

Comments on Strawberry Fruit Management

Santa Maria Strawberry Field Day – May 10, 2016

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San Luis Obispo • Guadalupe • Salinas • Five Points CA • Lansing MI • Tampa FL

Susceptibility of strawberry fruit to post-harvest losses is determined by multiple factors, most notably: the presence of pathogens during production, picking injury, field handling logistics, environmental conditions during storage and transport, and inherent genetic traits of the fruit itself. It is well known that high sugar and acid levels in berries contribute to preferable flavor profiles, but the higher sugar content is indicative of elevated respiration, which contributes to rapid degradation of harvested fruit if improperly managed post-harvest. The following will demonstrate some of the key factors for maintaining post-harvest strawberry integrity.

I. Environmental and Physical Factors

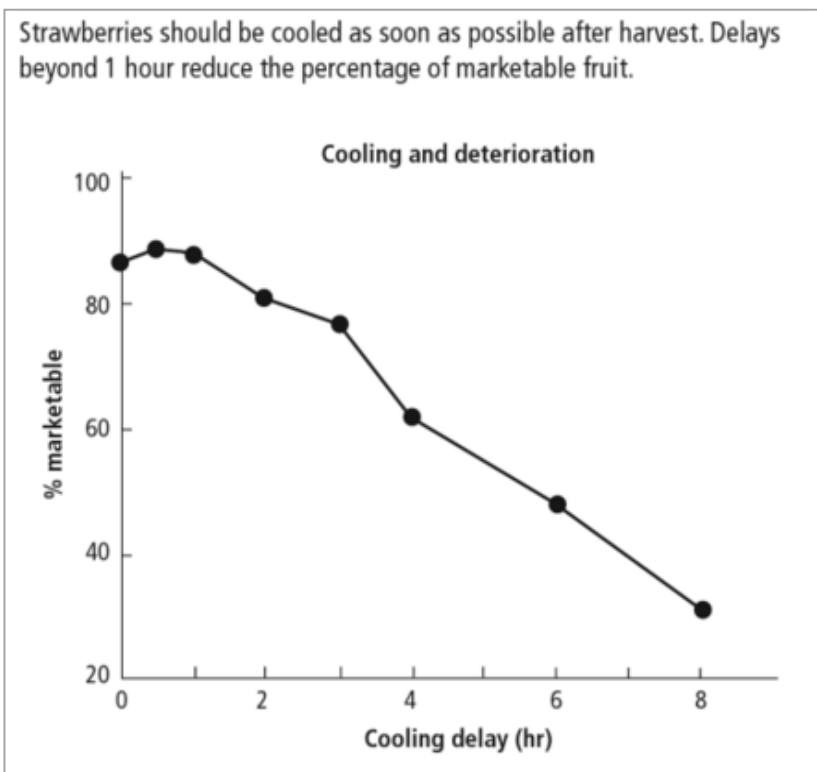


Figure 1. Percentage of marketable berries following hours of exposure post-harvest to 30°C (86°F) temperature. From: Kader, A. 2001. *Postharvest Technology of Horticulture Crops*

- ❖ Prompt cooling by transfer to shade and then to the cooler where cold air is circulated among the fruit is the most effective method for reducing post-harvest losses.

- ❖ Berries can last from 5-7+ days in cold storage if immediately cooled after harvest.

- ❖ Extended exposure to warm temperatures has shown to decrease the percentage of marketable fruit by 50% after 7 hours (Fig. 1).

- ❖ Storage at 0°C under low O₂ conditions with relative humidity in the 90-95% range extends shelf stability up to 10 days (controlled atmosphere).

- ❖ Depending on fruit sweetness, losses are associated with elevated respiration which makes handling at harvest highly important to fruit integrity. Worker training for recognizing proper maturity for harvest, using care to prevent nicks or pressure damage to fruit, and timing picks to cooler hours of the day all extend shelf stability of the fruit.

Respiration increases 2-4 times for every 10°C above 0°C. At 1°C, one ton of strawberries generates 3300 Btu/day but at 27°C (80°F) the same ton will produce 41,800 Btu/day

A. Cold Storage Strategies



❖ Under controlled atmosphere conditions, modified atmosphere packaging (MAP) materials which have micropores to allow gas and moisture exchange, can also contain decay causing organisms such as *Botrytis* and *Rhizopus*. However, MAP together with temperature management, can further reduce respiration rate and fungal growth to extend shelf life to 21 days (Fig. 2).

