm std of the mean of 2 replicates.

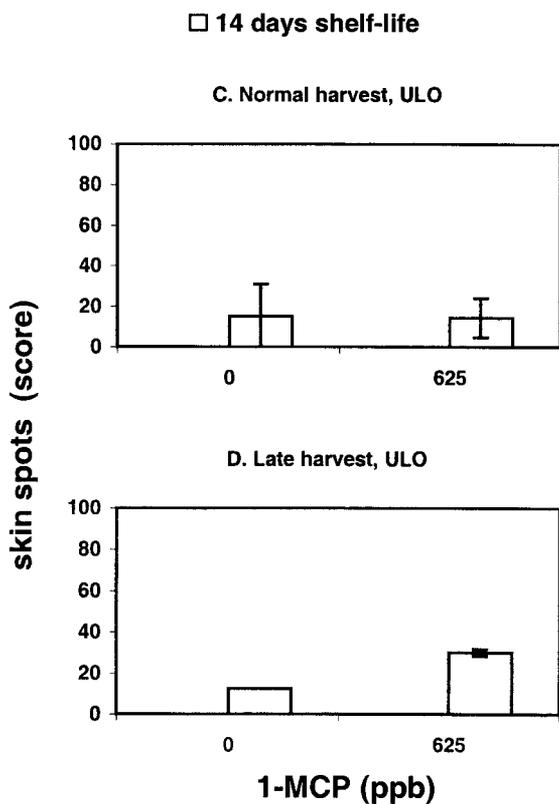


Fig. 6. Skin spots of Elstar (% of maximum score) after 8 months storage. Vertical bars indicate \pm std of the mean of 2 replicates.

3 Skin spots Elstar, extra origins

To investigate the effect of 1-MCP on skin spots, late harvested Elstar (standard) apples of 2 extra origins were stored under air conditions (no ULO) for 6 and 8 months plus 14 days shelf-life.

1-MCP increased the incidence of skin spots for these late harvested apples both after 6 months storage (Fig. 7) and after 8 months storage (Fig. 8). (Due to the high incidence of rot in control apples of grower GII after 8 months of storage, these apples could not be assessed on skin spots).

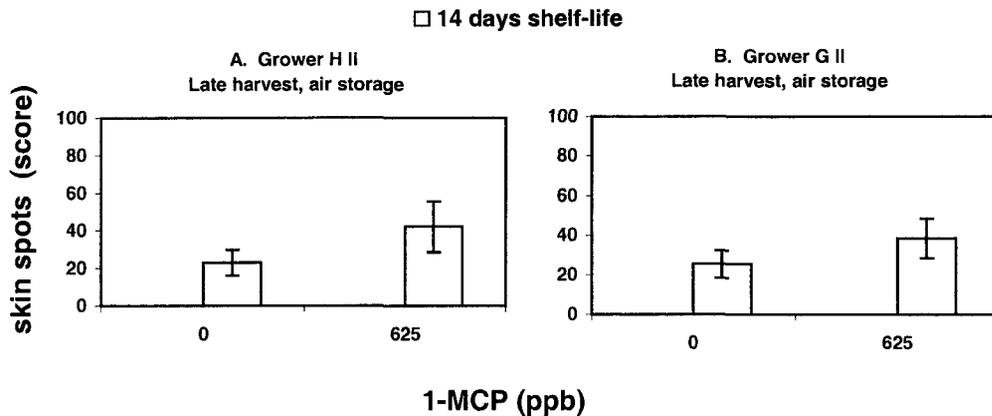


Fig. 7. Skin spots of Elstar (% of maximum score) for 2 extra origins after 6 months storage. Vertical bars indicate \pm std of the mean of 2 replicates.

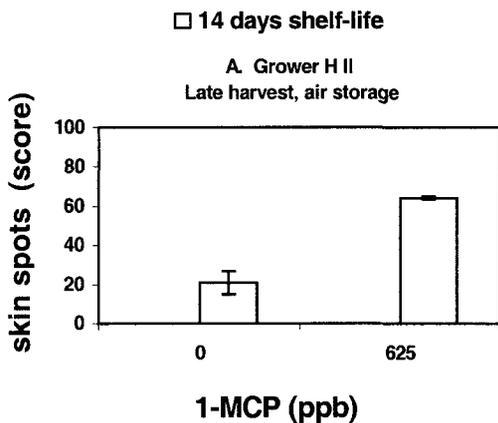


Fig. 8. Skin spots of Elstar (% of maximum score) for 1 extra origin after 8 months storage. Vertical bars indicate \pm std of the mean of 2 replicates.

4 Does the 1-MCP effect depend on the amount of product during application?

4.1 Introduction

It was tested whether the 1-MCP effect depends on the amount of product during application.

4.2 Materials and methods

Eistar apples of late harvest were used. After harvest apples were placed in a temperature controlled room at 1.8°C.

Apples were treated with 1-MCP during 24 h. at 1.8 °C. A 1-MCP dose of 312 ppb 1-MCP was applied, calculated on basis of an empty room (67 L. container). The amount of product inside the containers varied.

Treatments were:

1. 312 ppb 1-MCP, 300 kg/m³ (20 kg/67 L. container)
2. 312 ppb 1-MCP, 150 kg/m³ (10 kg/67 L. container)
3. 312 ppb 1-MCP, 50 kg/m³ (3.3 kg/67 L. container)

After treatment, apples were stored under standard ULO conditions. Assessments were done after 4, 6 and 8 months storage plus 0 or 14 days shelf-life. Samples of 20 apples were used.

4.3 Results

There were no clear differences between the applied treatments regarding firmness (Fig. 9), colour (Fig. 10), soluble solids (Fig. 11) and titratable acidity (Fig. 12). Only after 8 months storage, the treatment with 300 kg/m³ showed a higher incidence of rot (Fig. 13) but lower incidence of skin spots (Fig. 14). As this was not the case after 4 and 6 months of storage and variation after 8 months of storage was large, this is probably coincidental.

