RETAILING REQUIRES TQBM: TOTAL QUALITY BERRY MANAGEMENT

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We have just begun to move into berry season, with the first row-covered strawberry production coming on locally this week (week of 6/13). Despite very cold temperatures in the region on the morning of May 13 (23°F in Burnt Hills, 27°F widely0 I saw little or no cold injury in strawberries, raspberries, and blueberry plantings I have visited. Most injury was confined to tip dieback of summer red raspberries, more so with purple and black. Our recent tropical heat wave -- complete with random monsoons -- pretty much reversed our earlier heat unit deficit. As of 6/15, we are about at normal berry cropping times across the board. Because of the moisture, berries are likely to be on the larger side, and for strawberries and raspberries, may be especially prone to rapidly reach over-maturity; this will be accentuated if the heat resumes. With this in mind, I have incorporated an earlier article I prepared having to do with harvest and post harvest berry handling. The timing on this should be close to ideal.

Total Quality Berry Management (TQBM) involves aspects of proper site selection and preparation, the choice of suitable cultivars, maintaining optimum nutrition and pest management, and educating pickers regarding point of harvest criteria, especially careful handling. TQBM places emphasis upon the rapid movement of the crop from the farm to a pre-arranged market destination via a continuous maintained cold-temperature handling chain. TQBM addresses the need for storage-life plus shelf life, where 'Shelf-life' refers to the extent to which sufficient berry eating quality (i.e. marketing quality) is maintained without cold storage. While in contrast, 'Storage-life' refers to the extent to which eating quality is maintained in berries with cold storage. The goals of TQBM are to expand berry marketing options by using rapid refrigeration to 1) extend the widow of quality fruit availability, and 2) the shipment range of this excellent eating quality fruit than was previously thought possible. TQBM changes the 1 - 2 day shelf life of picked berries @ ambient temperatures (68°F.) to a specific crop's maximum attainable post-harvest quality range. Using proper harvesting and storage techniques, it is possible to maintain quality raspberries for 7 days after harvest, strawberries for 2 weeks, and blueberries for 3 weeks.

Perhaps the three most important keys to achieving TQBM are the following:

- Appreciating the dynamics of post-harvest physiology.
- Using rapid two-stage cooling.
- Maintaining a refrigerated transport and handling chain.

First and foremost, remember that following harvest fruit remains alive! And while harvest is a radical event in a fruitlet's existence, it is not the end of the berry's life -- not yet. Life encompasses senescence and deterioration as well as growth and maturity. Respiration and transpiration are processes governing this cycle of life and post-harvest decline. Post-harvest life span is directly related to the inherent respiration rates of fruit.

Respiration rates of various fruits stored at different temperatures °F (in mg CO2 kg^{-1} h^{-1}).

	@32	@41	@50	@59	@68
Raspberry	24	55	92	135	200
Blackberry	22	33	62	75	155
Strawberry	15	28	52	83	127
Blueberry	10	12	35	62	87

Respiration is the oxidation (O_2) of food reserves in the fruit to produce energy. A simple representation of the process would be:

$$\text{Starches / sugars} \rightarrow \overset{\downarrow O_2}{} \rightarrow \text{organic acids} \rightarrow \overset{\downarrow O_2}{} \rightarrow \text{simpler carbon compounds} \rightarrow \overset{\downarrow O_2}{} \rightarrow \text{eventually } CO_2 + H_2O + \text{heat}$$

Our second concern, transpiration, involves water loss. It is prompted by differences of water vapor concentration (i.e. which means pressure differences). Like all gasses, water vapor disperses from regions of greater concentration to regions of lesser concentration. Harvested fruits, and indeed all plants, constantly loose water to the environment. Vapor pressure decreases over a gradient between the fruit cell, the intercellular spaces surrounding those cells, to the atmosphere surrounding the fruit. This means a concentration gradient moving from about a 99% relative humidity to one of 50% to 80% depending upon the outside environment.

Putting these two forces together, unmanaged respiration and transpiration cause many undesirable outcomes:

- Sugars are oxidized and cells loose turgor pressure.
- Energy deficit and membrane disarray open fruit to pathogen invasion.
- Symptoms of deterioration and senescence as follow:
- Loss of berry crispness, texture, flavor, sweetness, and nutritive value.
- Loss of Berry weight due to shrinkage, shriveling.
- Wilting, softening, and berry rot (death).

What then must be done with harvested fruit to put the brakes on respiration and transpiration to ensure TQBM?

- Harvest in the cool of the day. Have a runner or individual pickers take filled flats to a shaded central pickup point.
- Cover flats with a moist, light-colored tarp and provide shelter from the wind in order to retain water vapor.
- Rapidly cool fruit to remove field heat. An 18° drop in fruit temperature equals a 2X - 4X drop in respiration rate.
- E.G. Raspberries held at 32°F and 90% RH, rather than 77°F and 30% RH, water loss rate will be 35 times slower.
- E.G. Strawberry shelf life, at 30°F, is 50% greater than at 40° F.

