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# THE EFFECT OF 1-MCP, STAGE OF MATURITY AND LENGTH OF STORAGE TIME ON QUALITY OF 'CHERRY' TOMATO FRUITS

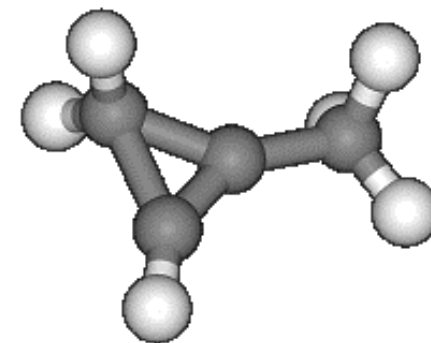
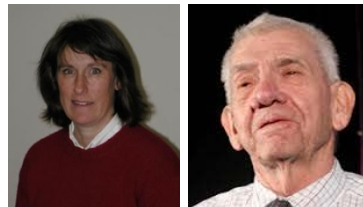
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# Introduction



## The way to 1-MCP

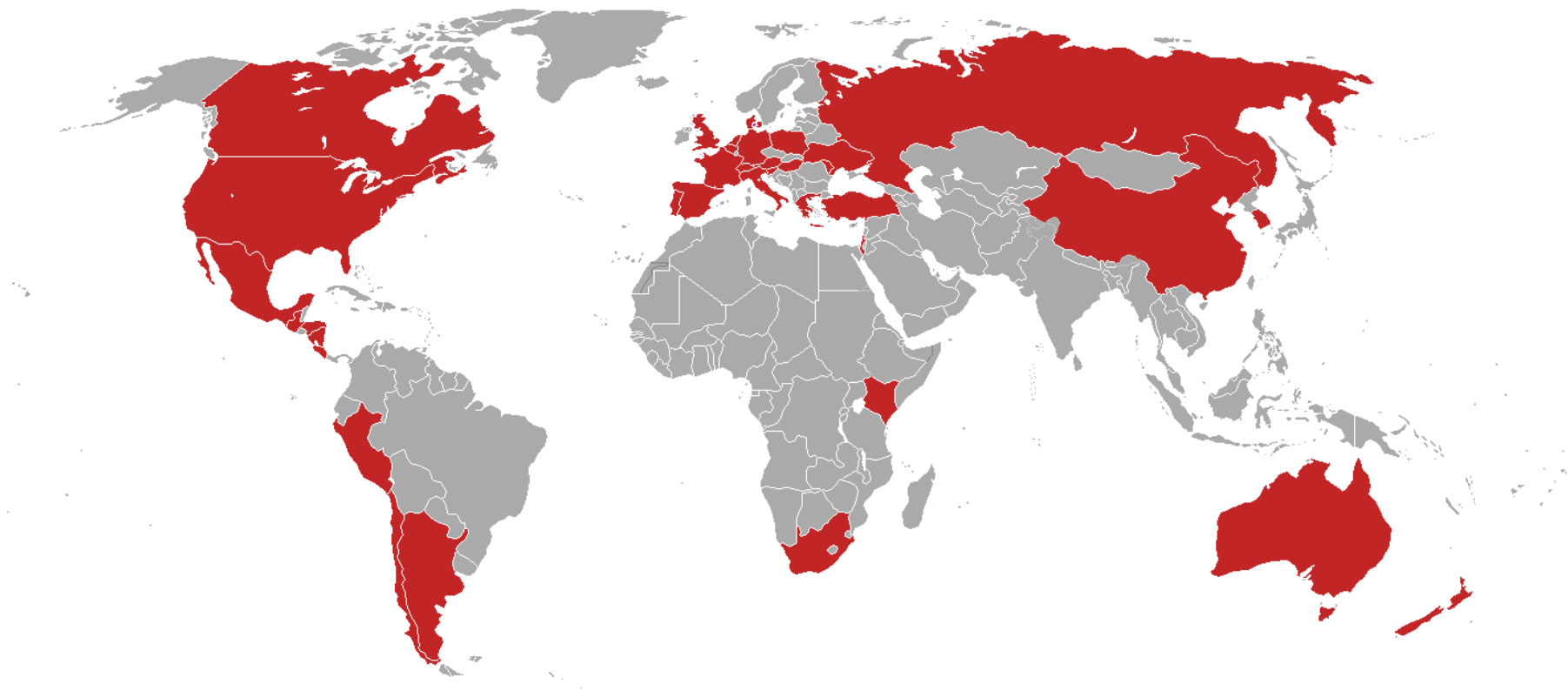
- 1996 – 1-methylcyclopropene was explored and patented as gas, which was especially anti ethylene active<sup>1)</sup>
- Powdered formulation as effect of cyclodextrin-bound with 1-MCP<sup>2)</sup>