Figure 2. Modified atmosphere packaging (MAP) can equilibrate moisture and gas content to extend shelf life to as much as 21 days post-harvest. From rop.co.il (L) and packworld.com (R)

B. Pallet Cover Systems

Controlled atmosphere (CA) shipping allows for extended shelf life, particularly when pallets are wrapped with plastic to maintain consistent low O₂ and high moisture conditions. Proprietary cover systems developed by CO₂ West (San Luis Obispo, CA, a system which releases CO₂ from a pad in the bag), PEAKfresh USA (Lake Forest, CA), Destiny Packaging (PrimePro, Monterey, CA), and TransFresh Corp., (Tectrol, Salinas, CA; which seals the entire pallet including the base). Macnisch et. al. *HortTechnology*. 2012.

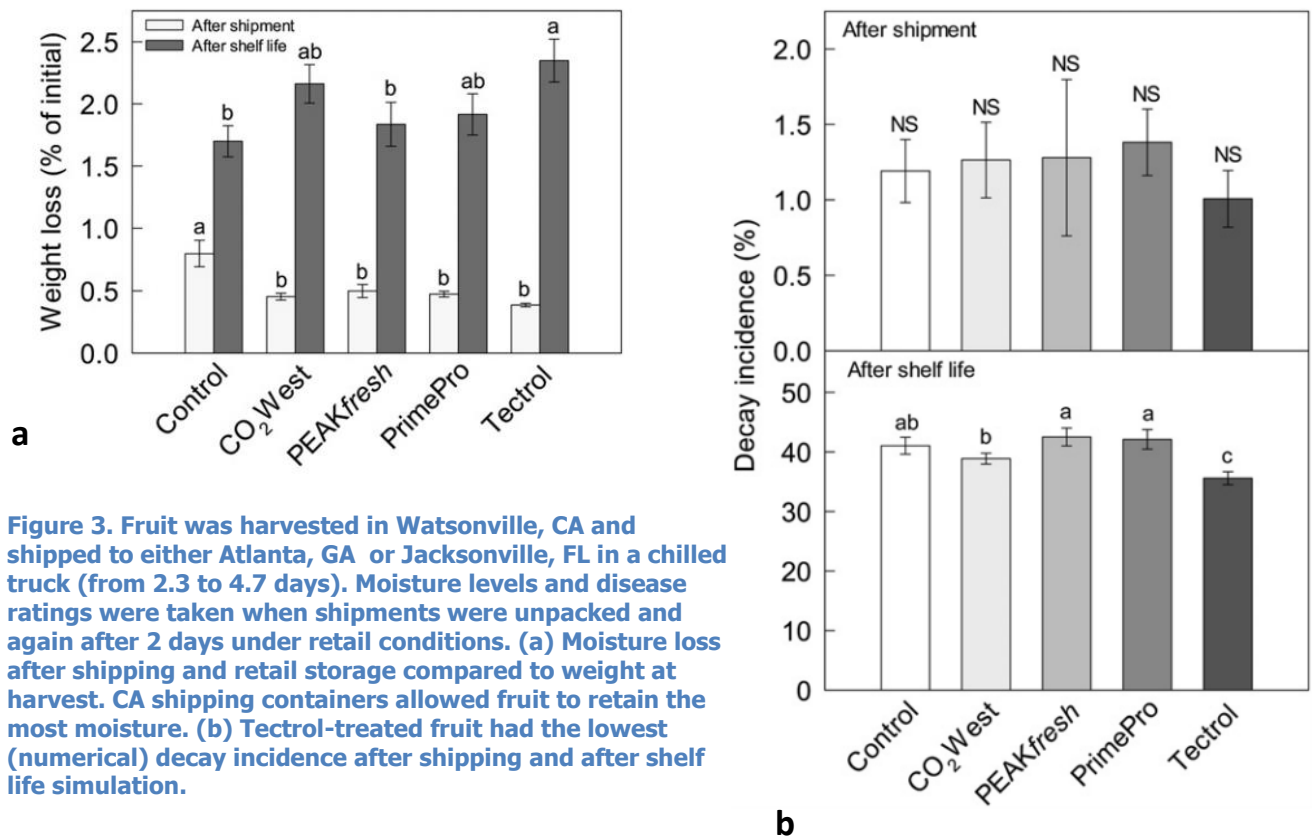
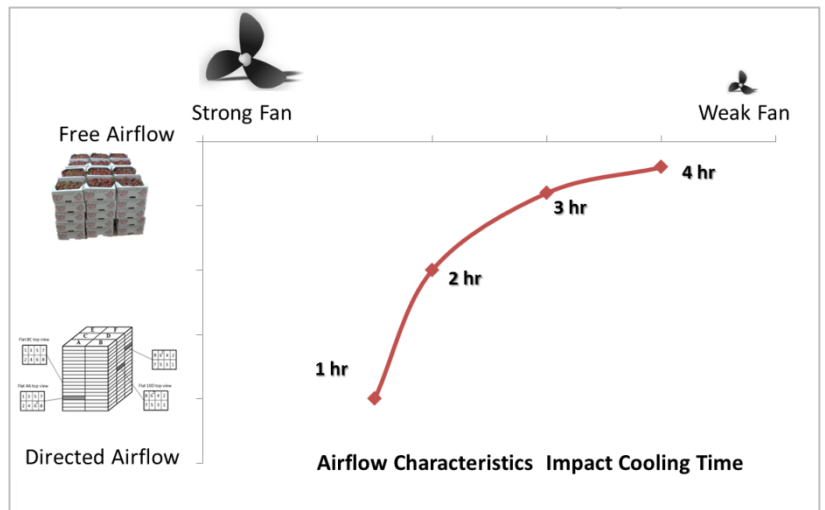


