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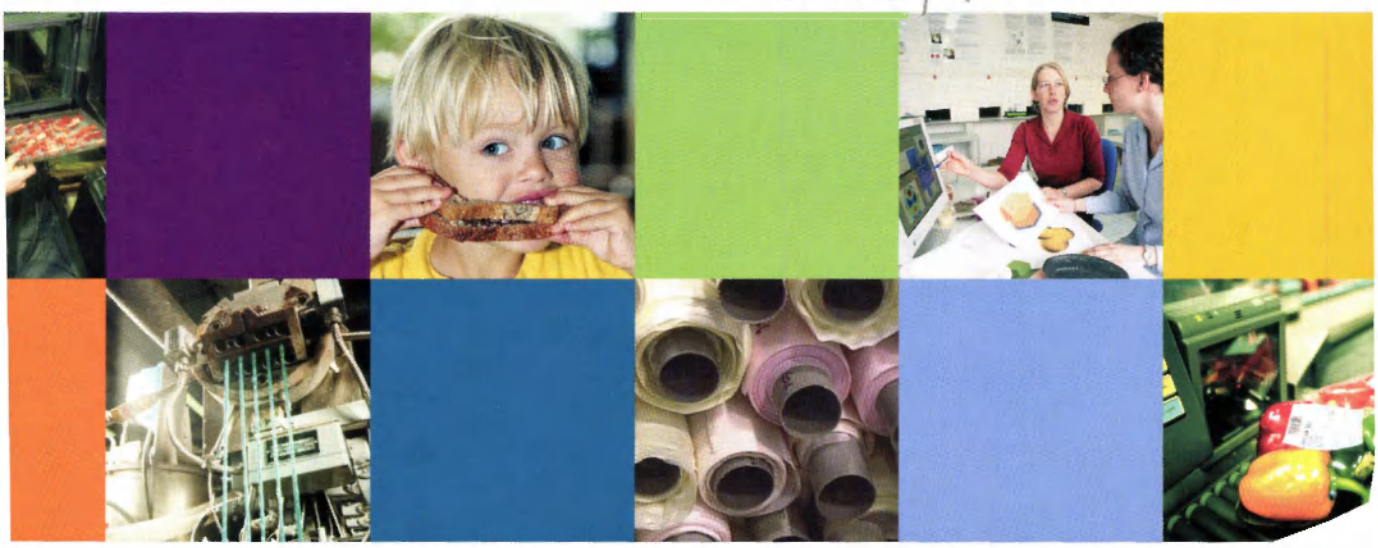
Report 922



Abstract

A new approach on SmartFresh treatments on pears was promising in several other countries. This was in contrast with former tests with Conference pears where we experienced problems with softening after the SmartFresh treatment and if softening occurred there was a great variation in softening within a batch. The new approach was a combined treatment of SmartFresh and ethylene.
In the experiments ethylene was applied simultaneous with 1-MCP directly after harvest. It was done with 300 and 600 ppb 1-MCP with or without the same concentration of ethylene. Ethylene production and firmness were measured on pears, stored for 1 month at -0.5°C and normal air. Ethylene production was considered as an indication of the ability of pears, treated with 1-MCP, to soften after storage.
Quality measurements such as firmness and colour were measured after another 2½ months normal air storage and, after 6 months CA-storage and after the subsequent shelf life's. Pears treated with only 300 or 600 ppb 1-MCP remained very firm after storage followed by 5 days of shelf life at 18°C. Applying ethylene simultaneous with 1-MCP caused softening of the pears during shelf life, but there was a great variation in firmness, especially in those batches that had just started to soften. This variation in softening might very well be caused by a difference in ripeness at harvest. Pears treated with 1-MCP and ethylene seemed softer after 6 months CA storage + shelf life than after 3 months air storage + shelf life.
The most important result is that pears will soften after the new SmartFresh/ethylene treatment (this in contrast with our previous research on only SmartFresh). So ripening control seems possible with a smart combination of 1-MCP concentration, ethylene concentration, ripeness of the pears at harvest and the storage period. On the other hand, it is still not possible to get a batch of pears with homogeneous firmness. This remains difficult as long as it is not possible to determine the ripeness of a batch of pears at harvest. On the other hand, a batch of pears with mixed firmness could be attractive for consumers, allowing consumption in a longer period of time. And if it is desirable to put pears on the market that are firmer during shelf life, a different ratio between 1-MCP and ethylene could give the solution.
The concentration of 600 ppb 1-MCP might be too high because of the danger of internal browning and cavities. However, the treatment of 600 ppb 1-MCP together with ethylene gave no internal disorders.

Content

1 Introduction

Research with SmartFresh on pears was promising in several other countries. In our former tests with Conference pears however we experienced problems with softening after SmartFresh treatment and if softening occurred we had to deal with a great variation in softening within a sample. Applying of SmartFresh is only advisable if softening after firmness retention due to 1-MCP treatment is controlled.
Therefore treatments with only 300 ppb and 600 ppb 1-MCP and 300 ppb and 600 ppb 1-MCP combined with 300 or 600 ppb ethylene were tested on pears from 2 orchards, picked just after the optimum harvest time. After the pre-storage treatments the pears were stored for 2½ - 3 months under air and for 6 months under CA conditions.
Ethylene production and firmness of the separate pears were measured at harvest to get an idea of the (variation in) ripening stage. Ethylene production and firmness were measured again 4 weeks later to see the effect of the different SmartFresh +/- ethylene treatments.

Formal recognition

For conducting post-harvest treatments of agro-products, A&F has an official recognition to perform efficacy evaluation trials. This research was done following the rules of this recognition.

2 Material and Methods

2.1 Product

Conference pears from 2 growers were harvested Tuesday, the 11th of September. As this was rather late, orchards in the north of Holland were chosen, where the climate is slightly colder thus the pears ripe somewhat slower than in the centre of the country. (Wijdenes = A and Westwoud = B)

2.2 Pre-storage conditions and SmartFresh and ethylene preparation and treatment.

After harvest the pears were directly stored at 1°C in 4 storage rooms at A&F, 2 rooms for each orchard. The next day the pears of each room were randomized over 8 restless steel containers of 68 liter and 2 crates (untreated control), 90 average sized pears in each container / crate. The crates with untreated pears were moved to another 1°C storage room to avoid any contact with ethylene.