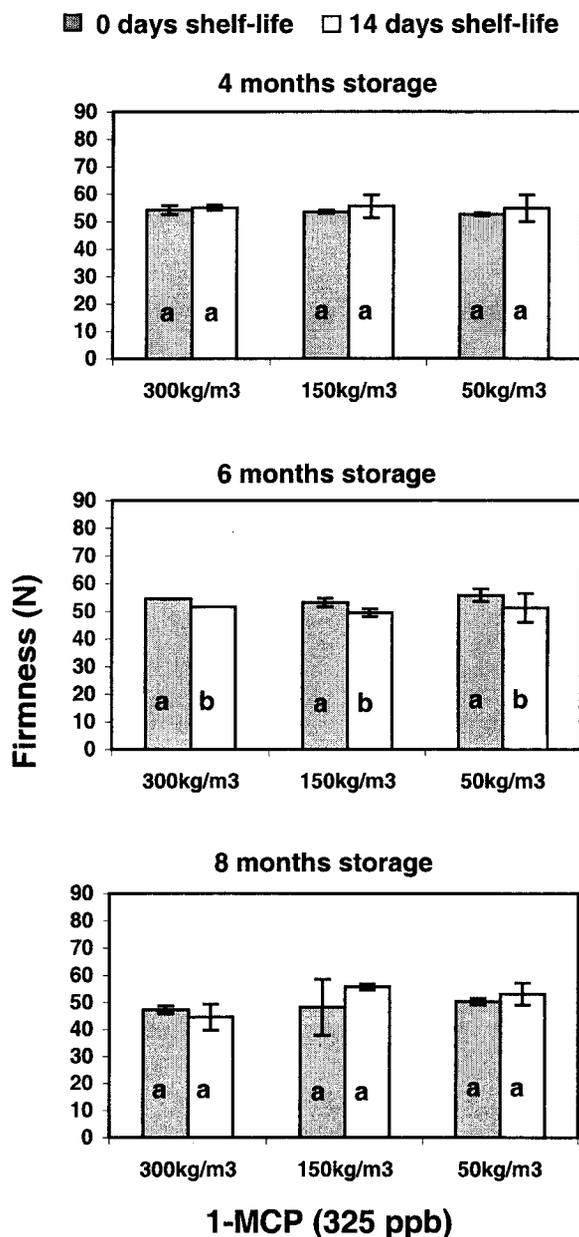


Fig. 9. Firmness of Elstar after 4, 6 and 8 months of storage. Vertical bars indicate \pm std of the mean of two replicates. Columns within a chart marked with a same letter are not statistically different ($P=0.05$).

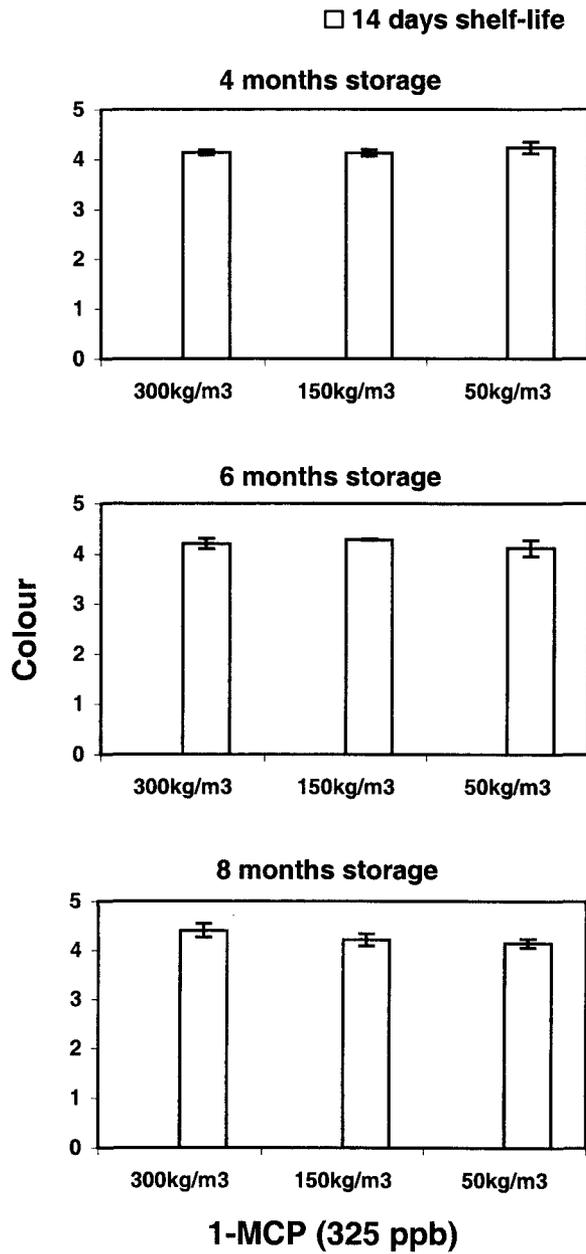


Fig. 10. Colour of Elstar after 4, 6 and 8 months of storage. Vertical bars indicate \pm std of the mean of two replicates.

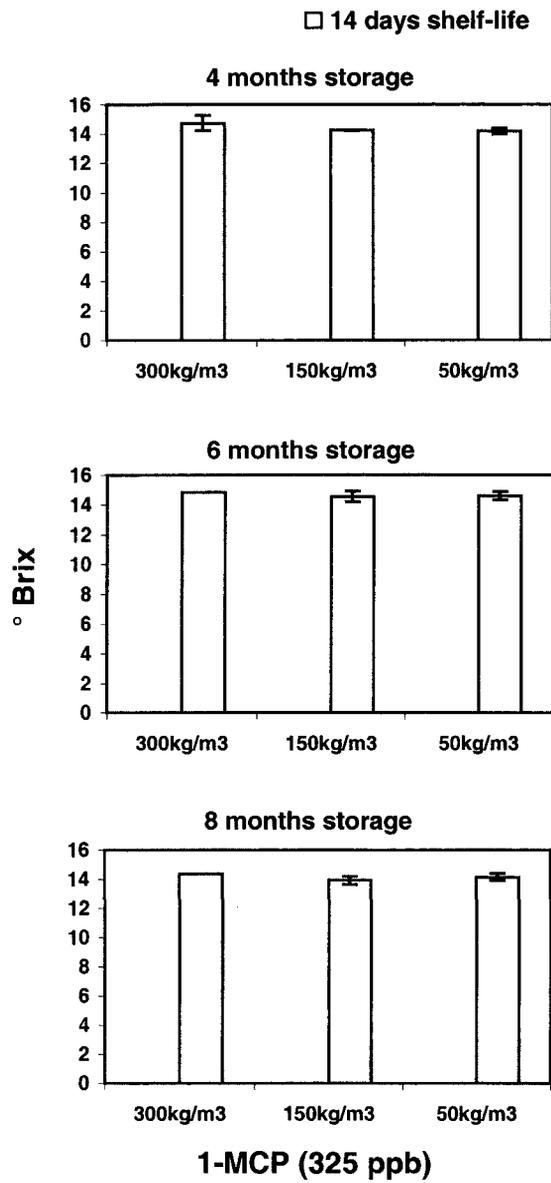


Fig. 11. Soluble solids content of Elstar after 4, 6 and 8 months of storage. Vertical bars indicate \pm std of the mean of two replicates.