Refrigeration is an absolute to TQBM. Passive refrigeration has the advantage of being relatively inexpensive, but involves a long cool-down period, which severely compromises storage-life potential. Controlled atmosphere (CA) cold storages (which combine refrigeration, higher CO_2 levels, and reduced O_2 levels to reduce respiration rates) has a similar cool-down phase, but due to the modified gas environment, it is conducive to long-term produce storage. However, it is not rapid enough for highly respiring fruits (such as our small fruits) and is cost-prohibitive to smaller growers. A third general cooling approach is pre-Cooling which utilizes two-stage refrigeration. It has the advantage of being relatively easy to construct and adapt, and it is the least expensive approach after passive. Liquid ice, hydro cooling, or vacuum cooling as pre-cooling methods, have differing problems of practicality for small fruit processing, higher pathogen transmittal risk, and relative expense. Rapid forced-air pre-cooling is the most practical choice for most small fruit operations. Several operating principles are involved for rapid forced-air cooling:

- Refrigerated air (35°F) is ducted so that it is pulled to and through covered vented flats. Warm air then returns to flow over the coils of cooling unit to repeat the cycle. Air leakage is controlled in the loop and the larger cooler.
- Heat is removed by convection not conduction. A monitoring unit tracks fruit flesh temperature drop and trips fans (i.e. turns them off) within 5° of 32°F. (Excess air movement causes dehydration).
- Ideal design: a separate cooling chamber sized to harvest flow. Can be adapted to a portion of a cooler.

TQBM requires both rapid pre-cooling and high relative humidity (RH). Theoretically, if the cold storage could be at 100% RH, so long as there is a vapor pressure differential between the warmer fruit and the cold air of the storage, fruit would continue to rapidly loose moisture until temperatures were equated. Cool-down in a passive system is too slow. Even if fruit and cooler have similar relative humidities, the differences of temperatures represent very different drying powers, for vapor pressure deficit. (VD)

Location and Temperature °F	Humidity Relative % Fru, Air	Pressure (mm Hg) Vapor Fru, Air	Deficit
Fruit, Air @ 37	100, 90	5.69, 5.12	.57
Fruit, Air @ 32	100, 90	4.58, 4.12	.46

(See example →) (Note: Storage RH & VD never = 0) (Information from USDA Agricultural Handbook 68, p 20.)

- Recommended storage regimens:
  Raspberries and Strawberries at 32°F and 90-95% RH. Blueberries at 32°F and 85% RH

Rapid pre-cooling puts the brakes on pathogens too. *Rhizopus* rot is unable to grow below 40°F, and *Botrytis spread* to healthy fruit is arrested at 32°F. In general, Rapid cooling to 32°F complements fungicide control to counter the incidence of various food spoilage fungi, including: *Cladosporium, Penicillium, Mucor, Aureobasidium, Alternaria, Epicoccum, Didymella Species.*

TQBM also requires that you maintain the 'Cool Quality Chain'. Consider this: farmgate to consumer fruit loss, due to deterioration and rot, is estimated at about 40%, and it is largely due to poor handling. Some 14% of the loss occurs in the chain from farmer to wholesaler, 6% from wholesaler to retailer, and 22% from the retailer to the consumer. (Gives new meaning to loss leaders in the produce section.) In the cool quality handling chain, there are plenty of opportunities or places for things to go wrong. You need to focus on your percentage piece of the problem and you need to educate your customer on his, so that together you may enhance everyone's profit and satisfaction.

TQBM seeks to avoid the losses associated with handling and transport breaks in the cool quality chain. This can be achieved by observing the following:

- After pre-cooling, cover berry containers with rubber-banded cellophane (reduces water loss, excludes contaminates, and aids overall appearance).
- Cover flats with plastic before removal from cold storage. Maintain covers over cellophaned fruit through each phase of refrigerated movement.
- When placed in ambient air, allow berries to warm above the dew point before removing the outer plastic. (Deters sweating or condensation on either berries or cello. Reduces pathogen development risk and appearance problems.)
- Pre-cool fruit first, and move by refrigerated transport. (Refrigerated trucks are incapable of removing field heat.)
- Avoid non-refrigerated breaks in cool fruit movement.
- Properly position flats on pallets in truck. Do not overload the vehicle, as free air movement is critical. Air should flow from the front elevated cooling unit, to the rear of the truck, to be deflected down and under flats.
- Avoid flat contact with the truck body (this can raise flat temperatures as much as 20°F).
- Use trucks with good air suspension. Avoid stacking over wheels. Make sure to stabilize the load

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