For the SmartFresh treatment, each container had its own 30 ml flask, with a lid containing a septum, containing the correct amount of 1-MCP powder. For the ethylene treatment, 10 ml pure ethylene was injected in a 1 l. bottle. Injection of 2 ml from this bottle in a 68 l. container gave 2 ml / 68 l *0.01 = 294 ppb. 4 ml was given for the 600 ppb treatment.

Treatments were:

- 300 ppb 1-MCP (0.033 g 1-MCP + 3 ml water)
- 300 ppb 1-MCP + 300 ppb C2H4 (idem + 2ml from the ethylene bottle)
- 600 ppb 1-MCP (0.065 g 1-MCP + 3 ml water)
- 600 ppb 1-MCP + 600 ppb C2H4 (idem + 4 ml from the ethylene bottle)
- untreated

Injection of the containers was as follows:

Room 4.11: for the 4 containers treated with only SmartFresh, preparation was done shortly before injecting the container. Outside the room, 3 ml air was drawn from the closed 30 ml flasks with a syringe and 3 ml demineralized water of 20°C was added with a syringe. The solution was shaken by hand to dissolve the powder. The containers with only SmartFresh were treated first, 30 ml air (with SmartFresh) was drawn from the bottle with a syringe and injected into the container and 15 ml of demineralized water was added with a syringe to the SmartFresh solution. This was repeated once and at last the left air in the SmartFresh bottle was injected into the container.

After that the containers with SmartFresh and ethylene were treated. The SmartFresh treatment was done as described above. Between the second and third injection of SmartFresh, the ethylene (2 or 4 ml) was injected into the container. Pears in containers in room 4.12, 4.13 and 4.14 were treated in the same way.

Ca. 24 hours after applying SmartFresh the containers were opened outside the building the 14th of September and the pears were taken out and put into crates. 15 random pears from each crate were taken to measure the firmness, colour and content of soluble solids after 10 days of shelf life. When the firmness and colour of the duplicates proved not to differ, the duplicates were put

together and brix was measured on a mixed sample of 30 pears. The remaining pears were brought to an other building at A&F to be stored under air or CA.

2.3 Storage Conditions

After 4 days of pre-storage treatment at 1°C the pears were stored under normal air and -0.5°C. Four weeks after harvest (10 October) half of the pears were stored under "normal air" (18% O2, <0.7% O2), the other half under CA conditions, starting at 6% O2 and decreasing 1% per day till 3% O2 and <0.7% CO2, at -0.8 à -0.9°C.
Pears under normal air were stored for 2½ - 3 months till the 29th of November.
Pears under CA were stored during 6 months till the 14th of March.

2.4 Measurements

2.4.1 Direct after harvest and after subsequent shelf life.

Quality parameters: firmness, colour, soluble solids and starch

Direct after harvest initial quality measurements of 30 pears of each orchard were carried out, such as firmness (individual pears), colour (individual pears), content of soluble solids (sugars, mixed sample) and starch (individual pears).
After 10 days of shelf life at 18°C and 70-85% RH the quality parameters firmness, colour and content of soluble solids were measured again on 30 pears of each orchard. A shelf life of ten days was chosen as the pears of the control treatment had softened enough at that time.

Ethylene

After harvest 20 average sized pears of both orchards acclimated at 1°C for 1 day and were then separately put in a gastight cuvette and stored overnight at 1°C. Ethylene production was measured by analyzing head space samples after 24 hours by gas chromatography (Shimadzu GC-17A for ethylene).

2.4.2 After SmartFresh +/- ethylene treatment and storage for 1 month at -0.5°C under air

Ethylene

In fact these ethylene measurements should have taken place after 10 days of shelf life after harvest (2.4.1), but measuring took place after SmartFresh/ethylene treatment and 1 month storage at -0.5°C and normal air. At this moment it was still useful to measure ethylene production and firmness of pears of the various SmartFresh treatments as a way to predict the ability of the pears to soften during shelf life after storage. From orchard A pears from each treatment were used for ethylene measurements, so 5 treatments and 3 cuvettes with 3 pears each per treatment. The 11th of October the pears were transferred to 18°C, the next day they were weighted and put into the open cuvette. The 15th of October, after 4 days at 18°C, the cuvettes were closed and after 1 hour ethylene was measured.

Firmness

The firmness of the same pears that were used for the ethylene measurements was measured 1 day after the ethylene measurements (5 days at 18 °C).

2.4.3 After 2½-3 months of air storage and after subsequent shelf life

Direct after storage the quality parameters: firmness, colour and content of soluble solids (mixed sample) were measured on 30 pears and external and internal disorders were scored. After 5 days of shelf life at 18°C and 70-85% RH the same parameters were measured as direct after storage except for the content of soluble solids.

2.4.4 After 6 months of CA storage and after subsequent shelf life

Firmness, colour and external and internal disorders were scored again direct after 6 months of CA storage and after 5 days of subsequent shelf life at 18°C and 70-85% RH.

Firmness was measured with a fruit texture analyser (Güss, electronicmeasuring system). Colour was measured visually using a colour chart (Unifruco Research Services LTD/Agricura) with a scale from 0.5 to 5 where 0.5=green and 5=yellow. The content of soluble solids was measured with a digital refractometer (Atago, PR-1 brix-meter). Disorders included flesh browning and cavities.

Some untreated and ethylene treated pears were tasted simultaneous with cutting the pears for disorders, just to check if they were not overripe.

3 Results

3.1 At harvest and after subsequent shelf life

3.1.1 Ethylene production and quality parameters at harvest

Table 1 and 2 show that pears from both orchards were of comparable ripeness at harvest as ethylene production, firmness, colour, soluble solids and starch values of pears of the two orchards were not significantly different. Within a batch pears appears to be of difference in ripeness, as some already started to produce ethylene while others did not (see maximum and minimum ethylene production and the large standard deviation in table 1). Difference in firmness within a batch is less obvious (see standard deviation in table 2).

Table 1. Initial ethylene production. Average, maximum and minimum of 20 pears for each orchard.