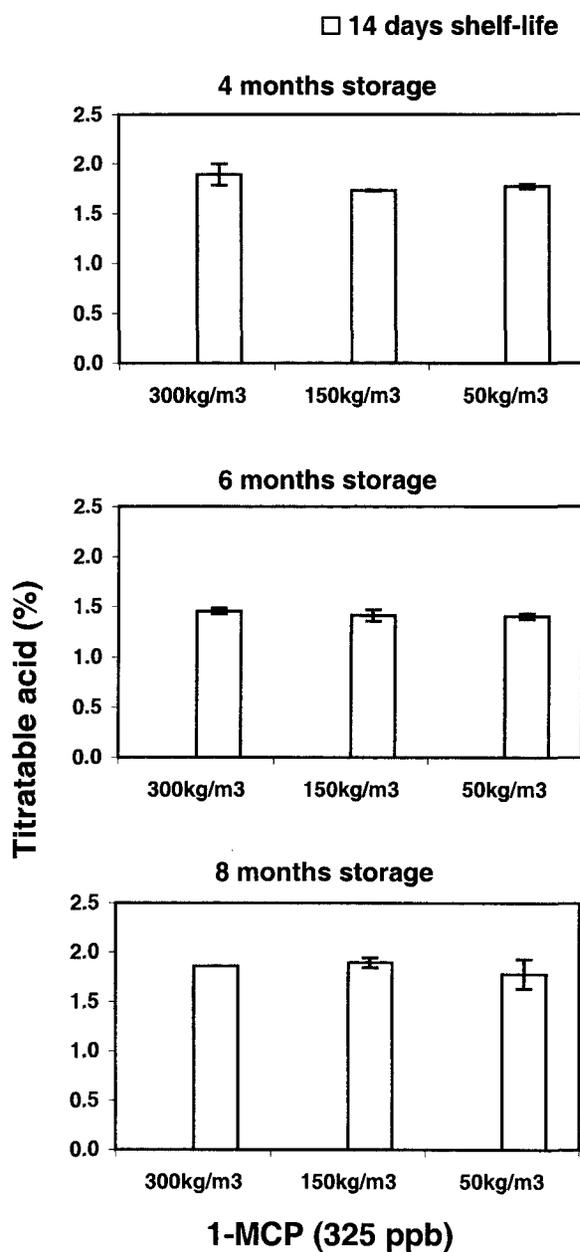


Fig. 12. Titratable acidity of Elstar after 4, 6 and 8 months of storage. Vertical bars indicate \pm std of the mean of two replicates.

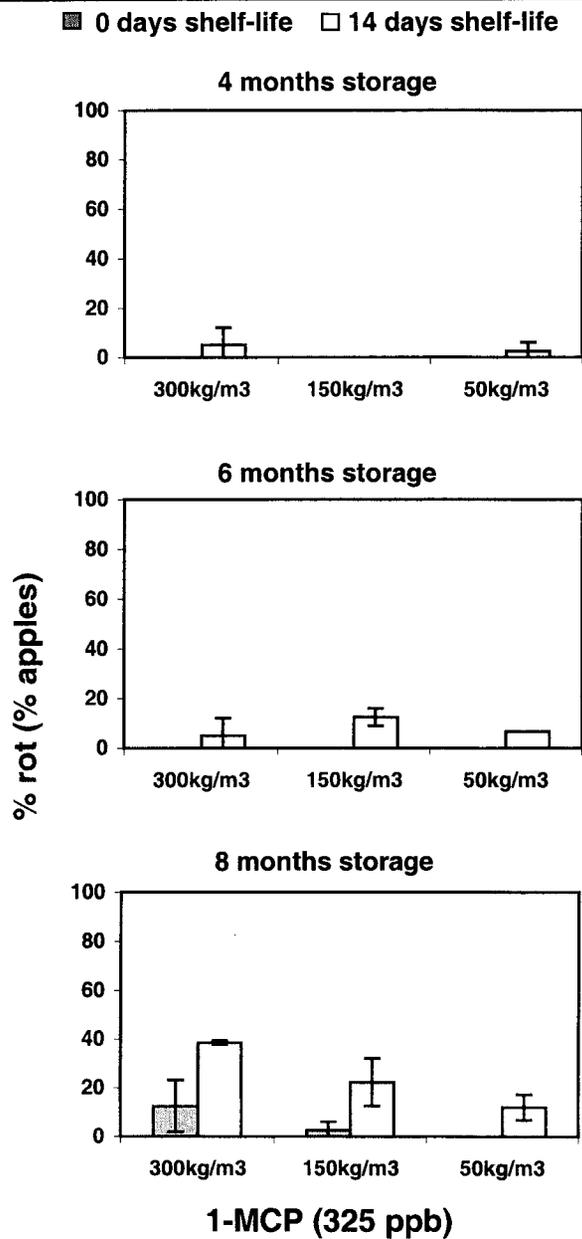


Fig. 13. % apples with disorders of Elstar after 4, 6 and 8 months of storage. Vertical bars indicate \pm std of the mean of two replicates.

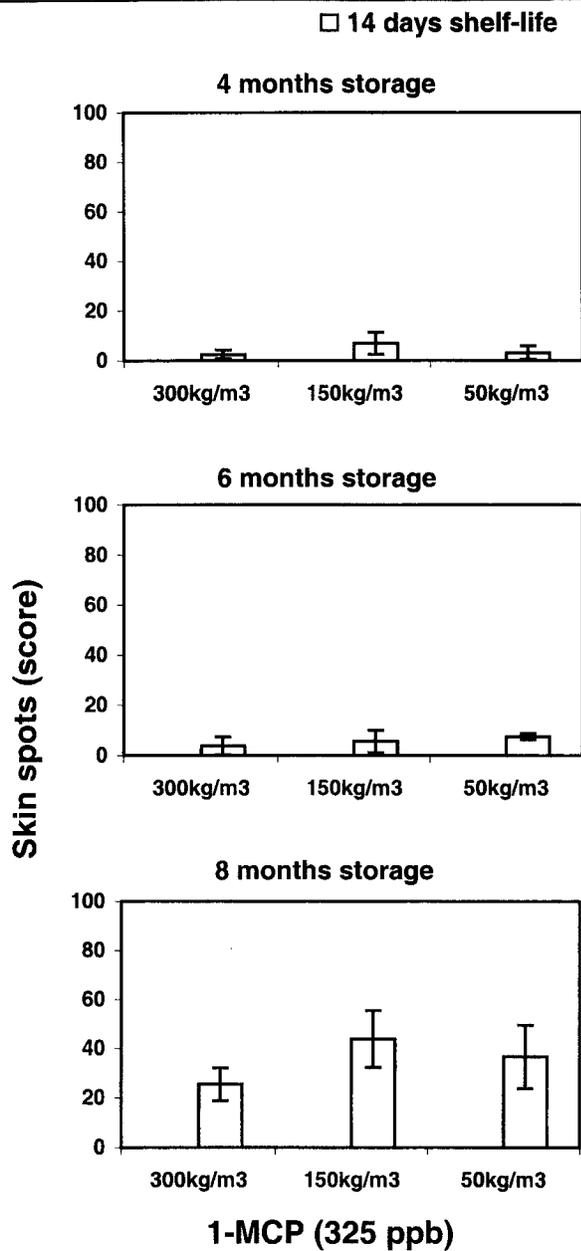


Fig. 14. Skin spots of Elstar (% of maximum score) after 4, 6 and 8 months of storage. Vertical bars indicate \pm std of the mean of two replicates.

5 Results Tentation

5.1 Tentation, 6 months storage

Apples of late harvest developed severe rot after 6 months air storage. For these apples, quality parameters other than % rot and scald are not given.

