Maximizing SmartFresh™ Utilization for Farm Markets

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The adoption of SmartFresh™ technology in our retail farm markets has been slow. However, the use of this technology in the form of SmartTabs can provide significant advantages for growers who sell their fruit directly from the farm. Fruit intended for sale in farm markets is often harvested at a more advanced stage of maturity, allowing it to develop a flavor and aroma profile typical of the cultivar that consumers who purchase fruit from farm markets expect. Apples sold in our farm markets are often exposed to high temperatures in the retail market, causing the fruit to ripen quickly, limiting their shelf life and consumer appeal. This article discusses how SmartFresh™ technology can be used to enhance the quality of apple fruit sold in this type of retail farm market.

The Quality Challenge in Farm Markets

Fruit destined for sales in retail markets is harvested at a more advanced stage of maturity compared to fruit harvested for long term storage. Fruit harvested for wholesale markets may be kept for many months in cold storage or controlled-atmosphere storage before it is packed and shipped. In contrast, the fruit harvested for direct farm market sales is often held in regular cold storage for shorter periods before sale. Once fruit are removed from cold storage, they may be held continuously at ambient temperatures in the market until they are sold. Fruit in these markets may be exposed to temperatures above 70° F, particularly during the months of August and September. Such high temperatures cause the fruit to ripen quickly, hastening the rates of fruit softening and loss of fruit acidity, and limiting the shelf life of fruit after sale.

Consumers who purchase fruit from retail farm markets are likely to have different sensory expectations compared to those who purchase fruit from a local supermarket. Most growers who sell fruit from farm markets readily acknowledge this point, and seek to deliver a product that fully meets these expectations. Customers who come to your farm market are looking to purchase fruit that have been allowed to ripen on the tree, developing a more complete flavor/aroma profile before it is harvested. They are expecting an apple that it is not only fresher, but also tastes better than a store-bought apple, because that extra time on the tree has allowed the fruit to develop a flavor profile that is typical of the cultivar. The dilemma, however, is that while late harvested fruit will develop a more favorable flavor profile, they also exhibit reduced firmness and acidity compared to fruit harvested at an earlier stage of maturity (Figure 1). Unmet consumer expectations for firmness and flavor will result in low customer satisfaction, and a reduction in repeat sales. SmartFresh™ (1-MCP), however, delays fruit softening and maintains fruit acidity, but can also reduce the development of volatile esters and alcohols that contribute to the characteristic flavor of a particular cultivar. The stage of fruit maturity at the time of harvest will have a pronounced effect

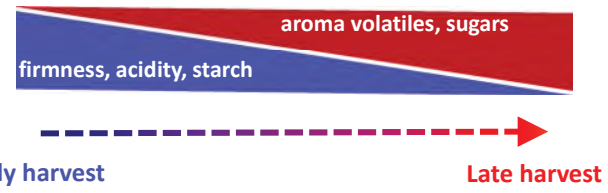


Figure 1. Firmness and 'flavor', which can be considered as the combined sensory effect of sweetness, acidity, starch content, and volatile aroma compounds, are critical components of overall consumer acceptance. Arguably, firmness and flavor are more critical to consumer acceptance of apples sold in farm markets compared to grocery stores. It is important to time the harvest so that the balance between firmness and flavor in the fruit will match consumer expectations. Tools like SmartFresh SmartTabs can be used to maintain this balance from the time of harvest until the time of consumption.

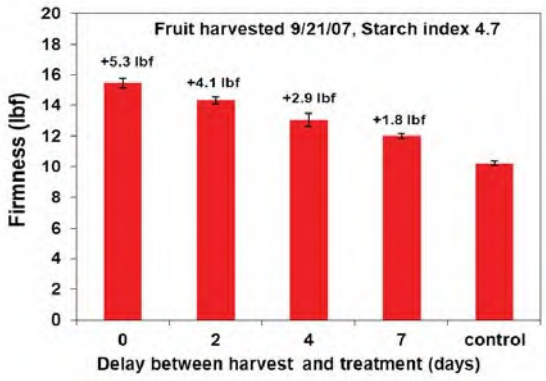


Figure 2. Effects of delay between harvest and SmartFresh application on firmness of Law Rome after 40 days at 32° F followed by 7 days at room temperature. Values above each bar indicate increase in firmness compared to untreated control.

on the quality perception of SmartFresh-treated fruit sold in retail farm markets, with fruit harvested at a more advanced stage of maturity more likely to have developed a desirable flavor profile.