Ethylene production			Temperature (°C)	1
			Air pressure (Pa)	1020
Orchard	pmol.kg-1.s-1	*stand.dev.*	maximum	minimum
A	0.29	*0.220*	1.05	0.13
B	0.24	*0.151*	0.53	0.00

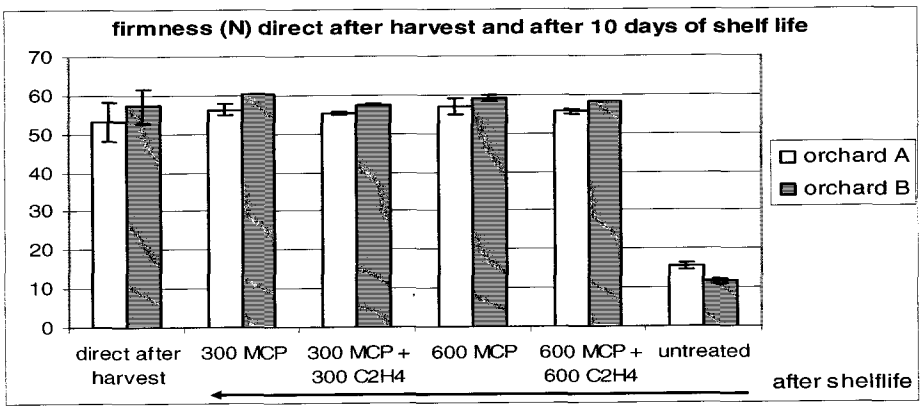
Table 2. Initial quality characteristics. Average, maximum and minimum values of 30 pears for each orchard.

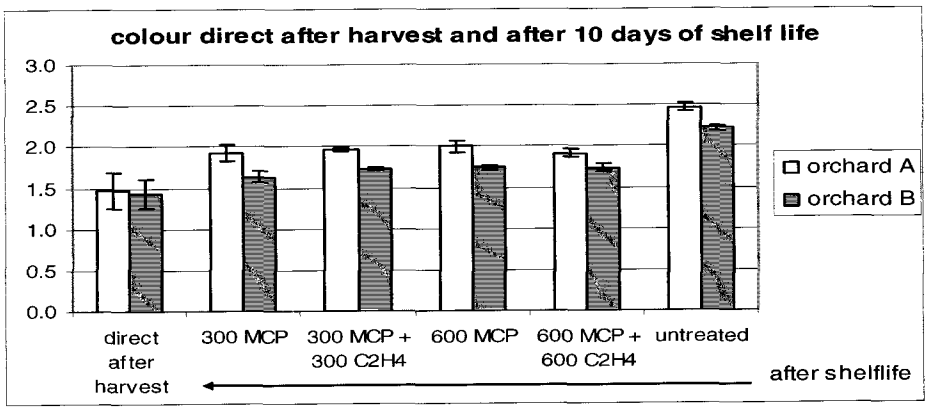
	Orchard A				Orchard B			
	firmness (N)	colour	°Brix	starch	firmness (N)	colour	°Brix	starch
maximum	6.8	2.0	14.6	10	7.2	1.5	13.6	10
average	5.3	1.5	12.9	7.5	5.7	1.4	12.7	7.7
minimum	4.6	1.0	11.4	3	5.0	1.0	11.7	5
stand. dev.	*0.5*	*0.2*	*0.7*	*1.9*	*0.4*	*0.2*	*0.5*	*1.3*

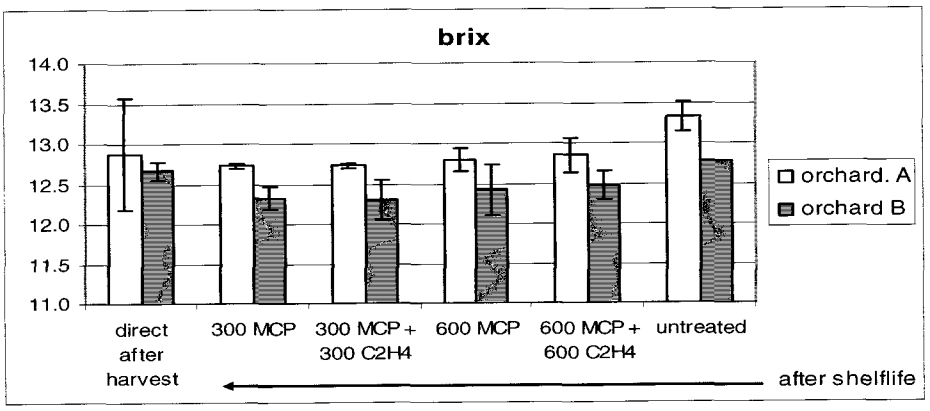
3.1.2 Quality parameters after shelf life.

After 10 days of shelf life following harvest, not much difference was found between the 1-MCP and ethylene treatments. Only the untreated pears were less firm, more yellow and had more soluble solids than the treated ones (fig.1). And pears from orchard A were less firm, more yellow and had more soluble solids than pears from orchard B. There was no difference between the 1-MCP +/- ethylene treatments.

Figure 1. Quality characteristics of Conference Pears direct after harvest and after a subsequent shelf life of 10 days at 18°C and 70-85% RH. The error bars are for the two replica's per treatment. Colour: 1 = green , 5 = yellow







3.2 After SmartFresh +/- ethylene treatment and storage for 1 month at -0.5°C under air

Ethylene production and firmness

Pears treated with SmartFresh had a much lower ethylene production and a much higher firmness than the untreated pears (see table 3). When besides 300 ppb 1-MCP (SmartFresh) also 300 ppb ethylene was applied ethylene production increased and firmness decreased. With 600 ppb 1-MCP (SmartFresh) + 600 ppb ethylene this effect was much smaller for ethylene production and there was no effect on firmness (see table 3).

Table 3. Ethylene production and firmness of pears of orchard A after 4 weeks of air storage at -0.5°C and 4 days at 18°C. Three cuvettes per treatment with 3 pears each.