Firmness loss of normal harvested apples, during air storage and subsequent shelf-life, was completely prevented by 1-MCP (Fig. 14A). Firmness of 1-MCP treated apples after air storage (0 or 14 days shelf-life) was equal to firmness of control apples after ULO (Fig. 14C)

While firmness at harvest was 69.7 ± 0.9 N, the firmness after 6 months air was 53.4 ± 0.2 , 70.8 ± 0.8 and 70.7 ± 0.7 for control, 312 ppb and 625 ppb 1-MCP respectively.

Firmness loss during ULO and subsequent shelf-life was very small, 1-MCP was not necessary for firmness retention (Fig. 14C and 14D).

Yellowing was inhibited by 1-MCP in all cases (Fig. 15).

1-MCP caused higher soluble solids content in some cases but effects were small (Fig. 16).

1-MCP treatments resulted in higher titratable acidity for normal harvest after air storage and for late harvest after ULO (Fig. 17).

For air storage of normal harvest, 1-MCP inhibited the development of rot during shelf-life (Fig. 18A) which was related to inhibition of scald (Fig. 19A).

For air storage of late harvest severe rot occurred (Fig. 18B) which was also related to scald (Fig. 19B). In this case there was no effect of 1-MCP.

Less rot developed after ULO storage (Fig. 18C and 18D). There was no clear effect of 1-MCP.

Scald was only found for air storage, not for ULO (Fig. 19C and 19D).

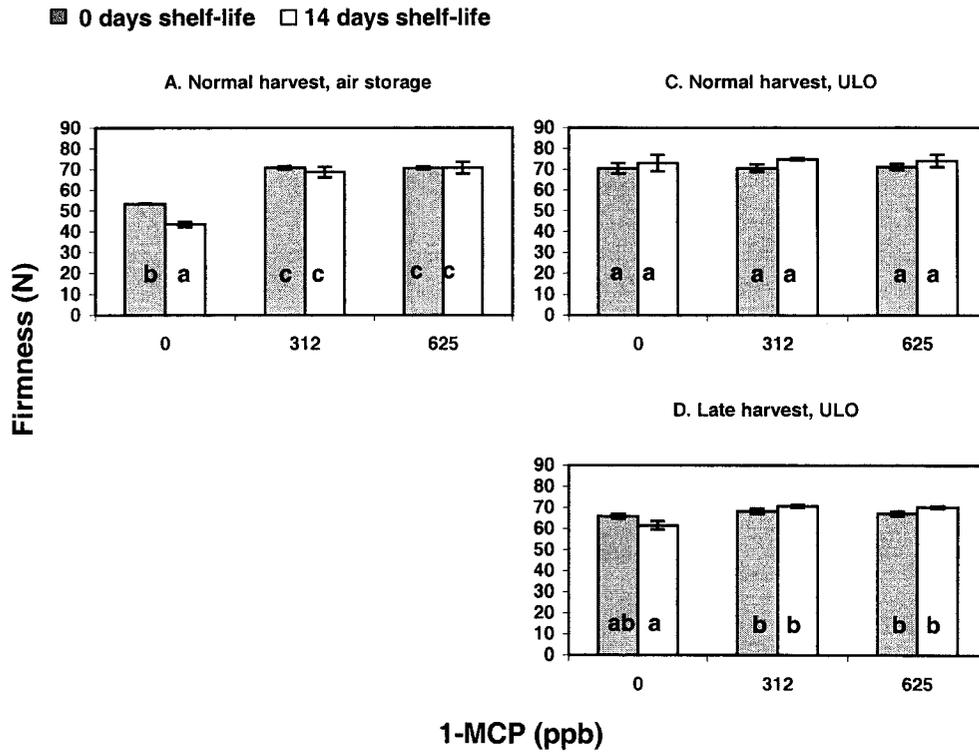


Fig. 14. Firmness of Tentation after 6 months of storage. Vertical bars indicate \pm std of the mean of two replicates. Columns within a chart marked with a same letter are not statistically different ($P=0.05$).

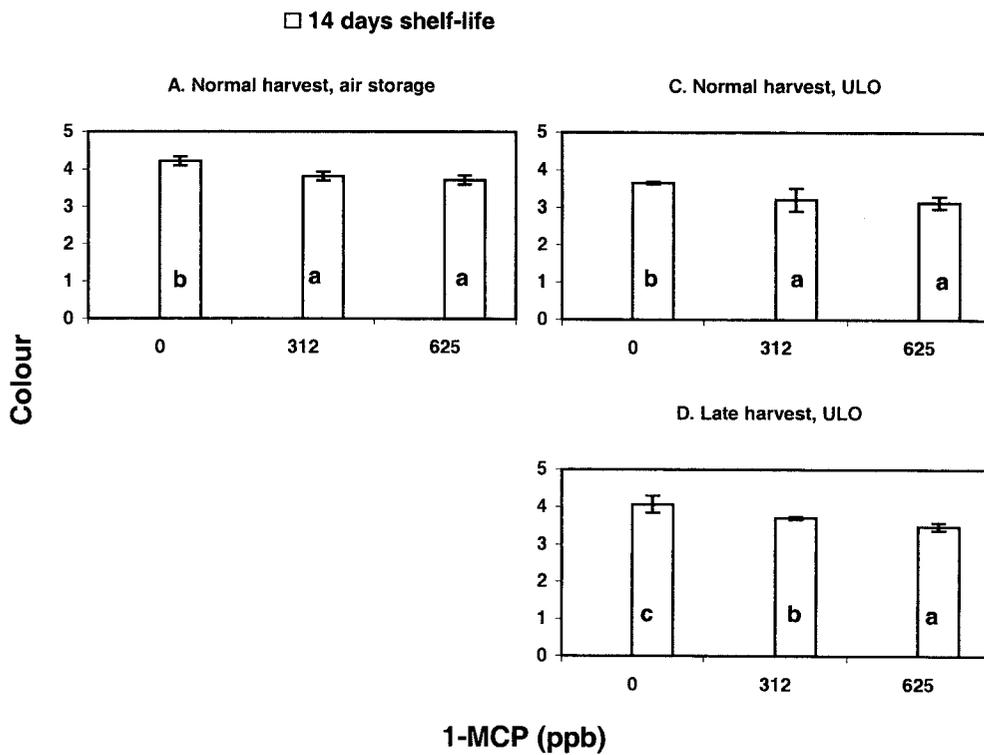


Fig. 15. Colour of Tentation after 6 months of storage. Vertical bars indicate \pm std of the mean of two replicates. Columns within a chart marked with a same letter are not statistically different ($P=0.05$).