Treat Fruit as Soon As Possible after Harvest

Variety specific guidelines for SmartFresh treatment are published by Agro-Fresh Inc. These guidelines list the recommended maturity parameters (flesh firmness and starch index) and a maximum interval between harvest and treatment for each variety. At NCSU we have examined how the delay between harvest and treatment affects fruit firmness after short-term cold storage for the cultivars Law Rome (Figure 2), Golden Delicious, and Gala. We found a consistent decline in the effectiveness of SmartFresh, measured as the firmness after 40 days in cold storage followed by 7 days at room temperature, for Law Rome and Golden Delicious, but not for Gala, as the delay between harvest and treatment increased from 0 to 7 days. This decrease in efficacy was more dramatic for Law Rome than for Golden Delicious. The maturity of fruit harvested for sale in farm markets may be more advanced than those recommended in commercial practice. When fruit maturity is advanced, it becomes more important to treat the fruit immediately after harvest.

SmartFresh Maintains Firmness of Fruit Kept at Ambient Conditions

We placed samples of untreated and SmartFresh-treated fruit of the cultivars Gingergold, Gala, and Golden Delicious into three different farm markets in the southeast and monitored firmness for up to 4 weeks (Figure 3). Under the high ambient temperatures (often greater than 75° F) that prevailed in these markets, the firmness of untreated fruit rapidly declined to levels that most consumers would find unacceptable (less than 12 lb.), whereas treated fruit maintained their harvest firmness for up to 4 weeks (Figure 3). We do not advocate the use of SmartFresh to maintain firmness of fruit held continuously under high temperatures for several weeks, but these data show that a consumer will still enjoy a crunchy apple even the fruit is "abused" by

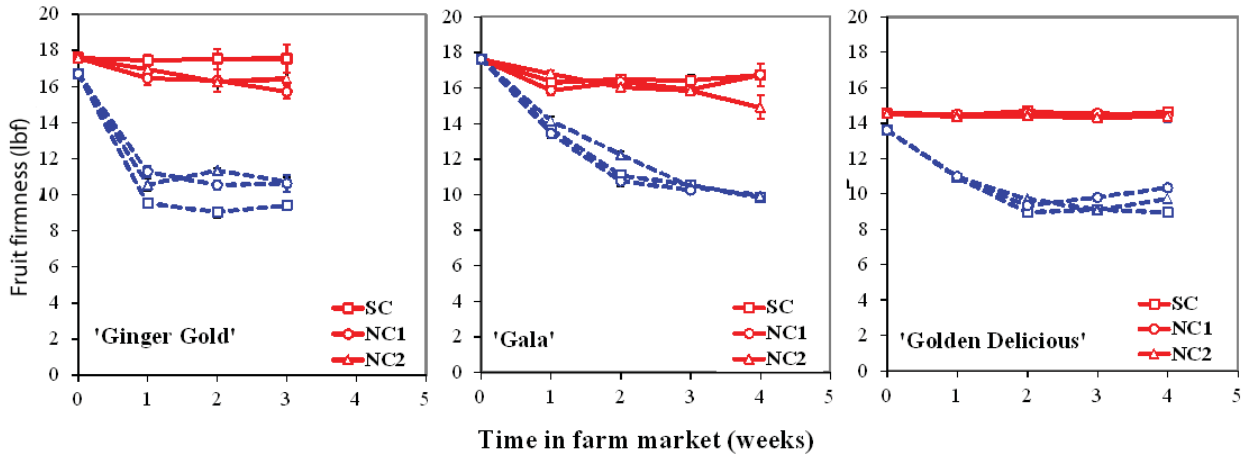


Figure 3. Effects of SmartFresh on firmness of Ginger Gold, Gala, and Golden Delicious apples kept continuously at ambient conditions in three farm markets (SC, NC1, NC2). Red lines represent SmartFresh™ treated fruit, and blue lines represent untreated fruit.