[http://cals.ncsu.edu/hort\\_sci/people/faculty/pages/blankenship.php](http://cals.ncsu.edu/hort_sci/people/faculty/pages/blankenship.php)  
<http://www.multibriefs.com/briefs/saf/SAF112812.php>

- 1) Sisler and Blankenship, 1996; Gajewski, 2002; EFSA Scientific Report, 2005; Reid and Staby, 2008; Kostansek, 2010; Yuan *et al.*, 2010
- 2) EFSA Scientific Report, 2005; Reid and Staby, 2008; Kostansek, 2010

| United States Patent [19]  |   | [11] Patent Number: 5,518,988     |                           |
|--|---|-----------------------------------|---------------------------|
| Sisler et al.  |   | [45] Date of Patent: May 21, 1996 |                           |
| [54] METHOD OF COUNTERACTING AN ETHYLENE RESPONSE IN PLANTS                          | 5,100,462   | 3/1992                            | Sisler et al. .... 71/121 |
| [75] Inventors: Edward C. Sisler, Raleigh; Sylvia M. Blankenship, Apex, both of N.C. | OTHER PUBLICATIONS  |                                   |                           |
| [73] Assignee: North Carolina State University, Raleigh, N.C.                        | M. C. Pirrung; <i>Proposal to the Fred C. Gloeckner Foundation</i> (1991).  |                                   |                           |
| [21] Appl. No.: 253,951  | Pirrung et al. "Ethylene Biosynthesis, Aminocyclopropene carboxylic acid", <i>J. Chem. Soc., Chem. Commun.</i> , (13), 857-859, 1989.   |                                   |                           |
| [22] Filed: Jun. 3, 1994   | Wheeler et al., "Synthesis of 1-aminocyclopropene carboxylic acid", <i>J. Org. Chem.</i> , 52(22) 4875-4877, 1987.  |                                   |                           |
| [51] Int. Cl. <sup>6</sup> ..... A01N 3/02; A01N 27/00; A01N 29/04; A01N 33/04       | <i>Primary Examiner</i> —Allen J. Robinson<br><i>Assistant Examiner</i> —Brian G. Bembenick<br><i>Attorney, Agent, or Firm</i> —Bell, Seltzer, Park & Gibson  |                                   |                           |
| [52] U.S. Cl. .... 504/114; 504/115; 504/320; 504/326; 504/353; 504/356; 504/357     | [57] <b>ABSTRACT</b>  |                                   |                           |
| [58] Field of Search ..... 504/114, 115, 504/320, 326, 353, 356, 357                 | A method of inhibiting an ethylene response in a plant is disclosed herein. The method comprises applying to the plant an effective ethylene response-inhibiting amount of cyclopropene, 1,1,1-propellane, or derivatives thereof. Also disclosed are methods of inhibiting abscission in plants and methods of prolonging the life of cut flowers. |                                   |                           |
| [56] <b>References Cited</b>   |   |                                   |                           |
| U.S. PATENT DOCUMENTS  |   | 44 Claims, 4 Drawing Sheets       |                           |
| 3,879,188  | 4/1975  | Fritz et al. ....                 | 424/200                   |

# Introduction



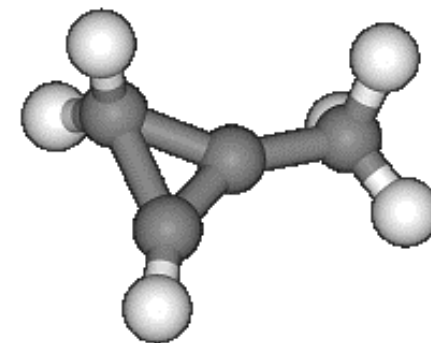
- 2000 – commercialisation of 1-MCP for postharvest treatment on fruits and vegetables to maintain their quality dealt AgroFresh, Inc. – SmartFresh™ or SmartFresh 03VP<sup>1)</sup>

