Postharvest Control of Strawberry Decay
White paper by BotanoCap September 2016

Summary:
Gray mold is the most common fruit rotting pathogen of strawberry. It is a major problem during ripening and marketing of harvested fruit. In order to improve the postharvest life of strawberries, application of BotanoFresh™, innovative impregnated pads, was evaluated during storage of the fruit. Results indicate beneficial effects of BotanoFresh™ essential oil impregnated pads on the postharvest quality of strawberry, increasing the shelf life up to 3 weeks while effectively suppressing post-harvest fungal decay and resultant losses.

Introduction:
Strawberries are among the most perishable fresh produce items. They are harvested at a point where they are ready to be consumed, unlike many other fruit that are harvested when mature but not fully ripe, ripening later during storage and shelf life. Quality characteristics and criteria for a high-quality strawberry is uniformly red, firm, green calyx, tasty and free of defects and disease.

Strawberries Quality Indices

- Appearance: color, size, shape, freedom from defects
- Firmness
- Flavor: soluble solids, titratable acidity and flavor volatiles
- Nutritional value: Vitamin C

Strawberries are harvested and packed in the field. They are most often packed directly into plastic clamshell containers held in corrugated flats. This packaging holds the berries through to the consumer. The flats are collected and palletized in the field. Strawberries have a relatively high rate of respiration and are highly susceptible to water loss and mechanical damage. They are also highly susceptible to decay from fungi - principally Botrytis cinerea and Rhizopus stolonifer. Even without decay, strawberry fruit (Fragaria ananassa) have a short postharvest life mainly due to rapid softening (see Figure 1 and Figure 2).

Figure 1:
Postharvest strawberry fruit decay caused by the fungi Penicillium spp. (circular blue and white molds) and Botrytis cinerea (fluffy gray mold) (A), Rhizopus stolonifer (B), Colletotrichum spp. (C), and Mucor spp. (D). (Feliziani E., Romanazzi G., 2016)
Maintaining strawberry temperature as close as possible to the optimum temperature about of 0°C + 1 (32°F) will maximize strawberry quality and shelf life in several ways including:

- Slowing the growth of plant pathogens (Botrytis; Rhizopus, etc.)
- Reducing the respiration rate
- Minimizing water loss

Studies indicate a significant loss of shelf life if cooling is delayed over 2 hours after harvest (See graph at Figure 2).

**Figure 2:**

Delay in strawberry cooling vs. Marketability  
(Best Handling Practices for California Strawberries guide)

20% loss of shelf life if cooling is delayed over 2 hours
The traditional strategy for control of postharvest strawberry decay relies on the application of fungicides during the crop growing cycle. Conventional fungicides are applied around flowering, and treatments can be repeated up to harvest. Nowadays, there are many alternatives to conventional fungicides that are characterized by low impact on the environment and on human health.

According to an integrated pest-management approach, management of postharvest diseases starts before cultivation in the field, with the suitable choice of the strawberry variety, place of cultivation, and cultivation technique. This continues during the crop development, with weed control, soil sanitation, and management of water and humidity.

Postharvest fungicides are not used on strawberries, therefore, careful picking at harvest and then prompt cooling, storage at 0°C (32°F), preventing fruit injury, and shipment under high carbon dioxide are the best methods for disease control and are the key factors to assure good quality of harvested strawberry fruit. Figure 3 shows the overall quality index and decay index of strawberries stored at 0°C, 5°C, and 10°C. Overall quality loss increased continuously at a higher rate in strawberries stored at 10°C than in those stored at 5°C and 0°C. Fungal decay increased rapidly in berries stored at 10°C especially after 7 days of storage. Berries stored at 5°C showed slight fungal decay during 13 days of storage. Storage temperature of 0°C was very effective in suppressing fungal decay of strawberries (Figure 3).

A modified atmosphere (MA) that is enriched in ozone, oxygen, or carbon dioxide is frequently used during strawberry storage, to slow down senescence and reduce decay. Fruit will have a 10 to 14 day shelf life at 1°C under modified atmospheres of 3-5% O2 and 15-20% CO2.

Factors Affecting Postharvest Shelf life:
- Harvest system
- Packing
- Rate of cooling
- Storage temperature
- Relative humidity
- Transit and retail display temperature
- Other postharvest technologies: Modified and controlled atmospheres, Edible coatings.
Figure 3:
Overall quality (left) and decay index (right) of strawberries stored in various temps: (J. Fernando Ayala-Zavala et al. 2004).