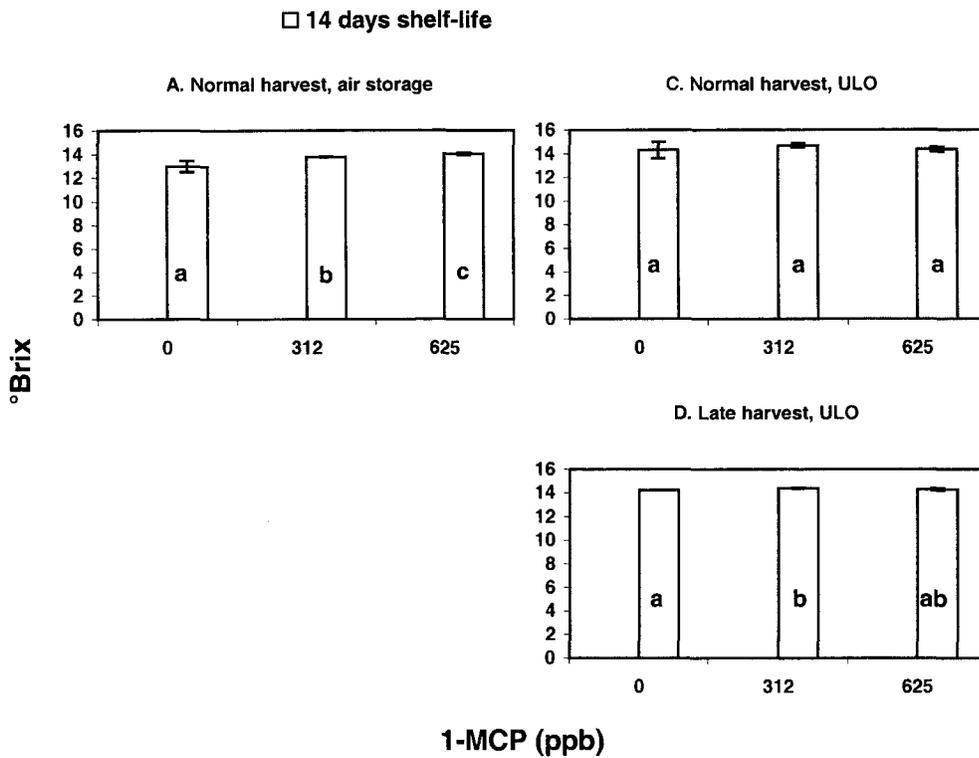


Fig. 16. Soluble solids content of Tentation after 6 months storage. Vertical bars indicate \pm std of the mean of 2 replicates. Columns within a chart marked with a same letter are not statistically different ($P=0.05$).

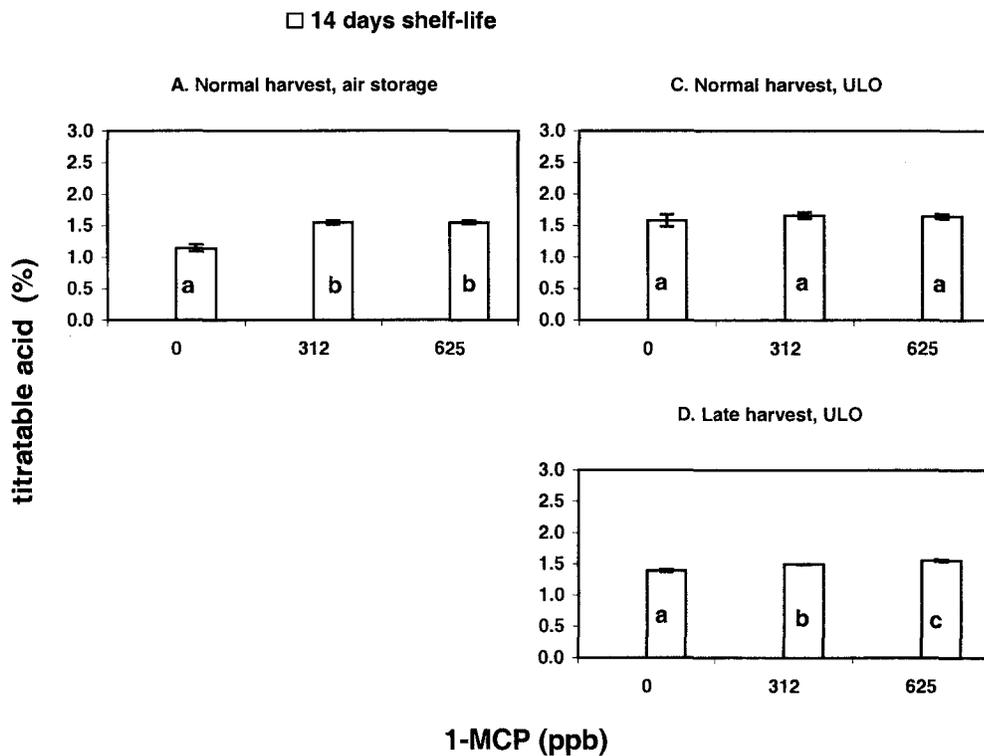


Fig. 17. Titratable acidity of Tentation after 6 months storage. Vertical bars indicate \pm std of the mean of 2 replicates. Columns within a chart marked with a same letter are not statistically different ($P=0.05$).

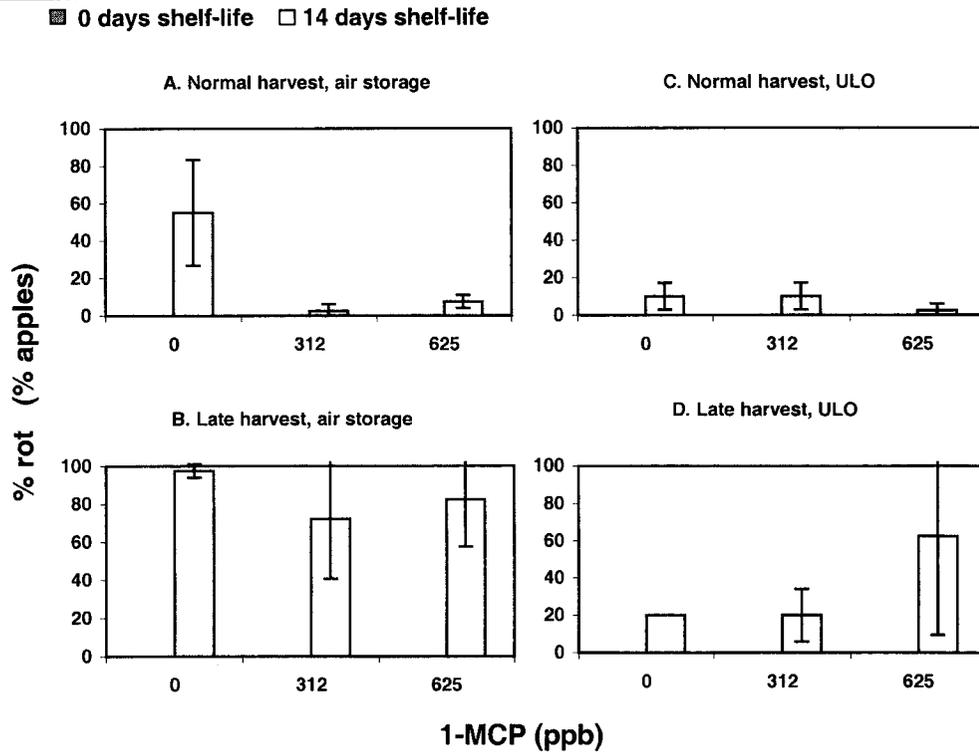


Fig. 18. % apples with rot of Tentation after 6 months storage. Vertical bars indicate \pm std of the mean of 2 replicates.