1) Kostansek, 2010; Yuan *et al.*, 2010

# Introduction

## How to use 1-MCP?

- Application – after dilution in small amount of water, directly after harvest of fruits/vegetables
- An amount depends on cubature of chamber
- Time depends on species of vegetable/fruit and storage temperature
- It can be used in cooling chamber as well as in chamber with modified atmosphere – controlled atmosphere (CA) or ultra low oxygen (ULO)<sup>1)</sup>



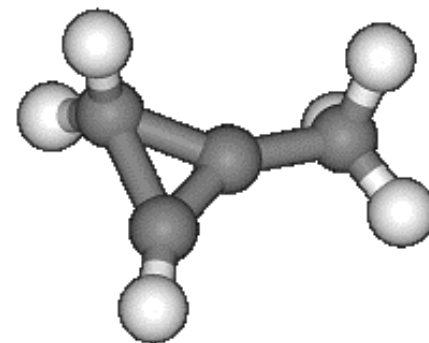
1) Gajewski, 2002

[http://krwil.sggw.pl/index.php?section=research&subsection=lab\\_view&p=storage](http://krwil.sggw.pl/index.php?section=research&subsection=lab_view&p=storage)

# Introduction

## Efficiency of using 1-MCP depends on

- stage of maturity of fruit/vegetable
- gas tightness of storage building/chamber during treatment by 1-MCP
- length of time between harvest and putting products to chamber



# The aim of the study

- The aim of this study was to obtain the effect of 1-MCP treatment, two stages of maturity and three length of storage time on quality of 'cherry' tomato (*Solanum lycopersicum* L. var. *cerasiforme*) fruits during storage.



# Materials and methods

## Fruits

- *Solanum lycopersicum* L. var. *cerasiforme*
- 'Pareso' F<sub>1</sub>
- coconut fibre
- harvest – June 2013
- greenhouse and storage chambers of WULS
- 12 °C





# Materials and methods

## Combination which were used

### A – the length of storage time

- a1 – 0 days
- a2 – 14 days
- a3 – 21 days
- a4 – 28 days

### B – the stage of maturity

- b1 – pink (3<sup>rd</sup>)



- b2 – light-red (5<sup>th</sup>)



### C – the concentration of 1-MCP

- c1 – control (untreated fruits)
- c2 –  $1.0 \mu\text{l} \cdot \text{l}^{-1}$  1-MCP

# Materials and methods

## Analyses

- dry matter (%)
- total sugars content (Luff-Schoorl method,  $\text{g} \cdot 100 \text{g}^{-1}$ )
- total soluble solids – TSS (refractometric method, % Brix)
- pH of juice (PN-90 A-75 101/06)
- titratable acidity (PN-90 A-75 101/04, percent of citric acid as equivalent)

# Materials and methods

## Statistical analysis

- three-way ANOVA v. 3.0
- the Tukey's HSD test (in StatgraphicsPlus 4.1)

# Results

## Dry matter (%)

| Stage of maturity           | 1-MCP treatment              | Length of storage (days) |               |                |               | Means for stages of maturity | Means for treatment combinations |
|-----------------------------|------------------------------|--------------------------|---------------|----------------|---------------|------------------------------|----------------------------------|
|                             |                              | 0                        | 14            | 21             | 28            |                              |                                  |
| 3 <sup>rd</sup>             | Control                      | 7.83                     | 7.57          | 7.63           | 7.34          | 7.46 b                       | 7.79 n.s.                        |
|                             | 1.0 µl l <sup>-1</sup> 1-MCP |                          | 7.86          | 7.49           | 6.89          |                              | 7.72 n.s.                        |
| 5 <sup>th</sup>             | Control                      | 8.09                     | 8.45          | 7.86           | 7.91          | 8.05 a                       |                                  |
|                             | 1.0 µl l <sup>-1</sup> 1-MCP |                          | 8.05          | 8.19           | 7.86          |                              |                                  |
| Means for length of storage |                              | <b>7.96</b>              | <b>7.98 a</b> | <b>7.79 ab</b> | <b>7.50 b</b> |                              |                                  |