0°C (●), 5°C (○), 100°C (▼)

45% Fruit & Vegetables waste - The highest food losses rates of any food products (FAO)

Key facts on food loss from FAO show that fruit and vegetables, plus roots and tubers have the highest wastage rates of any food. The economical implication is that food losses and waste amount to roughly US$ 680 billion in industrialized countries and US$ 310 billion in developing countries.

Groundbreaking innovative solution by BotanoCap

Strawberry fruit has a short postharvest life mainly due to its rapid softening and susceptibility to rots. The effectiveness of essential oils in delaying decay development from both fungal pathogens of fresh strawberries was reported at the end of the century by Bhaskara Reddy et al., 1998, but only recently was a practical method reported for applying this knowledge by Peretto et al., 2014.

In order to improve strawberry postharvest life, application of BotanoFresh™ innovative impregnated pads was evaluated during postharvest storage of the fruit. Strawberry fruit of uniform size, free of physical damage and fungal infection were selected and packed in aerated PVC lidded punnets, lined with or without BotanoFresh™ innovative essential oil impregnated pads and randomly distributed into replicates of treatments (Figure 4 and 5).
Twenty-four replicates of each treatment were divided into 2 lots and placed in a 50 L plastic boxes with tightly fitting lids (Figure 5 - open boxes). One set of boxes was stored under simulated local marketing conditions for 2 days at 0-1°C and 2 days at 20°C. The second set of boxes was stored immediately at 0-1°C for 2 or 3 weeks, simulating export by sea. At removal from cold storage fruit was examined momentarily before transfer to shelf life. After 2 weeks, shelf life conditions were 2 days at 20°C, but after 3 weeks shelf life lasted 3 days and was conducted at lower temperatures: 3 punnets per treatment were held at 12°C and 3 punnets were held at 6-7 °C. Decay was monitored and the number of healthy fruit was counted (Figure 6).

Results simulating local marketing: Decay developed rapidly in the control punnets, caused by Rhizopus stolonifer, but was effectively controlled with the BotanoFresh™ pads (Figure 6 and 7).
Figure 7:
Decay incidence (% of control) and percent of healthy fruit in punnets with essential oil impregnated pad after 2 and 3 weeks at 0°C and 2-3 days shelf life at different temperatures.

**BotanoFresh™ impregnated pads reduced strawberry decay by 30-50%**

**Conclusion**

These data indicate beneficial effects of BotanoFresh™ essential oil impregnated pads on postharvest quality of strawberry (Figure 7). BotanoFresh™ impregnated pads were able to increase the shelf life of fruit after cold storage for up to 3 weeks as evidenced by the reduced development of both Botrytis cinerea and Rhizopus stolonifer, which had been effectively inhibited when the fruit was in storage at 0°C.

**Benefits**
- Effective, anti-fungal and anti-microbial protection for 3 weeks
- GRAS approved natural ingredients
- Controlled release of effective essential oil concentrations
- Patented formulation
- Free from residuals
- Extends shelf life
- Enhanced yield
- Smart innovative packaging solution
- Easy to use
BotanoFresh™ pads incorporation in retail punnet packaging together with refrigerated storage is a promising method for extending strawberry shelf life and we recommend it as the best practice for delivering the freshest product possible to customers.

### About BotanoCap

Founded in 2004, BotanoCap is a privately held company in the field of environmentally friendly pesticides. BotanoCap has developed a platform for a wide range of safe pesticide products to reduce or replace toxic pesticides that are currently available in the market. Exploiting our strong base of patented technologies, BotanoCap provides alternatives to a variety of harmful and toxic compounds through environmentally friendly products to ensure a sustainable relationship between agriculture and natural eco systems according to the new worldwide regulations. Botanocap’s products are based on patented micro encapsulation technologies for volatile materials such as essential oils and other natural substances.

For further information about BotanoCap postharvest innovative solutions, please contact us: info@botanocap.com

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**Application mode**

- **Disease treatment**
- **Crop**

**Recommended for covering fruit in punnets/ plastic clamshell containers or other retail packaging**

**BotanoFresh™ impregnated pads are useful for controlling Botrytis cinerea and Rhizopus stolonifer rots**

**Strawberry**

Best Handling Practices for California Strawberries guide.


Introduction to Proper Postharvest Cooling and Handling Methods, http://www.bae.ncsu.edu/programs/extension/publicat/postharv/ag-414-1/

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