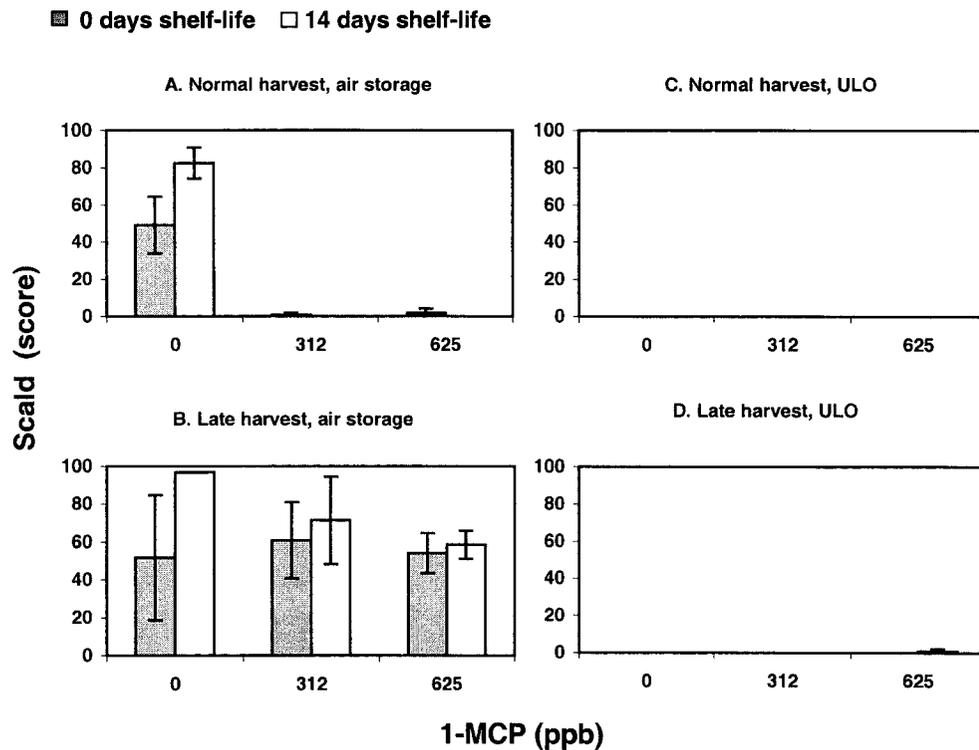


Fig. 19. Index for scald (% of maximum) of Tentation after 6 months storage. Vertical bars indicate \pm std of the mean of 2 replicates.

5.2 Tentation, 8 months storage

Control apples did not show firmness loss during ULO and subsequent shelf-life, 1-MCP was not necessary for firmness retention (Fig. 20).

While firmness at harvest was 69.7 ± 0.9 N, the firmness after 8 months ULO was 70.9 ± 1.2 , 71.6 ± 0.5 and 72.2 ± 1.0 for control, 312 ppb and 625 ppb 1-MCP respectively.

Yellowing was inhibited by 1-MCP, however not always statistically significant (Fig. 21).

In contrast to 6 months storage, 1-MCP caused lower soluble solids content in some cases, but again effects were small (Fig. 22).

1-MCP treatments resulted in higher titratable acidity (Fig. 23).

There were no clear effects of 1-MCP on rot development (Fig. 24).

Scald was only found scarcely for late harvest, which was not prevented by 1-MCP (Fig. 25).

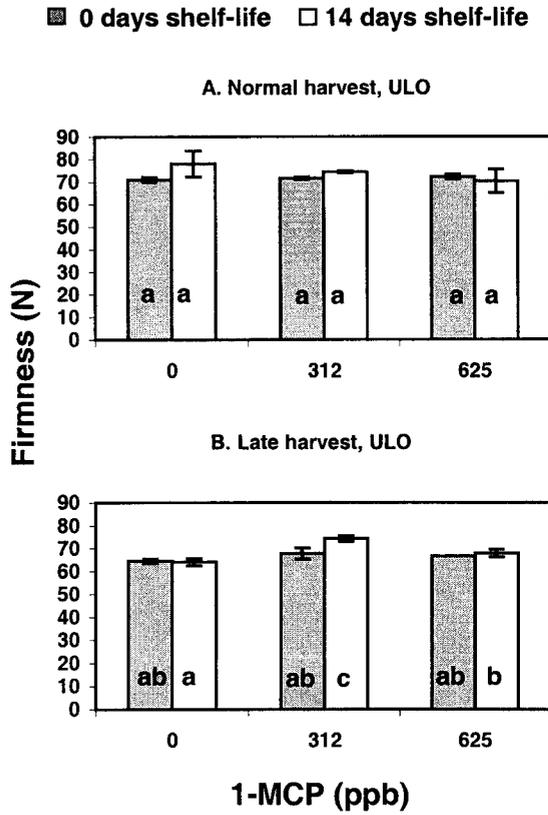


Fig. 20. Firmness of Tentation after 8 months of storage. Vertical bars indicate \pm std of the mean of two replicates. Columns within a chart marked with a same letter are not statistically different ($P=0.05$).

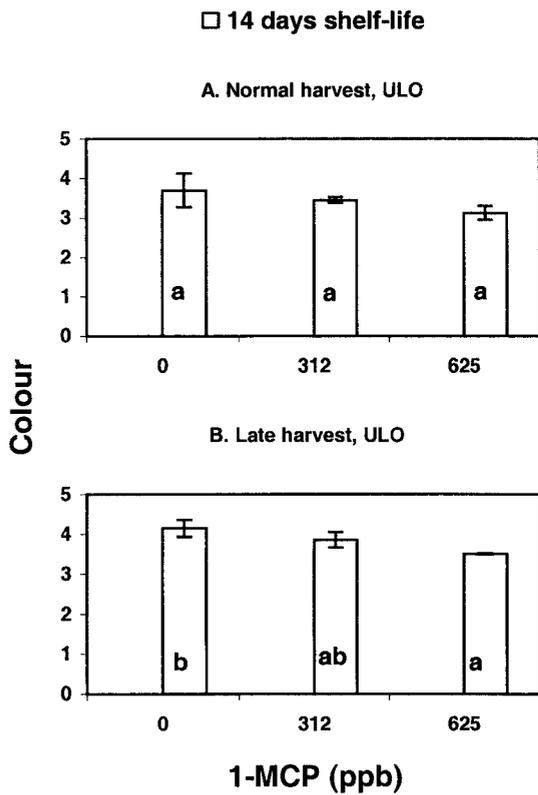


Fig. 21. Colour of Tentation after 8 months of storage. Vertical bars indicate \pm std of the mean of two replicates. Columns within a chart marked with a same letter are not statistically different ($P=0.05$).