# Results

## Dry matter (%)

| Stage of maturity                  | 1-MCP treatment              | Length of storage (days) |        |         |        | Means for stages of maturity | Means for treatment combinations |
|------------------------------------|------------------------------|--------------------------|--------|---------|--------|------------------------------|----------------------------------|
|                                    |                              | 0                        | 14     | 21      | 28     |                              |                                  |
| 3 <sup>rd</sup>                    | Control                      | <b>7.83</b>              | 7.57   | 7.63    | 7.34   | <b>7.46 b</b>                | 7.79 n.s.                        |
|                                    | 1.0 µl l <sup>-1</sup> 1-MCP |                          | 7.86   | 7.49    | 6.89   |                              | 7.72 n.s.                        |
| 5 <sup>th</sup>                    | Control                      | <b>8.09</b>              | 8.45   | 7.86    | 7.91   | <b>8.05 a</b>                |                                  |
|                                    | 1.0 µl l <sup>-1</sup> 1-MCP |                          | 8.05   | 8.19    | 7.86   |                              |                                  |
| <b>Means for length of storage</b> |                              | 7.96                     | 7.98 a | 7.79 ab | 7.50 b |                              |                                  |

# Results

## Total sugars content (g · 100 g<sup>-1</sup>)

| Stage of maturity           | 1-MCP treatment              | Length of storage (days) |               |               |               | Means for stages of maturity | Means for treatment combinations |
|-----------------------------|------------------------------|--------------------------|---------------|---------------|---------------|------------------------------|----------------------------------|
|                             |                              | 0                        | 14            | 21            | 28            |                              |                                  |
| 3 <sup>rd</sup>             | Control                      | 3.67                     | 2.79 d        | 3.14 cd       | 3.68 bc       | 3.21 b                       | 3.89 n.s.                        |
|                             | 1.0 µl l <sup>-1</sup> 1-MCP |                          | 3.22 cd       | 3.17 cd       | 3.27 c        |                              | 3.88 n.s.                        |
| 5 <sup>th</sup>             | Control                      | 5.24                     | 4.43 ab       | 4.48 a        | 4.82 a        | 4.56 a                       |                                  |
|                             | 1.0 µl l <sup>-1</sup> 1-MCP |                          | 3.98 b        | 4.79 a        | 4.84 a        |                              |                                  |
| Means for length of storage |                              | <b>4.46</b>              | <b>3.60 c</b> | <b>3.89 b</b> | <b>4.15 a</b> |                              |                                  |

# Results

## Total sugars content (g · 100 g<sup>-1</sup>)

| Stage of maturity           | 1-MCP treatment              | Length of storage (days) |         |         |         | Means for stages of maturity | Means for treatment combinations |
|-----------------------------|------------------------------|--------------------------|---------|---------|---------|------------------------------|----------------------------------|
|                             |                              | 0                        | 14      | 21      | 28      |                              |                                  |
| 3 <sup>rd</sup>             | Control                      | <b>3.67</b>              | 2.79 d  | 3.14 cd | 3.68 bc | <b>3.21 b</b>                | 3.89 n.s.                        |
|                             | 1.0 µl l <sup>-1</sup> 1-MCP |                          | 3.22 cd | 3.17 cd | 3.27 c  |                              | 3.88 n.s.                        |
| 5 <sup>th</sup>             | Control                      | <b>5.24</b>              | 4.43 ab | 4.48 a  | 4.82 a  | <b>4.56 a</b>                |                                  |
|                             | 1.0 µl l <sup>-1</sup> 1-MCP |                          | 3.98 b  | 4.79 a  | 4.84 a  |                              |                                  |
| Means for length of storage |                              | 4.46                     | 3.60 c  | 3.89 b  | 4.15 a  |                              |                                  |



# Results

## Total soluble solids content – TSS (% Brix)

| Stage of maturity           | 1-MCP treatment              | Length of storage (days) |               |               |               | Means for stages of maturity | Means for treatment combinations |
|-----------------------------|------------------------------|--------------------------|---------------|---------------|---------------|------------------------------|----------------------------------|
|                             |                              | 0                        | 14            | 21            | 28            |                              |                                  |
| 3 <sup>rd</sup>             | Control                      | 6.98                     | 7.37 e        | 6.97 f        | 7.03 f        | 7.22 b                       | 7.93 b                           |
|                             | 1.0 µl l <sup>-1</sup> 1-MCP |                          | 7.83 d        | 7.05 f        | 7.07 f        |                              | 8.08 a                           |
| 5 <sup>th</sup>             | Control                      | 8.33                     | 9.07 a        | 8.53 c        | 8.58 c        | 8.79 a                       |                                  |
|                             | 1.0 µl l <sup>-1</sup> 1-MCP |                          | 8.85 b        | 8.95 ab       | 8.75 bc       |                              |                                  |
| Means for length of storage |                              | <b>7.66</b>              | <b>8.28 a</b> | <b>7.88 b</b> | <b>7.86 b</b> |                              |                                  |

