Efficacy of It's Fresh! Palladium ethylene scrubber in reducing ethylene and extending strawberry quality

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Background

• Approached by the Florida Strawberry Growers Association to evaluate It’s Fresh!, a novel method for removing ethylene gas in consumer packages of strawberries and other produce.

• It’s Fresh! has been reported to show potential for extending postharvest life of strawberry by reducing softening, darkening and decay (Elmi et al., 2013*).

• Since 2012, It’s Fresh! package inserts have been used in multiple fruits, including: strawberries, stone fruit, tomatoes, avocados, pears, and cherries in both the U.K., and in the Americas.

The material is a palladium-impregnated zeolite giving finely dispersed palladium particles.
Wills & Kim from 1995: shelf life of strawberries at 0 or 20°C was doubled by reducing ethylene from 0.1 to <0.005 ppm.

Found that scrubbing ethylene at either 0 or 20 °C (to 0.005 or 0.05 ul l⁻¹, respectively) significantly extended the storage life of strawberries due to decreased tissue softening, tissue collapse, color change to a translucent dark red, green color loss in the calyx and blackening in the stem-end.

Also stated, “...the lack of of effect of ethylene reported by Siriphanich (1980) was probably due to his use of quite high ethylene levels of 1-100 ul l⁻¹ where fruit show little differential response.”

This study confirms the advantages of e⁺® in preserving postharvest fruit quality and has also demonstrated with the use of a highly sensitive ETD-300 ethylene detector, that ethylene may have a role in determining the postharvest quality of strawberry fruit.
Effects of ethylene and 1-MCP on the quality and storage life of strawberries
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Abstract
Strawberry quality declines rapidly after harvest. Deterioration may be accelerated by ethylene and is potentially increased, decreased or unaffected by the ethylene inhibitor 1-MCP (1-methylcyclopropene). We have examined the effects of 0.01, 0.05, 0.1 and 1 ml l⁻¹ of ethylene and 0.01, 0.1, and 1.0 ml l⁻¹ 1-MCP on the quality attributes and respiration rates of strawberries stored at 0 or 5 ⁰C. Ethylene did not affect the rate of rot development. However, calyx quality was significantly reduced by exposure to 0.1 or 1.0 ml l⁻¹ ethylene. Treatment with 1 ml l⁻¹ 1-MCP protected the calyx tissue from these effects. Exposure of strawberries to 0.01, 0.1 or 1.0 ml l⁻¹ 1-MCP did not affect overall fruit acceptability but did slightly increase the rate of rot development. 1-MCP treatment reduced ethylene production by the fruit. Increased production of CO₂ by 1-MCP treated fruit was associated with the earlier onset of rots. Although the results suggest that blocking ethylene perception interferes with disease resistance in strawberries, there was only a small effect on total storage life. It was concluded that neither the removal of low levels of ethylene from the storage environment nor the treatment with 1-MCP are likely to be cost effective methods of extending strawberry storage life.
RESULTS

Comparison of It’s Fresh (palladium) and Ethylene Control (permanganate) ethylene adsorbers
The initial rate of ethylene adsorption (reduction in concentration per minute) was almost 10 times greater for the KMnO₄ than for the It’s Fresh! (0.52 uL min⁻¹ versus 0.05 uL min⁻¹, respectively.

However, the amount of active ingredient in the It’s Fresh! sheets is less than 0.2% of the active ingredient in the sachets.

Therefore, the rate of ethylene adsorption on a per weight basis (uL min⁻¹ g⁻¹ of active ingredient) was over 50 times greater for It’s Fresh! than for KMnO₄.

When ethylene adsorption was compared for low and high humidity it was found that the adsorption rate was about 25 to 30% lower in saturated humidity than in 45% RH for both the KMnO₄ sachets and the It’s Fresh! sheets (data not shown).
After repeated injections of ethylene, it was determined that the ethylene absorption capacity of the It’s Fresh! sheets averaged 5,500 uL of ethylene per sheet and for the Ethylene Control sachets it was 8,000 uL of ethylene per sachet.

However, the potential ethylene adsorption capacity for the It’s Fresh! material is much greater than for KMnO₄ since the relative ethylene adsorption capacity on a per weight basis (uL g⁻¹ of active ingredient) is almost 400 times greater for It’s Fresh! than for KMnO₄.

Measurement of ethylene absorption capacity of a 4-in² (25.8 cm²) It’s Fresh! sheets and 9-g Ethylene Control sachets in sealed jars at 77°F and 45% RH.
(The reduction in ethylene concentration in the control was due to leakage, which was corrected for in calculating the ethylene adsorption rates.)
RESULTS

Strawberry shelf life evaluation in a simulated distribution system from farm to home
Sampling Procedure

• The strawberries were obtained from Wish Farms, Plant City, FL on the day of harvest and were collected immediately after forced-air cooling.

• A total of eight flats of strawberries with eight clamshells/flat (64 clamshells) were randomly divided into two sets at the cooling facility.

• It’s Fresh! filter sheets (1 in²) were attached to small fruit pads; one sheet per clamshell was placed inside one set of clamshells, and placebos (i.e., inactive sheets) were placed inside the other set.