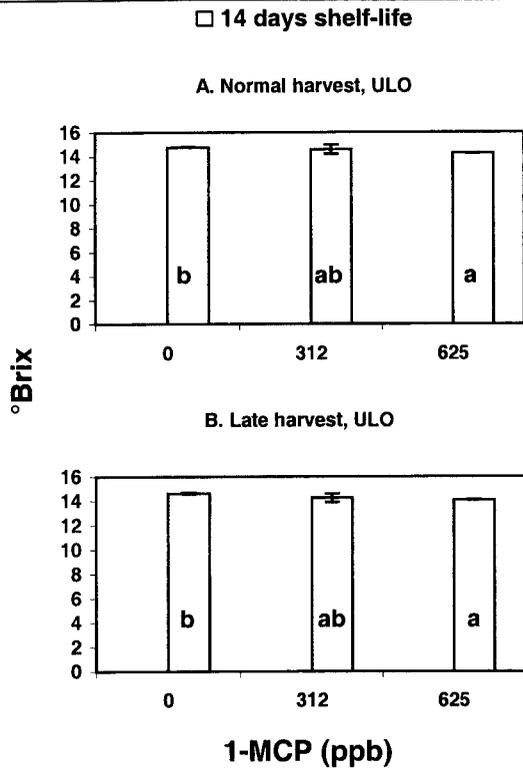


Fig. 22. Soluble solids content of Tentation after 8 months of storage. Vertical bars indicate \pm std of the mean of two replicates. Columns within a chart marked with a same letter are not statistically different ($P=0.05$).

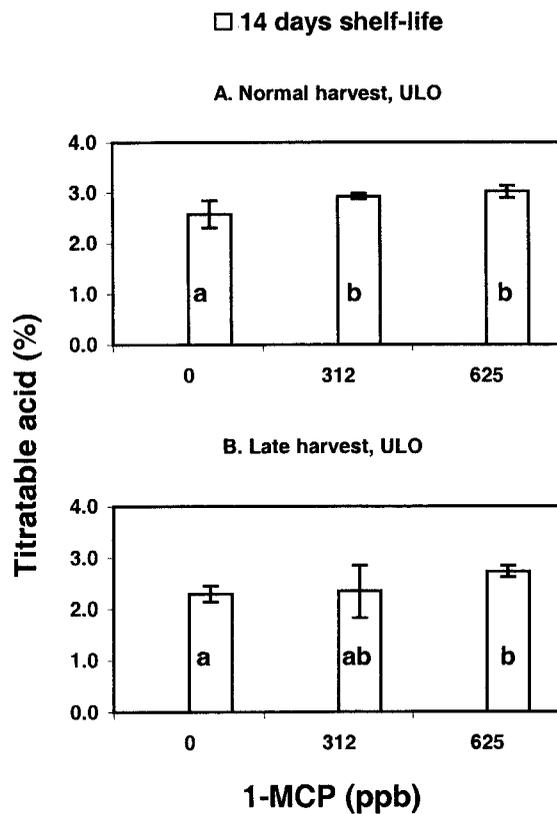


Fig. 23. Titratable acidity of Tentation after 8 months of storage. Vertical bars indicate \pm std of the mean of two replicates. Columns within a chart marked with a same letter are not statistically different ($P=0.05$).

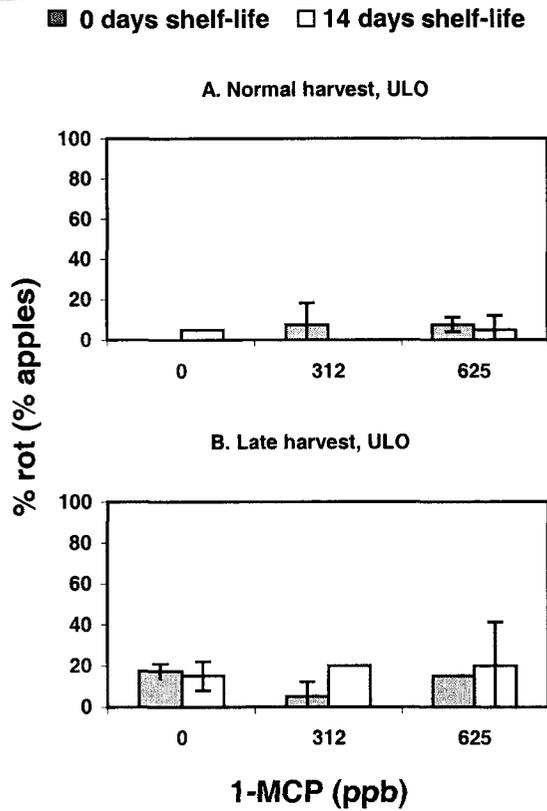


Fig. 24. % apples with rot of Tentation after 8 months of storage. Vertical bars indicate \pm std of the mean of two replicates.

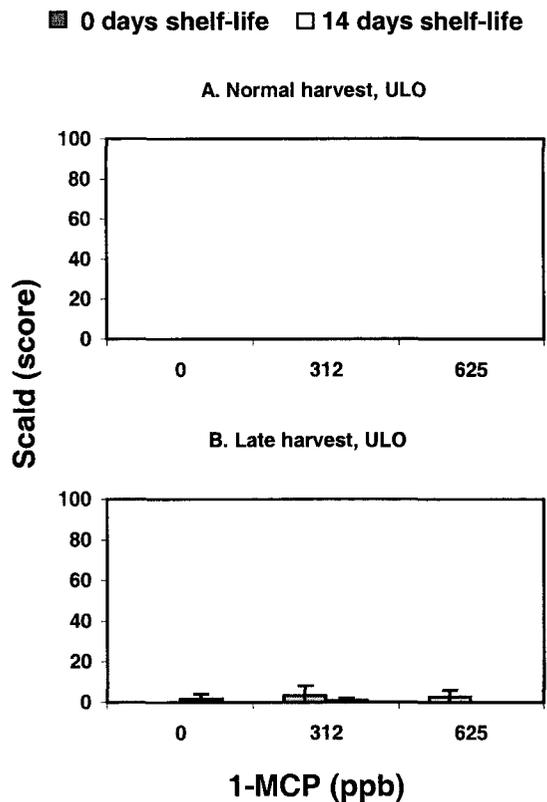


Fig. 25. Index for scald (% of maximum) of Tentation after 8 months of storage. Vertical bars indicate \pm std of the mean of two replicates.

6 Tentation, extra origins

For 2 extra origins, Tentation apples of extreme late harvest were stored. These apples were picked ± 14 days after the normal harvest date from trees that had not been strip-picked before. In practice, this is an uncommon situation. Assessments were done after 6 months storage (Fig. 26) and after 8 months storage (Fig. 27).

As shown in the main experiment, 1-MCP could not prevent the development of scald in these (extreme) late picked apples.