# Results

## Total soluble solids content – TSS (% Brix)

| Stage of maturity           | 1-MCP treatment                | Length of storage (days) |        |         |         | Means for stages of maturity | Means for treatment combinations |
|-----------------------------|--------------------------------|--------------------------|--------|---------|---------|------------------------------|----------------------------------|
|                             |                                | 0                        | 14     | 21      | 28      |                              |                                  |
| 3 <sup>rd</sup>             | Control                        | <b>6.98</b>              | 7.37 e | 6.97 f  | 7.03 f  | <b>7.22 b</b>                | 7.93 b                           |
|                             | 1.0 $\mu\text{l l}^{-1}$ 1-MCP |                          | 7.83 d | 7.05 f  | 7.07 f  |                              | 8.08 a                           |
| 5 <sup>th</sup>             | Control                        | <b>8.33</b>              | 9.07 a | 8.53 c  | 8.58 c  | <b>8.79 a</b>                |                                  |
|                             | 1.0 $\mu\text{l l}^{-1}$ 1-MCP |                          | 8.85 b | 8.95 ab | 8.75 bc |                              |                                  |
| Means for length of storage |                                | 7.66                     | 8.28 a | 7.88 b  | 7.86 b  |                              |                                  |

# Results

## Total soluble solids content – TSS (% Brix)

| Stage of maturity           | 1-MCP treatment              | Length of storage (days) |        |         |         | Means for stages of maturity | Means for treatment combinations |
|-----------------------------|------------------------------|--------------------------|--------|---------|---------|------------------------------|----------------------------------|
|                             |                              | 0                        | 14     | 21      | 28      |                              |                                  |
| 3 <sup>rd</sup>             | Control                      | 6.98                     | 7.37 e | 6.97 f  | 7.03 f  | 7.22 b                       | <b>7.93 b</b>                    |
|                             | 1.0 µl l <sup>-1</sup> 1-MCP |                          | 7.83 d | 7.05 f  | 7.07 f  |                              | <b>8.08 a</b>                    |
| 5 <sup>th</sup>             | Control                      | 8.33                     | 9.07 a | 8.53 c  | 8.58 c  | 8.79 a                       |                                  |
|                             | 1.0 µl l <sup>-1</sup> 1-MCP |                          | 8.85 b | 8.95 ab | 8.75 bc |                              |                                  |
| Means for length of storage |                              | <b>7.66</b>              | 8.28 a | 7.88 b  | 7.86 b  |                              |                                  |

# Results

## pH of juice

| Stage of maturity           | 1-MCP treatment                | Length of storage (days) |               |               |               | Means for stages of maturity | Means for treatment combinations |
|-----------------------------|--------------------------------|--------------------------|---------------|---------------|---------------|------------------------------|----------------------------------|
|                             |                                | 0                        | 14            | 21            | 28            |                              |                                  |
| 3 <sup>rd</sup>             | Control                        | 4.36                     | 4.38 d        | 4.39 d        | 4.42 d        | 4.31 b                       | 4.53 a                           |
|                             | 1.0 $\mu\text{l l}^{-1}$ 1-MCP |                          | 4.27 e        | 4.23 ef       | 4.19 f        |                              | 4.36 b                           |
| 5 <sup>th</sup>             | Control                        | 3.94                     | 4.75 a        | 4.61 b        | 4.62 b        | 4.58 a                       |                                  |
|                             | 1.0 $\mu\text{l l}^{-1}$ 1-MCP |                          | 4.48 c        | 4.50 c        | 4.49 c        |                              |                                  |
| Means for length of storage |                                | <b>4.15</b>              | <b>4.47 a</b> | <b>4.44 b</b> | <b>4.43 b</b> |                              |                                  |

# Results

## pH of juice

| Stage of maturity           | 1-MCP treatment                | Length of storage (days) |        |         |        | Means for stages of maturity | Means for treatment combinations |
|-----------------------------|--------------------------------|--------------------------|--------|---------|--------|------------------------------|----------------------------------|
|                             |                                | 0                        | 14     | 21      | 28     |                              |                                  |
| 3 <sup>rd</sup>             | Control                        | <b>4.36</b>              | 4.38 d | 4.39 d  | 4.42 d | <b>4.31 b</b>                | 4.53 a                           |
|                             | 1.0 $\mu\text{l l}^{-1}$ 1-MCP |                          | 4.27 e | 4.23 ef | 4.19 f |                              | 4.36 b                           |
| 5 <sup>th</sup>             | Control                        | <b>3.94</b>              | 4.75 a | 4.61 b  | 4.62 b | <b>4.58 a</b>                |                                  |
|                             | 1.0 $\mu\text{l l}^{-1}$ 1-MCP |                          | 4.48 c | 4.50 c  | 4.49 c |                              |                                  |
| Means for length of storage |                                | 4.15                     | 4.47 a | 4.44 b  | 4.43 b |                              |                                  |