• The strawberry clamshells were placed into insulated coolers and transported by car to the Horticultural Sciences Department, University of Florida (approximately 2 hours).
Shelf-life Procedure

• The shelf life test was conducted at the Postharvest Laboratory at UF.
• Replicating a retailers supply chain, strawberries were evaluated for quality daily.
  1. In-D.C., in-store
  2. In-Home
• The clamshells with and without It’s Fresh! sheets were stored in identical, separate temperature- and humidity-controlled rooms (temperatures variable; humidity 95% RH).
• Fruit quality evaluations were conducted daily; the evaluators did not know which It’s Fresh! sheets were active and which were the placebos (i.e., it was a blind test).
Shelf-life Scenario:

- **Day 1** – strawberries harvested and cooled to 38°F/3.3°C <4 hours after harvest; transported from Plant City to Gainesville and placed at 34°F/1.1°C

**In-D.C., in-store**

- **Days 1 to 3** – Simulated transport to and holding at Distribution Center (34°F/1.1°C)
- **Days 3 to 6** – Simulated retail store backroom and display (38°F/3.3°C)

**In-Home**

- **Days 6 to 9** – Simulated home refrigerator (41°F/5°C)

Quality evaluation schedule for shelf life test of ethylene scrubbing effect on strawberry quality.
Evaluation Procedure

64 clam shells per scenario x 2 (Control and It’sFresh!), evaluated from arrival at D.C. to in-home.

**In-D.C., in-store**
Clamshells scored as a “consumer” during the time in the D.C. and store, *i.e.*, “Would I buy this?”

1 = definitely would purchase, fruit is colorful, glossy and free of disease/damage,
2 = borderline purchase, fruit isn’t looking fresh,
3 = definitely would not purchase, fruit is no longer colorful and glossy, signs of mold

**In-Home**
Clamshells scored as a “consumer” during the time in the home, *i.e.*, “Would I eat this?”.

1 = definitely would eat/feed to my family,
2 = borderline, must eat immediately,
3 = definitely would not eat
Would I Buy?

<table>
<thead>
<tr>
<th>Rating</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>(definitely would) 75 to 90% bright and glossy red color; calyx is stiff and green; no signs of bruising or shriveling on fruit; fruit appear to be very fresh (excellent quality)</td>
</tr>
<tr>
<td>2</td>
<td>(borderline) 90 to 100% slightly less bright and glossy red color; calyx is green but slightly less stiff than at harvest; no signs of fruit shriveling (very good quality)</td>
</tr>
<tr>
<td>3</td>
<td>(definitely wouldn’t) 50 to 70% red color; calyx is less bright and less glossy than at harvest; calyx is green but less stiff than at harvest; color and texture of fruit shriveling may be noticeable (good to acceptable quality)</td>
</tr>
</tbody>
</table>

Would I Eat?

<table>
<thead>
<tr>
<th>Rating</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>(definitely would) 100% red color; calyx is less bright and less glossy than at harvest; calyx is green but less stiff than at harvest; color and texture of fruit shriveling may be noticeable (good to acceptable quality)</td>
</tr>
<tr>
<td>2</td>
<td>(borderline) 75% red color; calyx is less bright and less glossy than at harvest; calyx is green but less stiff than at harvest; color and texture of fruit shriveling may be noticeable (good to acceptable quality)</td>
</tr>
<tr>
<td>3</td>
<td>(definitely wouldn’t) 50% red color; calyx is less bright and less glossy than at harvest; calyx is green but less stiff than at harvest; color and texture of fruit shriveling may be noticeable (good to acceptable quality)</td>
</tr>
</tbody>
</table>

Rating scale with illustrations and definitions courtesy Cecilia Nunes, Univ. of South Florida

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Quality Assessments – from 1, "Definitely Would Buy/Eat“ to 3, “Definitely Wouldn’t Buy/Eat”
Comparing Control versus It’sFresh! Strawberries
Quality Assessments – Per cent "Definitely Would Buy/Eat“
Comparing Control versus It’sFresh! Strawberries

Percent of fruit classified as “definitely would buy/eat”

<table>
<thead>
<tr>
<th>D1</th>
<th>ITSFRESH</th>
<th>CONTROL</th>
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</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>100%</td>
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<tr>
<td></td>
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<tr>
<td>D2</td>
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<td></td>
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<td>92%</td>
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<tr>
<td>D4</td>
<td></td>
<td>91%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>92%</td>
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<tr>
<td>D5</td>
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<td></td>
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<td>50%</td>
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<tr>
<td>D8</td>
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<td>28%</td>
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<tr>
<td></td>
<td></td>
<td>42%</td>
</tr>
<tr>
<td>D9</td>
<td></td>
<td>23%</td>
</tr>
</tbody>
</table>

D1, D2, D3, D4, D5, D6, D7, D8, D9
FLORIDA STRAWBERRY RESULTS – DAY 11
Categorized as #3, “definitely would not eat”

“...clear differences in bruising severity and also drying of sepals between control and It’sFresh!”

CONTROL – 28 clamshells out of 64 = 44%
“definitely would not eat”

IT’SFRESH! – 10 clamshells out of 64 = 16%
“definitely would not eat”
Conclusions

• On a per weight basis It’s Fresh! adsorbed ethylene 50 times faster than KMnO₄ with an adsorption capacity 400 times greater.

• Ethylene adsorption rate was about 25 to 30% lower in saturated humidity than in 45% RH for both the KMnO₄ sachets and the It’s Fresh! sheets.

• In the simulated handling test from post-forced-air cooling to the consumer, 1-in² It’s Fresh! sheets extended strawberry quality both in-store and at home.
  • Shelf life was extended by about 1 day by slowing the development of dry calyx and sunken bruised areas starting on day 5 from harvest and continuing through simulated retail display and in the consumer’s home (day 9).
  • Additionally, at the end of the simulation, 44% of clamshells in the control were rated “definitely would not eat” while only 16% of clamshells in the It’s Fresh! treatment were similarly rated.

• This suggests that considerably more strawberries would likely be consumed and less fruit discarded by consumers in the home with the use of It’s Fresh!
Acknowledgements

• These tests would not have been possible without the collaboration and contributions of time, resources, and materials from:
  
  • **Wish Farms**, Plant City, FL (Gary Wishnatzki)
  
  • **It’s Fresh! Ltd.** (Greg Pavett)