Hot Tip

The treatment tent or room must me airtight in order to keep the concentration of 1-MCP (the active ingredient in SmartFresh) at an effective level during the 24-hour treatment period. Any leaks will result in concentrations falling below an effective level, and the product will not be as effective. How do you know if you have a leak? A trick we use in our research experiments is to include a few tomatoes at the breaker stage of maturity in the tent with the apples and leave a few more tomatoes at the same stage of maturity outside the tent. After treatment we place both treated and untreated tomatoes beside each other in a warm spot for a few days. The treated tomatoes remain green while the untreated tomatoes quickly turn red within a day or two. This method provides a quick confirmation treatment efficacy.

not storing it at ideal temperatures. What is remarkable about these data is that treated Golden Delicious fruit did not exhibit any softening over a 4-week period at ambient temperatures. These data also indicate that SmartFresh can maintain fruit quality in situations where fruit are stored at temperatures that are higher than ideal, perhaps due to cold storage rooms that are not running at optimum temperatures. After several weeks at the ambient temperatures and relative humidity levels in these markets, we saw some fruit rots developing in the fruit, and observed that SmartFresh reduced, but did not eliminate, the incidence of rots. If you are going to hold SmartFresh™ treated fruit for prolonged periods at ambient temperatures then you may need to consider a postharvest fungicide treatment to reduce the incidence of fruit rots.

A Question of Scale

Rooms for treating fruit with SmartFresh have

Figure 4. The Adjustable Apple Tent (http://theblimpworks.com/) has a four bin footprint and can treat 4, 8, or 12 bins of fruit at a time. The tent is raised or lowered to minimize dead space and maintain the concentration of active ingredient at an effective level for the duration of the 24-hour treatment period. It is easily sealed around the base with a water bladder.

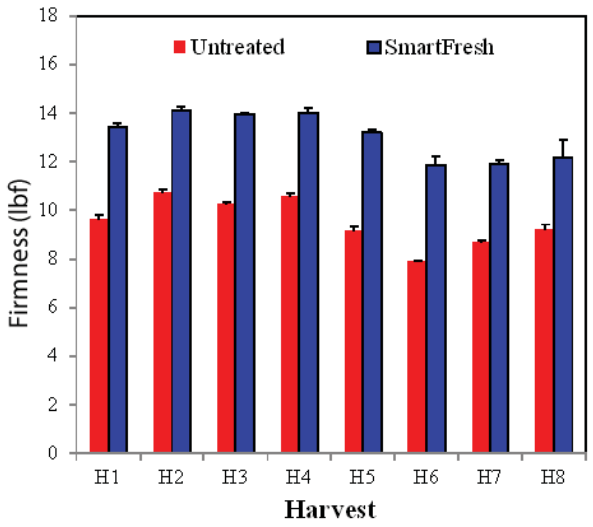


Figure 5. Effects of SmartFresh treatment at different harvest dates (H1-H8) on the firmness of Golden Delicious apple fruit after 8 weeks in cold storage. Fruit at the final harvest date (H8) had a starch index of 7.8 (maximum index is 8) and 80 percent of the fruit with an internal ethylene concentration greater than 1 ppm, indicating that maturity had progressed beyond the climacteric point.

typically been large, with capacities anywhere from 50-500 bins if fruit at a time. Many growers are not able to fill a room that size within one or two days after harvest. Growers can either build their own airtight chamber for SmartFresh treatment, or purchase a purpose-built unit. In our research we have used a two-bin capacity pallet tent where a 4 mil polyethylene pallet cover (64" × 56" × 108") is placed over a frame made from ¾" PVC pipe (60" × 50" × 70" H). To keep the pallet tent airtight we place it on a linoluem base and use duct tape to seal the pallet cover to the linoleum. Working with a local company (The Blimp Works, Statesville, NC; http://theblimpworks.com/), we have developed an Adjustable Apple Tent that has a capacity for treating 4, 8, or 12 bins of fruit at a time (Figure 4). A battery-operated fan is placed inside these tents to ensure good air circulation during the 24-hour treatment period.