Treatments	C2H4 prod.		Firmness	
	(pmol.kg-1.s-1)	*st dev*	N	*st dev*
300 MCP	1.5	*0.36*	56	*3.1*
300 MCP + 300 C2H4	23.5	*10.42*	46	*9.4*
600 MCP	1.7	*0.02*	53	*1.2*
600 MCP + 600 C2H4	4.9	*0.85*	53	*8.0*
untreated	195.8	*37.27*	12	*0.9*

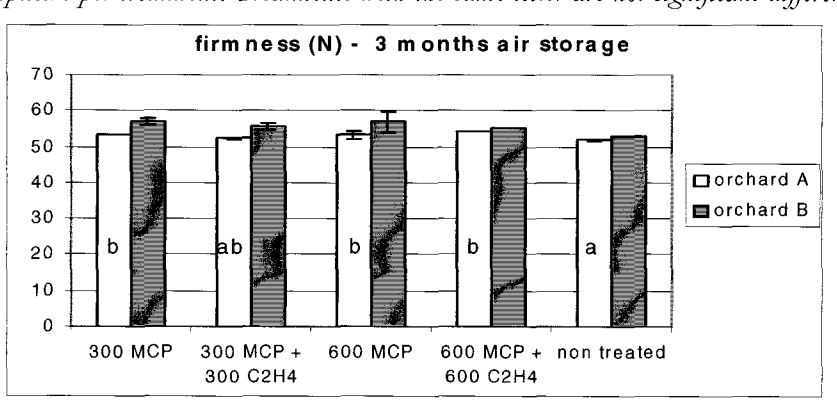
3.3 After 3 months of air storage and after subsequent shelf life

3.3.1 Quality characteristics after 3 months of air storage

Directly after 3 months of air storage the untreated pears were slightly softer than the other treatments, but between the untreated and the pears from the 300 MCP+C2H4 treatment, this difference was not significant (fig.2a). Pears from orchard B were firmer than those of orchard A, resp. 55.6 and 53.1 N.

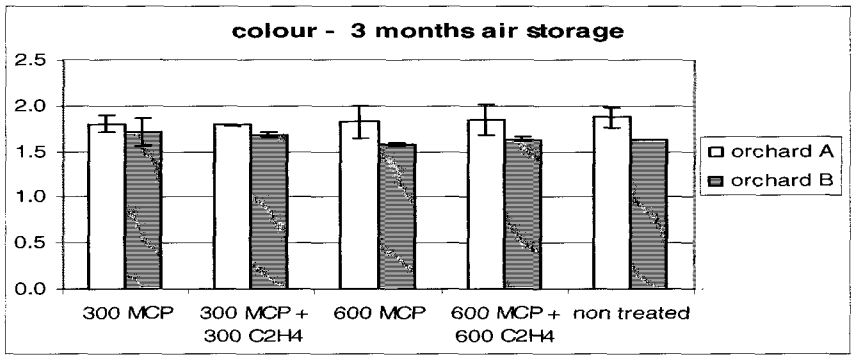
For the colour and soluble solids (brix) values there was no difference between the treatments, only pears from orchard B were greener and had a lower brix value than those from orchard A (fig.2b).

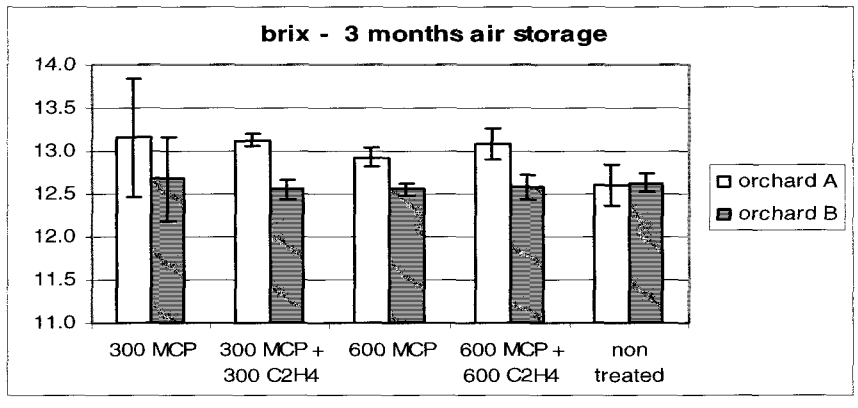
Figure 2a. Quality characteristics of Conference Pears after 3 months of air storage. The error bars are for the two replica's per treatment. Treatments with the same letter are not significant different from each other.



Fiure 2b. Quality characteristics of Conference Pears after 3 months of air storage. The error bars are for the two replica's per treatment. Treatments did not significant different from each other.

Colour: 1 = green, 5 = yellow





3.3.2 Quality characteristics after 3 months of air storage + subsequent shelf life.

After 5 days of shelf life at 18°C following the 3 months of air storage the effect of the 1-MCP (SmartFresh) treatment +/- the ethylene treatment became clear. The pears with only an 1-MCP treatment (300 ppb or 600 ppb) remained firm whereas the untreated pears became soft (fig. 3). When besides SmartFresh also ethylene (300 or 600 ppb) was applied the pears did soften. Pears treated with 300 ppb SmartFresh became softer than those treated with 600 ppb SmartFresh, but they remained firmer than the untreated pears. The (mostly) small error bars between two duplicates suggest that the pears from the same treatment soften in a homogeneous way. Although the average values of the duplicates do not differ very much, the variation within a batch could become very large (see table 4).

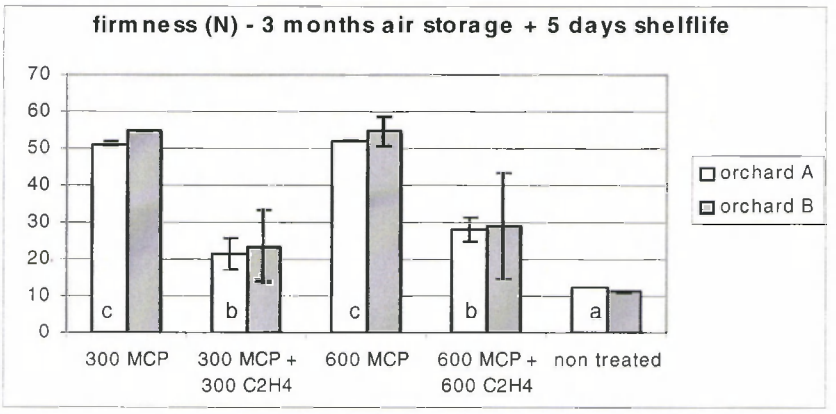
There was no difference in firmness between pears of the two orchards.