# Results

## pH of juice

| Stage of maturity                  | 1-MCP treatment                | Length of storage (days) |        |         |        | Means for stages of maturity | Means for treatment combinations |
|------------------------------------|--------------------------------|--------------------------|--------|---------|--------|------------------------------|----------------------------------|
|                                    |                                | 0                        | 14     | 21      | 28     |                              |                                  |
| 3 <sup>rd</sup>                    | Control                        | 4.36                     | 4.38 d | 4.39 d  | 4.42 d | 4.31 b                       | <b>4.53 a</b>                    |
|                                    | 1.0 $\mu\text{l l}^{-1}$ 1-MCP |                          | 4.27 e | 4.23 ef | 4.19 f |                              | <b>4.36 b</b>                    |
| 5 <sup>th</sup>                    | Control                        | 3.94                     | 4.75 a | 4.61 b  | 4.62 b | 4.58 a                       |                                  |
|                                    | 1.0 $\mu\text{l l}^{-1}$ 1-MCP |                          | 4.48 c | 4.50 c  | 4.49 c |                              |                                  |
| <b>Means for length of storage</b> |                                | <b>4.15</b>              | 4.47 a | 4.44 b  | 4.43 b |                              |                                  |

# Results

## Titrateable acidity (percent of citric acid as equivalent)

| Stage of maturity           | 1-MCP treatment                | Length of storage (days) |               |               |               | Means for stages of maturity | Means for treatment combinations |
|-----------------------------|--------------------------------|--------------------------|---------------|---------------|---------------|------------------------------|----------------------------------|
|                             |                                | 0                        | 14            | 21            | 28            |                              |                                  |
| 3 <sup>rd</sup>             | Control                        | 0.69                     | 0.66 c        | 0.63 d        | 0.61 de       | 0.72 a                       | 0.58 b                           |
|                             | 1.0 $\mu\text{l l}^{-1}$ 1-MCP |                          | 0.76 b        | 0.83 a        | 0.82 a        |                              | 0.72 a                           |
| 5 <sup>th</sup>             | Control                        | 0.95                     | 0.49 g        | 0.55 f        | 0.55 f        | 0.58 b                       |                                  |
|                             | 1.0 $\mu\text{l l}^{-1}$ 1-MCP |                          | 0.66 c        | 0.64 cd       | 0.59 e        |                              |                                  |
| Means for length of storage |                                | <b>0.82</b>              | <b>0.64 b</b> | <b>0.66 a</b> | <b>0.64 b</b> |                              |                                  |



# Results

## Titratable acidity (percent of citric acid as equivalent)

| Stage of maturity           | 1-MCP treatment                | Length of storage (days) |        |         |         | Means for stages of maturity | Means for treatment combinations |
|-----------------------------|--------------------------------|--------------------------|--------|---------|---------|------------------------------|----------------------------------|
|                             |                                | 0                        | 14     | 21      | 28      |                              |                                  |
| 3 <sup>rd</sup>             | Control                        | <b>0.69</b>              | 0.66 c | 0.63 d  | 0.61 de | <b>0.72 a</b>                | 0.58 b                           |
|                             | 1.0 $\mu\text{l l}^{-1}$ 1-MCP |                          | 0.76 b | 0.83 a  | 0.82 a  |                              | 0.72 a                           |
| 5 <sup>th</sup>             | Control                        | <b>0.95</b>              | 0.49 g | 0.55 f  | 0.55 f  | <b>0.58 b</b>                |                                  |
|                             | 1.0 $\mu\text{l l}^{-1}$ 1-MCP |                          | 0.66 c | 0.64 cd | 0.59 e  |                              |                                  |
| Means for length of storage |                                | 0.82                     | 0.64 b | 0.66 a  | 0.64 b  |                              |                                  |