Does the Fruit Need to be Cold Prior to Treatment?

We investigated the effect of fruit core temperature on the efficacy of SmartFresh on Golden Delicious in 2012. Fruit were harvested from the same trees on the same day, either early in the morning when the core temperature was coolest (approx. 60°F) or during the hottest part of the day when the fruit core temperature was around 95°F. Fruit harvested in the morning were cooled immediately. Fruit from the afternoon harvest were either treated in a pallet tent at ambient temperatures in a packhouse, or in a second pallet tent in a cooler together with the fruit that had been harvested and cooled that morning. Fruit harvested in the morning were already cool prior to treatment, with core temperatures around 40°F; whereas, fruit harvested in the afternoon still had the field heat at the beginning of the treatment period, but cooled slowly during treatment, with core temperatures starting at 95°F and finishing at 40°F after the 24-hour treatment interval. A third fruit sample had fruit core temperatures ranging from 77-86°F during the 24-hour treatment period. What we found was that SmartFresh was equally as effective regardless of fruit core temperature during the treatment period. We cannot claim that this is true of all cultivars, but for Golden Delicious, fruit temperature does not influence SmartFresh effectiveness.

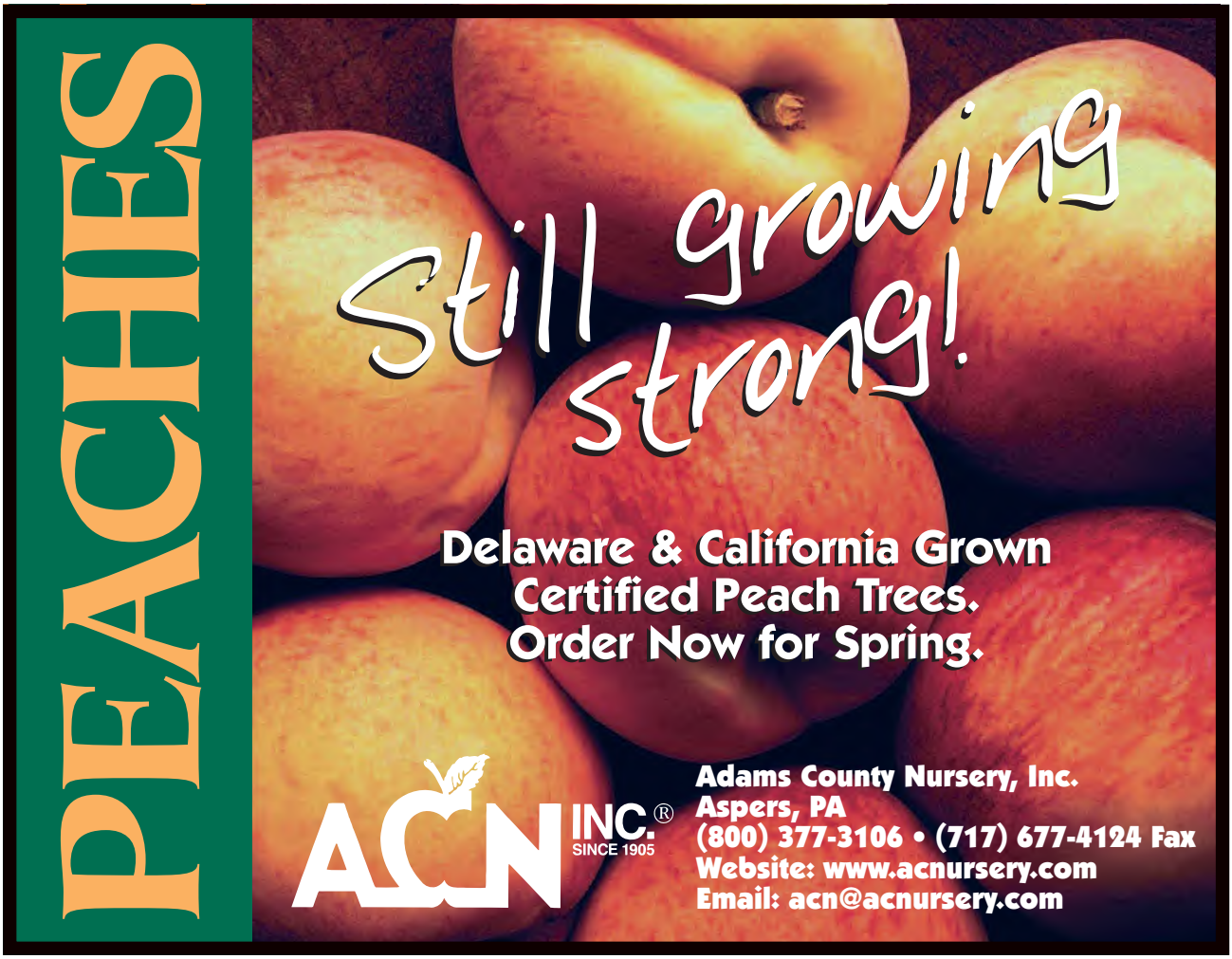
Mature Fruit Respond to SmartFresh

In research with Golden Delicious and Gala, we found that fruit harvested at a very advanced stage of maturity responded positively to SmartFresh treatment on the day of harvest by exhibiting reduced softening and ethylene production after short-term cold storage (see Figure 5 for firmness of treated and untreated Golden Delicious fruit after 8 weeks in storage). Golden Delicious fruit harvested with a starch index of 7.8 (using the Cornell 1-8 starch rating system) and more than 80 percent of the fruit climacteric i.e., with an internal ethylene concentration greater than 1 part per million, still exhibited acceptable firmness (12.2 lb) after 8 weeks storage at 34° F, whereas the firmness of untreated fruit harvested at the same time was only 9.2 lb. Similarly, Gala fruit that were harvested with a starch index of 7.6 and 100 percent of the fruit climacteric exhibited a firmness of 13.6 lb after 8 weeks storage; whereas, the firmness of untreated fruit from the same harvest dropped to 10.9 lb.