The treated pears (SmartFresh +/- ethylene) remained greener than the untreated pears, but between the orchards there was no difference in colour.

Disorders.

No external or internal disorders were found, nor direct after 3 months of air storage, nor after a subsequent shelf life.

Figure 3. Quality characteristics of Conference Pears after 3 months of air storage + 5 days of shelf life at 18°C and 70-85% RH. The error bars are for the two replica's per treatment. Treatments with the same letter are not significant different from each other. Colour: 1 = green, 5 = yellow



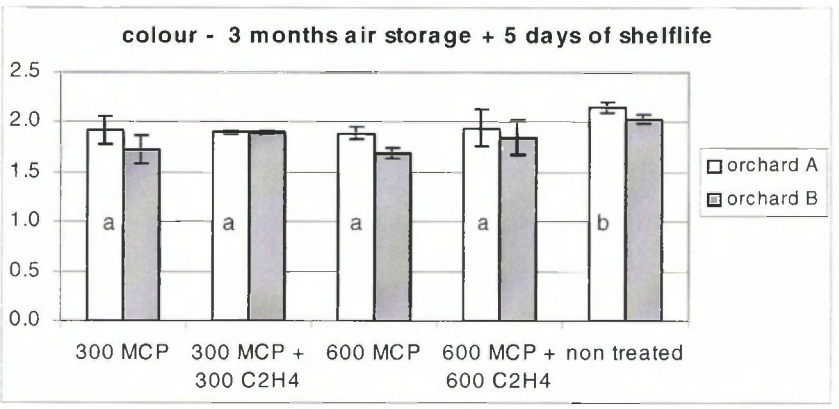


Table 4. The average firmness (N) and standard deviation per batch of pears from both orchards with different 1-MCP +/- ethylene treatments after 3 months of air storage + shelf life. The yellow values show a high standard deviation compared to the average firmness of that treatment.

3 months of CA storage + shelf life

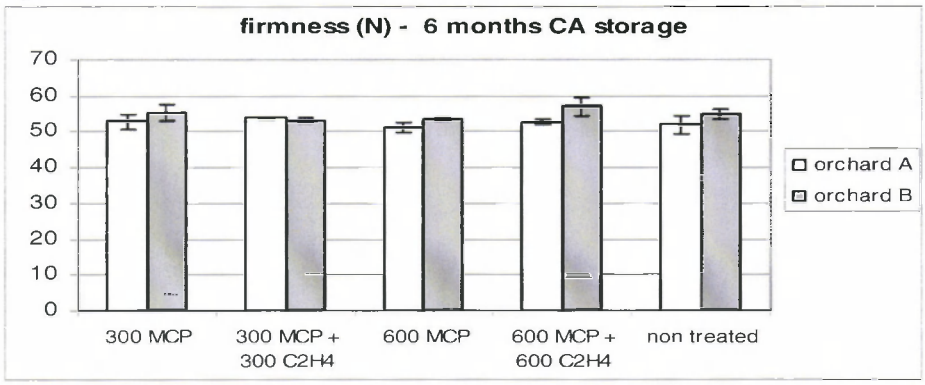
treatment	orchard	firmness (N)		orchard	firmness (N)	
		average	*stdev*		average	*stdev*
300 MCP	A	50.8	*4.9*	B	54.5	*5.7*
300 MCP + 300 C2H4	A	18.5	*7.7*	B	16.4	*7.1*
600 MCP	A	51.9	*4.7*	B	51.8	*3.2*
600 MCP + 600 C2H4	A	25.7	*10.5*	B	19.1	*6.9*
untreated	A	12.2	*3.2*	B	11.2	*1.9*
300 MCP	A	51.6	*4.0*	B	54.7	*7.7*
300 MCP + 300 C2H4	A	24.4	*10.0*	B	30.3	*11.7*
600 MCP	A	52.2	*3.7*	B	57.4	*5.4*
600 MCP + 600 C2H4	A	30.4	*11.2*	B	39.3	*11.5*
untreated	A	12.4	*3.1*	B	11.4	*2.5*

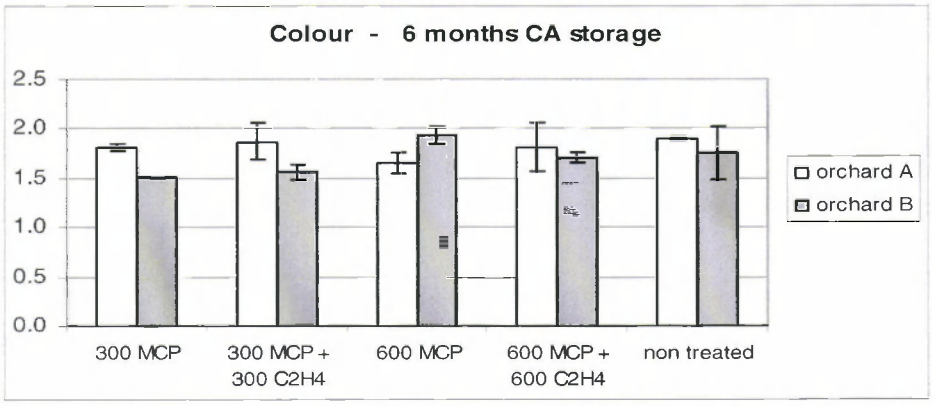
3.4 After 6 months of CA storage and after subsequent shelf life

3.4.1 Quality characteristics after 6 months of CA storage

Directly after 6 months of CA storage there was only a difference in firmness between the two orchards (fig. 4). Pears from orchard B were still firmer than pears from orchard A (resp. 54.7 and 52.4 N). There was no difference in firmness between the treatments and there was no significant difference in colour between the treatments or orchards (fig. 4) .