# Results

## Titrateable acidity (percent of citric acid as equivalent)

| Stage of maturity                  | 1-MCP treatment                | Length of storage (days) |        |         |         | Means for stages of maturity | Means for treatment combinations |
|------------------------------------|--------------------------------|--------------------------|--------|---------|---------|------------------------------|----------------------------------|
|                                    |                                | 0                        | 14     | 21      | 28      |                              |                                  |
| 3 <sup>rd</sup>                    | Control                        | 0.69                     | 0.66 c | 0.63 d  | 0.61 de | 0.72 a                       | <b>0.58 b</b>                    |
|                                    | 1.0 $\mu\text{l l}^{-1}$ 1-MCP |                          | 0.76 b | 0.83 a  | 0.82 a  |                              | <b>0.72 a</b>                    |
| 5 <sup>th</sup>                    | Control                        | 0.95                     | 0.49 g | 0.55 f  | 0.55 f  | 0.58 b                       |                                  |
|                                    | 1.0 $\mu\text{l l}^{-1}$ 1-MCP |                          | 0.66 c | 0.64 cd | 0.59 e  |                              |                                  |
| <b>Means for length of storage</b> |                                | <b>0.82</b>              | 0.64 b | 0.66 a  | 0.64 b  |                              |                                  |

# Results

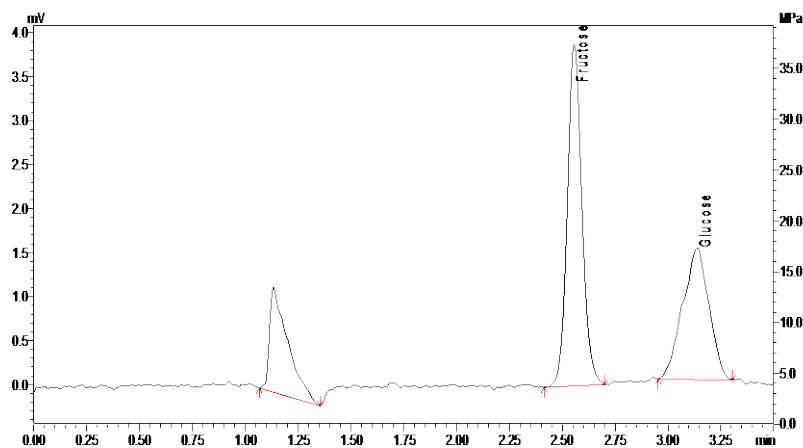
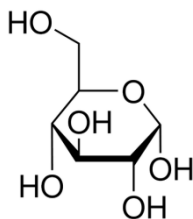
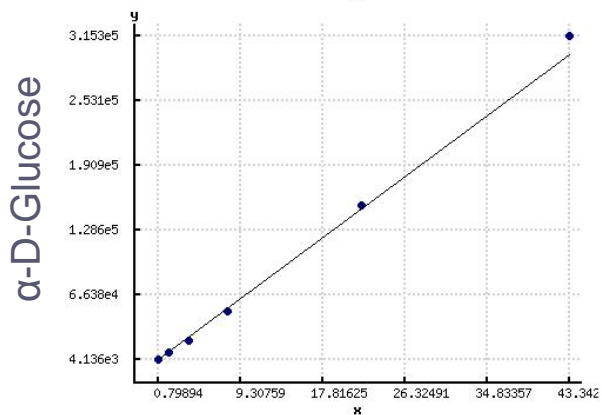
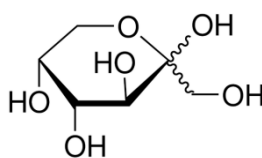
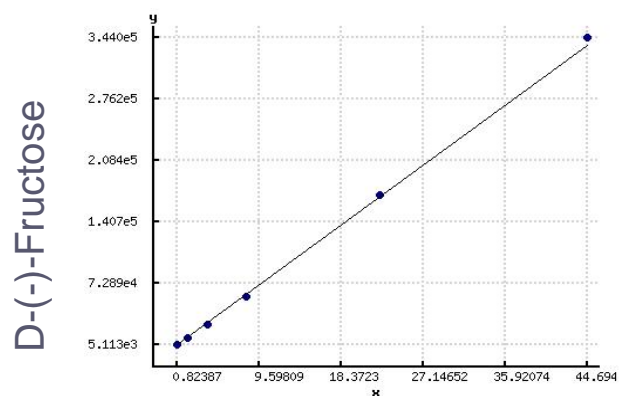
## Equipment