Figure 3. Fruit was harvested in Watsonville, CA and shipped to either Atlanta, GA or Jacksonville, FL in a chilled truck (from 2.3 to 4.7 days). Moisture levels and disease ratings were taken when shipments were unpacked and again after 2 days under retail conditions. (a) Moisture loss after shipping and retail storage compared to weight at harvest. CA shipping containers allowed fruit to retain the most moisture. (b) Tectrol-treated fruit had the lowest (numerical) decay incidence after shipping and after shelf life simulation.

Figure 4. Forced air cooling (strong fan) for palletized strawberries in optimized clamshell ventilation and stack arrangement (directed airflow) allows fruit to reach cold storage temperature in under 90 minutes. Weak cooling and undirected air flow increases time to cool. Modified from Kader, A. 2001.



- ❖ Cooling is sped up with increased ventilation in storage containers and ensures continuous airflow evenly through the pallet (Fig. 4).
- ❖ As fruit rests at ambient temperatures, the flesh can increase in temperature especially when encased in non-ventilated containers.

Heat exchange in 1-pound clamshell strawberry containers cools faster with 7% venting, but not any more rapidly with >13% sidewall ventilation

II. Biological Factors

Strawberry marketability is highly dependent on disease, with any symptom of fuzzy pathogen growth able to reduce value. *Botrytis* is the main culprit, but *Aspergillus*, *Mucor*, *Rhizopus*, and even powdery mildew grow on fruit that is not treated carefully before, or after, harvest. Spray programs for prevention of disease are crucial for reducing disease in the clamshell.