Figure 4. Quality characteristics (firmness and colour) of Conference Pears after 6 months of CA storage. The error bars are for the two replica's per treatment. Treatments with the same letter are not significant different from each other. Colour: 1 = green, 5 = yellow





3.4.2 Quality characteristics after 6 months of CA storage + subsequent shelf life.

After 5 days of shelf life at 18°C following the 6 months of CA storage large differences could be observed. Pears treated with 600 ppb SmartFresh were firmer than those treated with 300 ppb and both remained firmer than the untreated or ethylene treated pears, the latter were not significant different from each other (fig. 5). The firmness of pears from both orchards did not differ from each other. Taste and firmness of the untreated and ethylene treated pears were still fine at the moment of scoring after shelf life.

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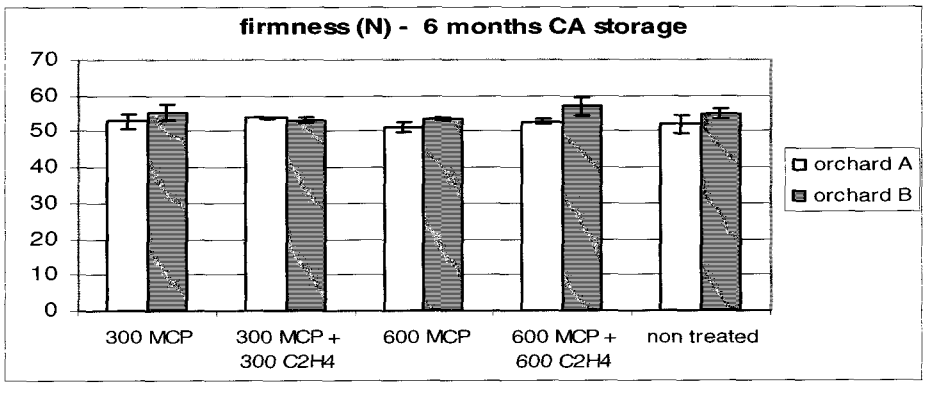

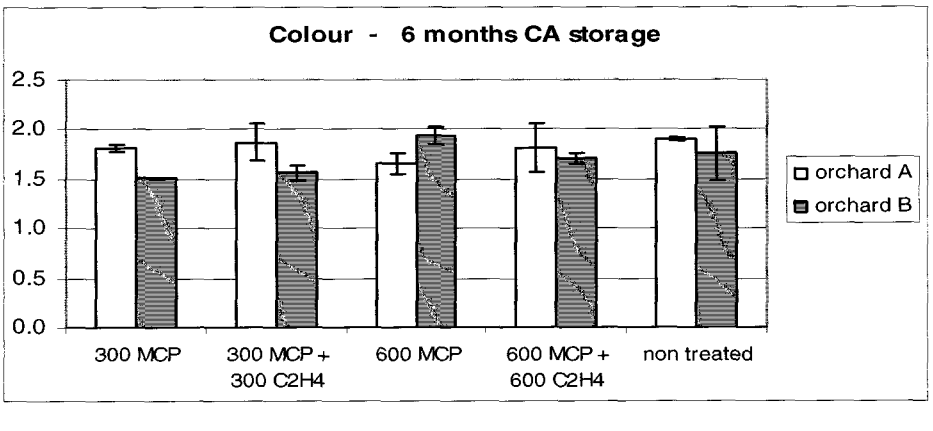

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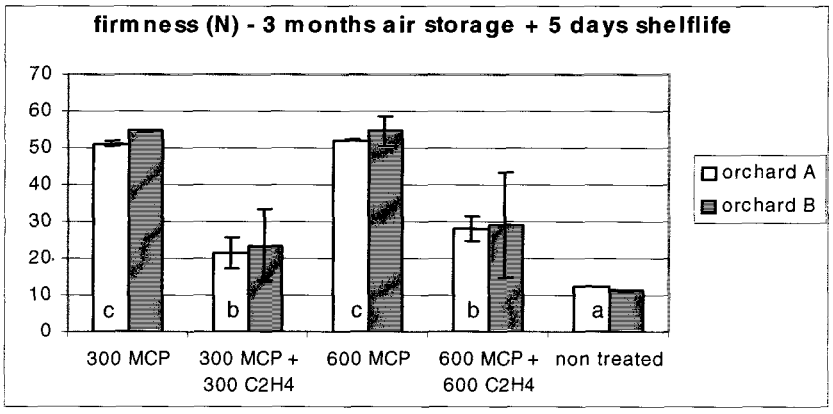
Figure 3. Quality characteristics of Conference Pears after 3 months of air storage + 5 days of shelf life at 18°C and 70-85% RH. The error bars are for the two replica's per treatment. Treatments with the same letter are not significant different from each other. Colour: 1 = green, 5 = yellow



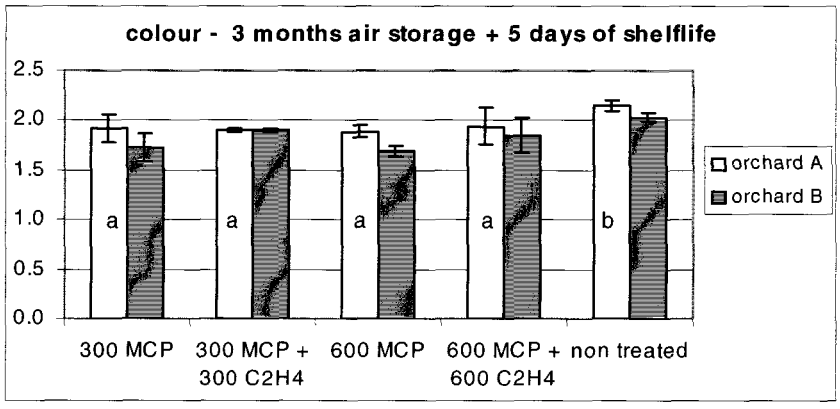


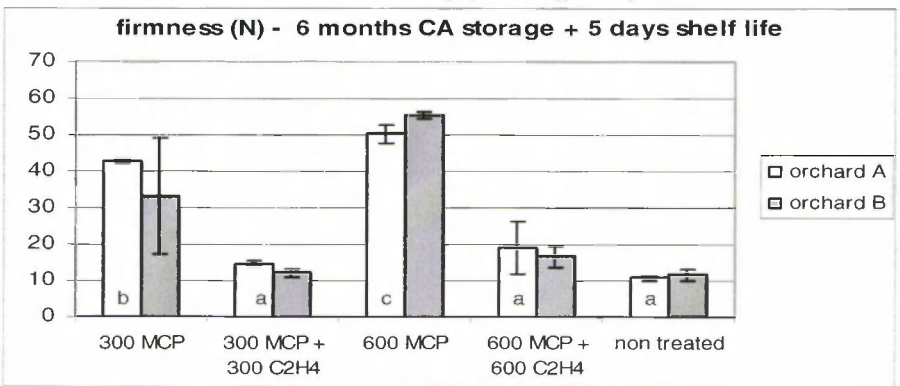
Table 4. The average firmness (N) and standard deviation per batch of pears from both orchards with different 1-MCP +/- ethylene treatments after 3 months of air storage + shelf life. The yellow values show a high standard deviation compared to the average firmness of that treatment.