fot. J. L. Przybył

# Results

## Validation of method

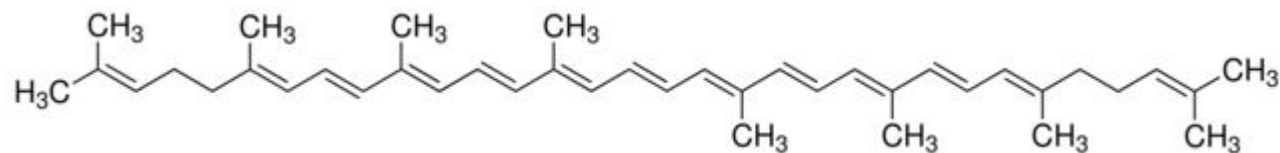


The sample chromatogram

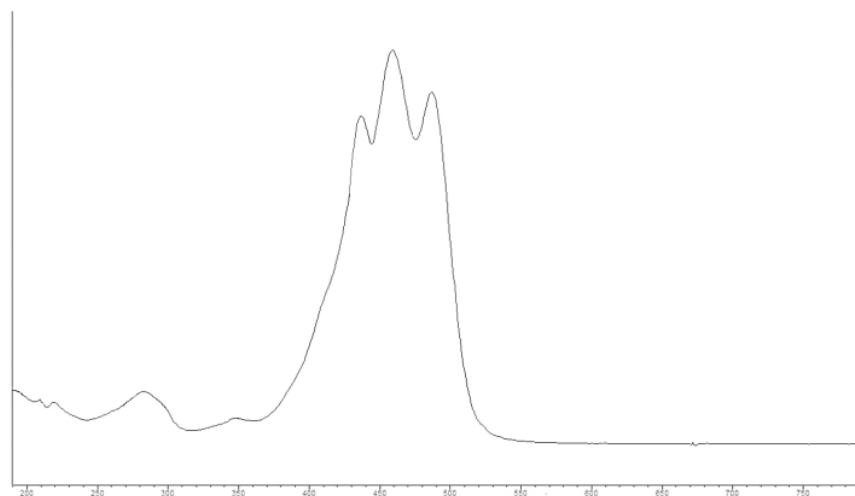
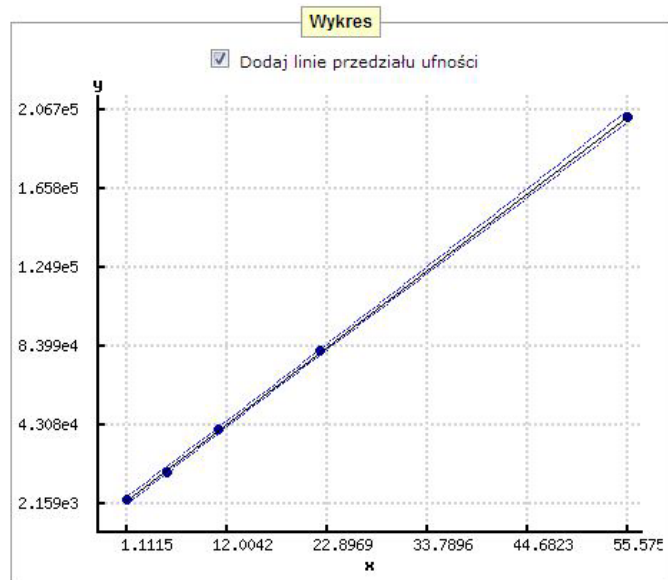
## Calibration curves

# Results

## Validation of method



Poziom ufności: 95 %



Calibration curve of lycopene

UV-spectra of lycopene



# Conclusions

- Higher level of dry matter and total sugars content were determined in fruits harvested in 5<sup>th</sup> stage of maturity.
- The content of dry matter and total sugars did not dependent on 1-MCP treatment. These parameters values decreased during storage.
- Fruits stored after treatment with 1-MCP had higher content of total soluble solids, lower value of pH of juice and higher titratable acidity than fruits from control combination. Comparing stored fruits to fresh one, the total soluble solids content and pH of the juice increased, while the acidity decreased.



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# Photos

- [http://cals.ncsu.edu/hort\\_sci/people/faculty/pages/blankenship.php](http://cals.ncsu.edu/hort_sci/people/faculty/pages/blankenship.php)
- <http://www.multibriefs.com/briefs/saf/SAF112812.php>
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- J. L. Przybył



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ありがとうございます  
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