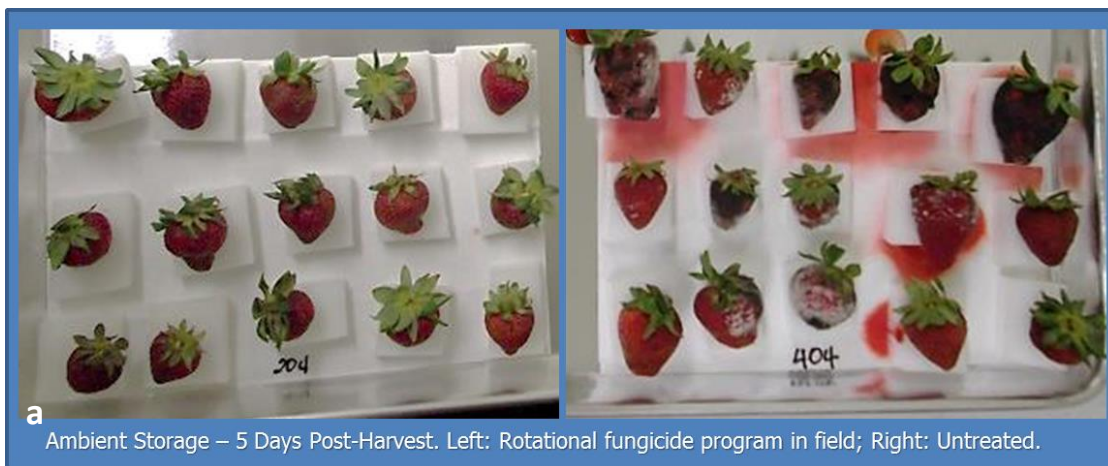
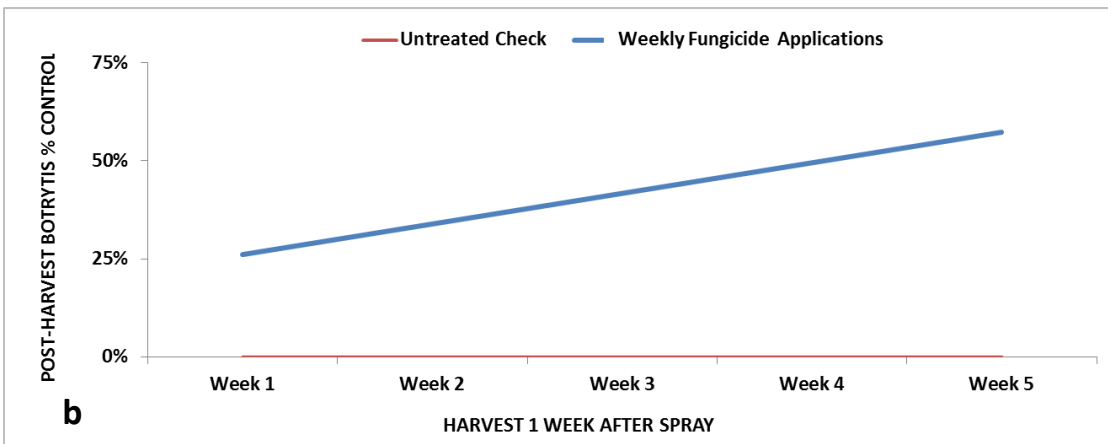


Figure 5. (a) Disease incident at 5 days post-harvest on treated (left) and untreated (right) berries. (b) Data from Pacific Ag Research for post-harvest disease control using fruit sprayed weekly with a commercial rate of available fungicide and harvested prior to subsequent apps. Percent control tabulated from SAUDPC of 3, 5 and 7 day post-harvest assessments for Botrytis severity. Relative to the untreated, post-harvest Botrytis control increases over time with additional sprays in the field.



- ❖ Rotational weekly applications of fungicidal products to strawberries prior to harvest results in significantly less incidence of *Botrytis* five days after harvest at ambient storage (Fig. 4b).
- ❖ Threats to fresh market berries in storage include *Botrytis*, *Rhizopus*, *Mucor*, Powdery Mildew and Aspergillus. Fungicide programs that target all potential pests should be evaluated (Fig. 6).
- ❖ Shelf life is extended by applications with the optimum product rotation (Fig. 7).