3 months of CA storage + shelf life

treatment	orchard	firmness (N)		orchard	firmness (N)	
		average	*stdev*		average	*stdev*
300 MCP	A	50.8	*4.9*	B	54.5	*5.7*
300 MCP + 300 C2H4	A	18.5	*7.7*	B	16.4	*7.1*
600 MCP	A	51.9	*4.7*	B	51.8	*3.2*
600 MCP + 600 C2H4	A	25.7	*10.5*	B	19.1	*6.9*
untreated	A	12.2	*3.2*	B	11.2	*1.9*
300 MCP	A	51.6	*4.0*	B	54.7	*7.7*
300 MCP + 300 C2H4	A	24.4	*10.0*	B	30.3	*11.7*
600 MCP	A	52.2	*3.7*	B	57.4	*5.4*
600 MCP + 600 C2H4	A	30.4	*11.2*	B	39.3	*11.5*
untreated	A	12.4	*3.1*	B	11.4	*2.5*

The pears treated with only 1-MCP (600 or 300 ppb) were greener than the untreated or the ethylene treated pears. Pears from orchard B were greener than pears from orchard A.

Figure 5. Quality characteristics (firmness and colour) of Conference Pears after 6 months of CA storage followed by 5 days of shelf life at 18°C and 70-85% RH. The error bars are for the two replica's per treatment. Treatments with the same letter are not significant different from each other



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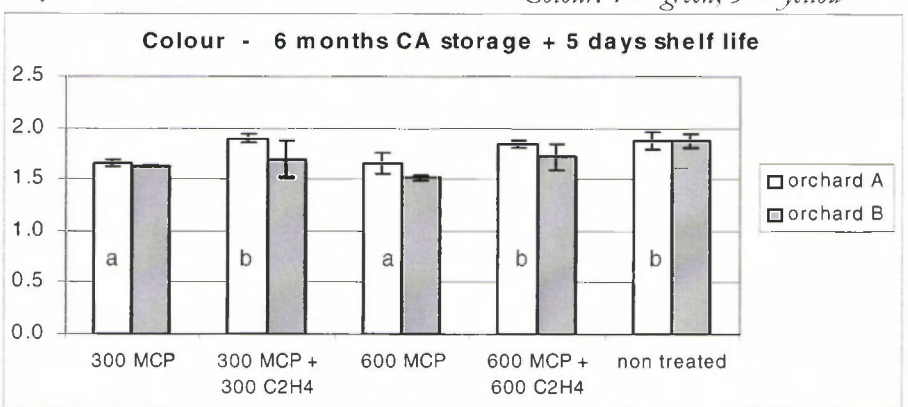


Table 5. The average firmness (N) and standard deviation per batch of pears from both orchards with different 1-MCP +/- ethylene treatments after 6 months of CA storage + shelf life. The yellow values show a high standard deviation compared to the average firmness of that treatment.

6 months of CA storage + shelf life

treatment	orchard	firmness (N)		orchard	firmness (N)	
		average	*stdev*		average	*stdev*
300 MCP	A	43.1	*12.7*	B	22.1	*7.7*
300 MCP + 300 C2H4	A	15.1	*4.5*	B	12.9	*2.1*
600 MCP	A	52.0	*4.7*	B	54.7	*5.9*
600 MCP + 600 C2H4	A	24.3	*8.7*	B	14.5	*2.5*
untreated	A	11.3	*3.1*	B	10.6	*1.6*
300 MCP	A	42.4	*13.1*	B	44.3	*11.0*
300 MCP + 300 C2H4	A	14.2	*4.8*	B	11.4	*2.6*
600 MCP	A	48.6	*3.7*	B	56.3	*7.4*
600 MCP + 600 C2H4	A	14.0	*4.8*	B	18.7	*8.7*
untreated	A	10.3	*2.6*	B	12.6	*2.2*

3.4.3 Disorders

As well after 6 months of CA storage as after a subsequent shelf life pears treated with 600 ppb 1-MCP and especially pears from Orchard B showed brown flesh and cavities.

Direct after 6 months of CA storage:

1 pear (of the 60) of orchard A showed browning and cavities

11 pears (of 60) of orchard B showed rather serious browning and cavities.

After 6 months of CA storage + shelf life:

7 pears (of 60) of orchard B showed rather serious browning and cavities.