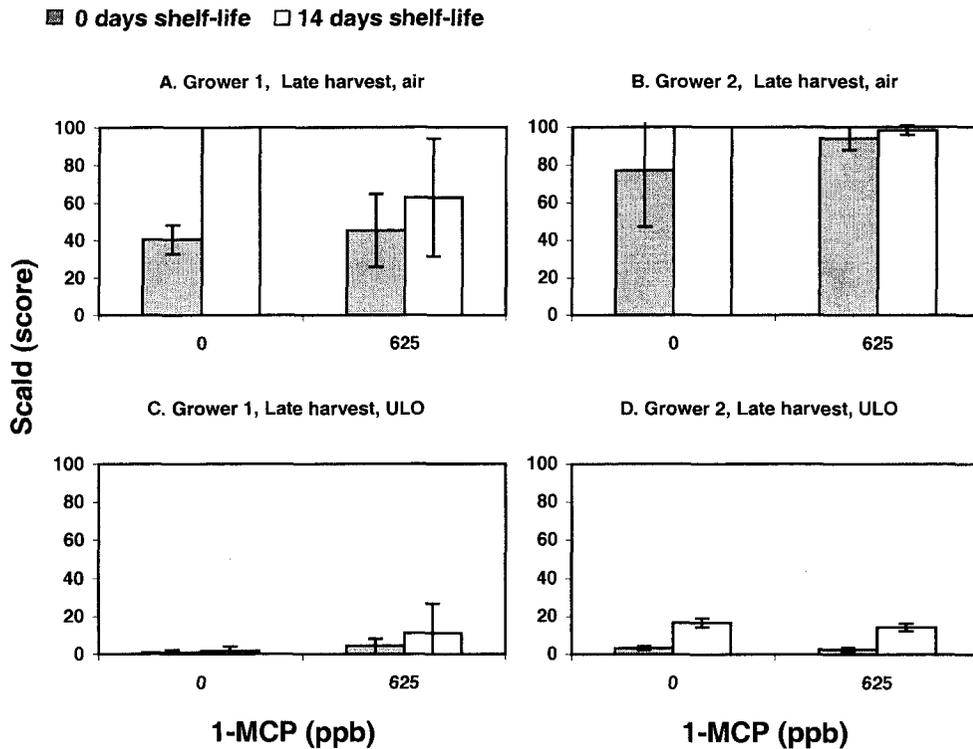


Fig. 26. Index for scald (% of maximum) of late harvested Tentation after 6 months of storage for 2 different growers. Vertical bars indicate \pm std of the mean of two replicates.

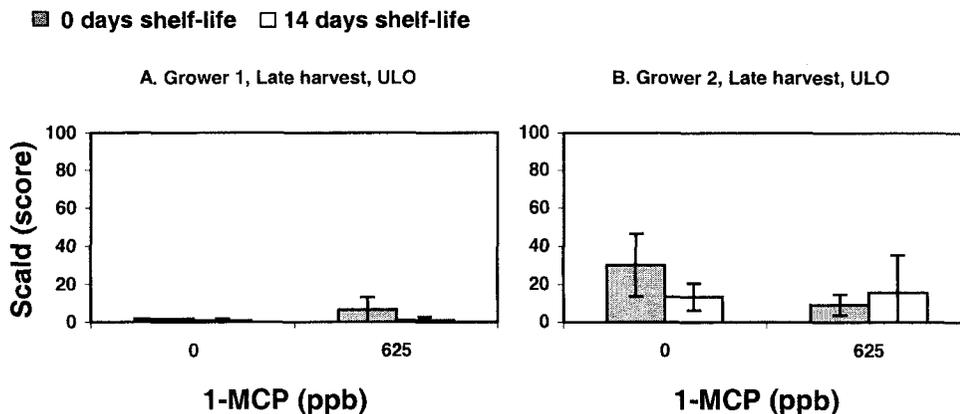


Fig. 27. Index for scald (% of maximum) of late harvested Tentation after 8 months of storage for 2 different growers. Vertical bars indicate \pm std of the mean of two replicates.

6 Conclusions

Conclusions are given in addition conclusion of trials described in the report 'Registration of 1-MCP treatments on Elstar and Tentation apples. Report of experiments storage season 2002-2003, April 2003'. For Elstar, results of 8 months storage (only ULO) are described. For Tentation, results of 6 months (air and ULO) and 8 months storage (only ULO) are described.

Even after 8 months ULO storage of Elstar, very positive effects of 1-MCP were found on firmness retention. For Tentation, 1-MCP was only necessary for firmness retention during air storage but not for ULO storage.

Positive effects were also found on retention of colour, retention of titratable acids, inhibition of rot and prevention of scald (normal harvest Tentation). There were no important effects of 1-MCP on soluble solids content.

For Tentation both 312 and 625 ppb 1-MCP was tested, but there were no important differences between these concentrations.

The effect of 325 ppb 1-MCP was tested for different amounts of Elstar apples (50 kg/m³, 150 kg/m³ and 300 kg/m³). There were no clear differences between these different treatments.

Conclusions on basis of the four objectives as formulated at the start of the experiments:

- **1-MCP can improve CA (ULO) storage**

Even after 8 months storage of Elstar, 1-MCP prevented firmness loss, both for normal and late harvest. For late harvest, 1-MCP inhibited development of rot during shelf-life. It was shown for late harvest of three origins (main experiment + extra experiment) that 1-MCP caused a higher incidence of skin spots.

For Tentation, treatment with 1-MCP was only necessary for firmness retention of air-stored apples. Firmness loss of ULO-stored control apples was absent or very small, even during 14 days shelf-life. In this case 1-MCP was not necessary for firmness retention. In many cases, 1-MCP resulted in greener apples and higher acidity.

- **1-MCP can be used to replace CA (ULO) under certain conditions**

For Tentation 1-MCP could be used to replace ULO during 6 months storage, but only for normal harvest. After storage + 14 days shelf-life, the firmness of 1-MCP treated apples from air storage was equal to the firmness of untreated apples from ULO. For the (extremely) late harvest, results obtained by ULO were better than for 1-MCP without ULO. This was due to the occurrence of scald (and consequently rot) which was prevented by ULO but not by 1-MCP.

- **1-MCP facilitates the storage of apples harvested at a more mature stage**

After 8 months storage plus shelf-life, firmness of 1-MCP treated Elstar of late harvest was still acceptable, while firmness of control Elstar was not.

For Tentation of late harvest, positive effects of 1-MCP were found on retention of colour and retention of titratable acids. 1-MCP could not prevent scald in (extremely) late harvested apples, which was also shown for apples of 3 origins (main experiment + extra experiment).

- **1-MCP improves the shelf-life of CA(ULO)-stored apples**

Important for Elstar, 1-MCP treatment (both normal and late harvest) prevented firmness loss of Elstar during shelf-life following ULO storage.

- **1-MCP inhibits development of scald in Tentation apples**

1-MCP prevented development of scald in Tentation apples of normal harvest. 1-MCP could not prevent scald in (extremely) late harvested apples.