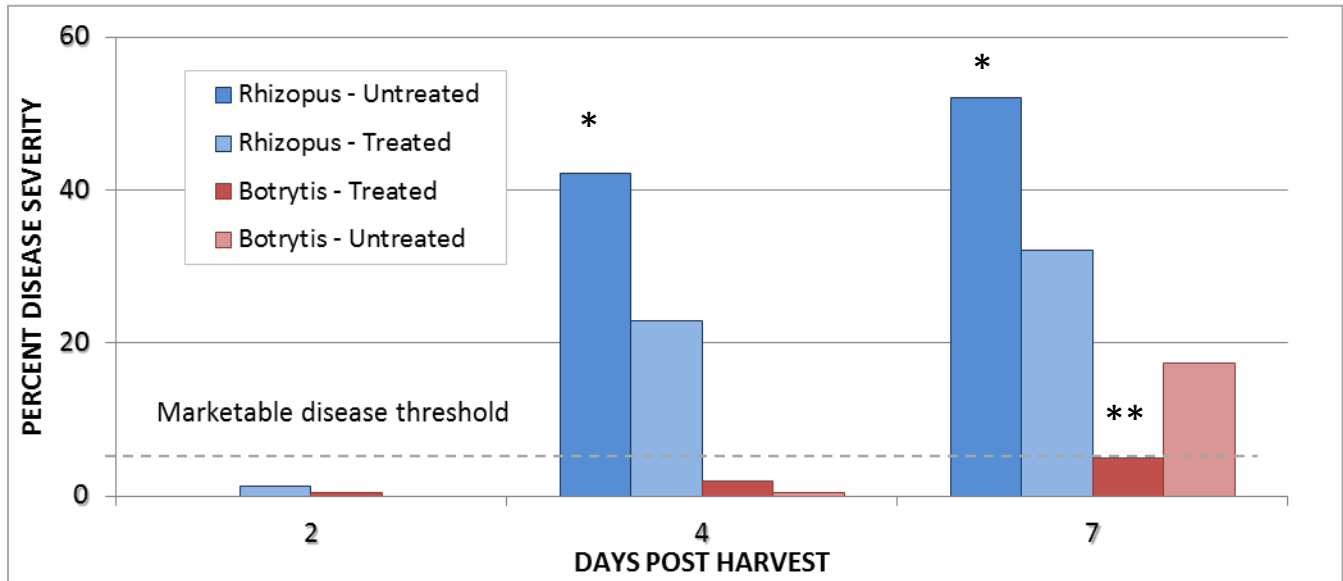


Figure 6. Incidence of fruit rot caused by *Rhizopus* and gray mold caused by *Botrytis* increases in severity over time on harvested fruit. By 7 days after harvest at ambient temperatures, pest severity on treated strawberries is significantly less than on untreated fruit. *Botrytis* on the treated fruit remains below a marketable threshold of 5% as far as one week after harvest.

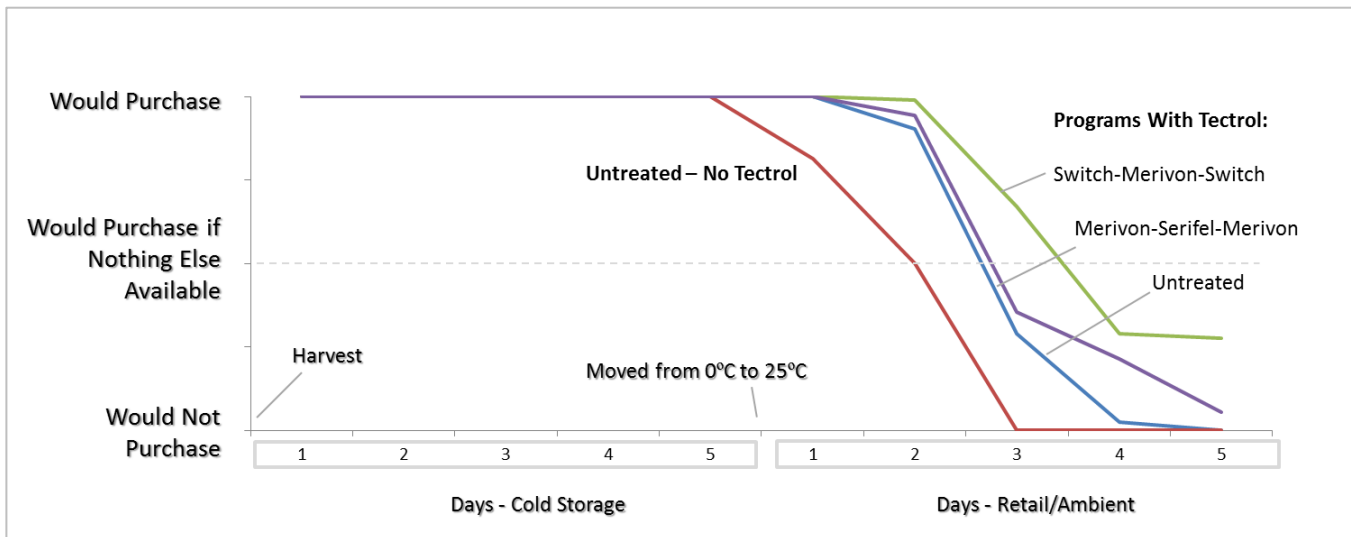


Figure 7. Results of fruit assessed on a 1-3 scale where 1. Would not buy even if it's the last one, 2. Would consider if there weren't better options, 3. Would definitely buy. Significantly lower quality at initial unveiling from storage for clamshells not treated with Tectrol. Berries treated with a rotation of Switch-Merivon-Switch in field and cold storage with Tectrol results in an extra three days of shelf life compared to the untreated berries stored with Tectrol.