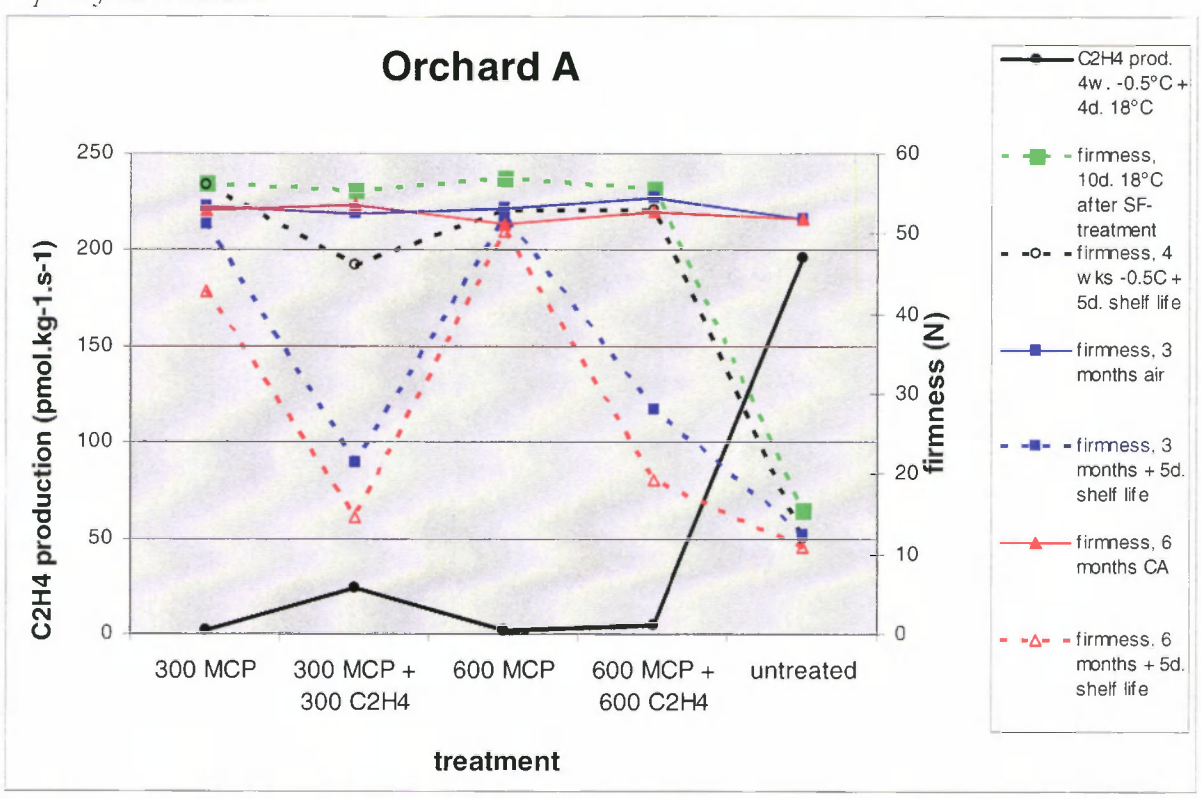
Pears from orchard A had no problems, nor had the pears that were treated with both ethylene and 1-MCP. The problems did not seem to be related to the size of the pear.

There were no external disorders, nor direct after 6 months CA storage, nor after shelf life.

4 Discussion

The most important parameters in this study were ethylene production and firmness. In figure 6 the ethylene production (bold black line) and firmness (coloured lines) of pears of orchard A are shown after the various treatments. The coloured continuing lines show the firmness direct after storage, the dotted lines represent the firmness after shelf life.
The bold black line shows the ethylene production of pears from the 5 treatments after 1 month at -0.5°C + 4 days at 18°C and the black dotted line shows the firmness of the same pears. When we compare those two black lines, we see that the untreated pears have a high ethylene production and are soft after shelf life. Pears from the 300 and 600 ppb SmartFresh treatment have hardly started ethylene production and are still firm. Pears from the 300 ppb SmartFresh+ethylene treatment have also started ethylene production and have already started to soften. But pears from the 600 ppb SmartFresh+ethylene treatment have already started ethylene production, but they do not yet show softening. So ethylene production seems to be an indication of the ability of the pears to soften after storage. (A high value for ethylene production goes together with a low value for firmness after shelf life and the other way round.)

Figure 6. Ethylene production (bold black line, left Y-axis) and firmness (coloured lines, right Y-axis) of pears from orchard A



However, the great variability in firmness within a batch has not yet been solved. It is remarkable that those batches that have started softening have a high variability in firmness within the batch, whereas the batches that are very firm or very soft have a small variability (table 5 and 6).

In earlier experiments with 1-MCP on pears, without ethylene, we found that some pears softened and others did not. This time, with adding ethylene, it seems that all pears treated with 1-MCP and ethylene do soften, but not at the same time. The cause that all those pears softened can be the adding of ethylene next to the 1-MCP. In table 1 the ethylene production of pears direct after harvest (an indication of the ripeness of the pears) is shown. It is probably the difference in that ripeness that causes the heterogeneity in firmness within a batch, making it impossible to completely control ripening with applying a combination of ethylene and 1-MCP. After 1 month of air storage and subsequent shelf life the pears treated with ethylene next to 300 ppb 1 -MCP started to soften slightly, those treated with 600 ppb 1-MCP and ethylene were still very firm. After 3 months of air storage and after 6 months of CA storage and subsequent shelf life's, these batches were soft or had very well started to soften. If it is desirable to keep the pears firmer during shelf life, a different ratio between 1-MCP and ethylene could give the solution. The most important result is that pears will soften after the new SmartFresh/ethylene treatment (this in contrast with our previous research on only SmartFresh). So ripening control seems possible with a smart combination of 1-MCP concentration, ethylene concentration, ripeness of the pears at harvest and the storage period. On the other hand, it is still not possible to get a batch of pears with homogeneous firmness. This remains difficult as long as it is not possible to determine the ripeness of a batch of pears at harvest. On the other hand, a batch of pears with mixed firmness could be attractive for consumers, allowing consumption in a longer period of time.

600 ppb 1-MCP should be avoided because of the danger of internal brown and cavities, although the treatment with 600 ppb 1-MCP together with ethylene gave no internal disorders..

Yellowing of the pears went more or less together with softening , but the pears were still fairly green after storage and shelf life.

5 Conclusions

- Ethylene production seems to be an indication of the ability of pears to soften after storage.

- 600 ppb 1-MCP might be too high for pears because of the danger of internal browning and cavities.

- The ability of pears to soften after storage depends on the amount of 1-MCP and ethylene, the ripeness of the pears and the storage period. In this experiment the pears treated with SmartFresh together with ethylene direct after harvest were rather soft after 5 days of shelf life following on storage. With a different ratio of 1-MCP and ethylene, shelf life of those pears can probably be prolonged.

- As long as the whole tree will be picked at the same time, there will always be a great variety in ripeness of pears within a batch. Apples are picked by colour or are sorted out at harvest, but there is no such a criterion (yet) for the ripeness of pears.

- After firmness retention of the pears by SmartFresh, it was possible to let the pears soften by applying ethylene simultaneous with SmartFresh directly after harvest. Within some batches, especially those that just started to soften, we found a great variation in firmness. It is not sure if this variation is a very big problem as long as the pears do ripen.