Fruit that are harvested at more advanced stages of maturity for immediate sale or short-term storage will have developed a more favorable flavor/aroma profile compared with fruit harvested at an earlier stage of maturity for long-term storage. While there are many individual chemical compounds that contribute to the aroma volatiles in apples, a small group dominates to

create the overall varietal impact characteristic of Gala. SmartFresh treatment can reduce levels of the dominant aroma compounds in Gala (2-methylbutyl acetate, butyl acetate, hexyl acetate, and butanol). The potential for SmartFresh to suppress development of aroma volatiles should provide a note of caution for its use on fruit that are harvested at an early stage of maturity. Such fruit may not develop an acceptable flavor/aroma profile. In contrast, fruit that are harvested at a more advanced stage of maturity, such as those destined for short term storage and sale in direct farm markets, can benefit greatly from SmartFresh treatment. The apples will have developed a more favorable flavor profile on the tree, and treatment with SmartFresh immediately after harvest will ensure minimal loss of firmness and fruit acidity both in storage and during the stressful conditions that may develop in the market or in the hands of the consumer.

Many retail growers in North Carolina have found that SmartFresh is a very effective tool to help them maintain the quality of their fruit. This technology helps them to sell more fresh fruit by providing customers with higher quality fruit over a longer selling season in addition to extending the market window of tree-ripened fruit. Growers who also make their own cider comment that SmartFresh-treated apples have a significantly greater juice yield that pays for the cost of treatment, which is approximately $0.90/bushel.



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