Postharvest Handling & Storage Of Saskatoons

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Factors Affecting The Shelf Life Of Fruit

Fruit quality, that is, flavour, color, texture and size, generally improve as the crop approaches maturity. Unfortunately, ripening increases the sensitivity of the fruit to damage and decay from handling. Fruit begin to deteriorate as soon as they are harvested. Fruit are comprised of living cells and continue to respire after harvest. Respiration involves the uptake of oxygen from the atmosphere and the release of carbon dioxide, moisture and heat. Moisture loss causes fruit to dehydrate and the heat produced causes loss of quality, in particular flavour. Freshly-harvested fruit are prone to injury and attack by micro-organisms, and high temperatures during harvesting increase the susceptibility of fruit to fungal infection. Therefore, effective temperature management is crucial for maintaining post-harvest quality and prolonging shelf life of saskatoons.

In general, the following factors have been found to decrease the shelf life of fruit: a) excessive use of nitrogen fertilizer; b) an excess of water; c) fruit damage resulting in cracks and abrasion allowing access by disease-causing organisms; d) fruit picked prior to optimal maturity; and e) long delays between harvesting and storage.

Fruit quality may be maintained by appropriately timing harvest, minimizing bruising and handling, harvesting early in the day to minimize heat load, cooling the fruit as quickly as possible, and transporting the harvested crop to market as quickly as possible.

Rapid Field-cooling Of Harvested Fruit

Freshly harvested fruit should be placed in clean, shallow trays that are rigid and reusable. The trays should have openings that permit heat to escape and allow cool air to enter. To prevent crushing and permit cold penetration, the depth of fruit in the containers should not exceed 15 cm. The trays should be routinely cleansed to prevent the accumulation of microorganisms and other unwanted residue.

The trays with the harvested fruit should be kept in the shade or covered with reflective tarpaulins to avoid warming in the sun. Fruit left in full sun can increase in temperature from 2 - 8°C per hour. Reflective tarpaulins have been found to keep fruit temperature lower, and also maintain a higher humidity around the fruit, reducing moisture loss.

Rapid cooling of fresh fruit after harvest is essential to maintain quality and lengthen shelf life. Pre-cooling of the fruit prior to storage is required to remove the field heat and reduce the heat of respiration as quickly as possible. Cooling should commence as soon as possible and should be completed within 6 hours after harvest in order to maintain fruit quality. Fruit sugars, acidity, and other flavour components, as well as moisture will be lost through fruit respiration if cooling is delayed. It is estimated that for every hour delay in cooling, shelf life is reduced by one day.

Cooling of fruit does not occur at a constant rate. The initial cooling rate is quite rapid as there is a large difference between the temperature of the air in the cooler and that of the fruit. However, the cooling rate decreases substantially as the fruit temperature approaches the air temperature. For example, if 5 hours are required to remove 50% of the field heat, then 10 hours of cooling are required to remove 75%, 15 hours to remove 87.5%, and 25 hours to remove 97% of the field heat.

Decay organisms thrive on warm fruit, decreasing their shelf life. Gray mold (*Botrytis cinerea*) is the most common fungal organism causing postharvest fruit decay in small fruits including saskatoons. Although this fungus continues to grow even at 0^oC, its development is significantly reduced at this temperature. Saskatoon fruit should be cooled and stored as close as possible to 0^oC.

In general, room cooling (that is, placing fruit in a storage cooler) is not an efficient means of quickly cooling large quantities of fruit even with evaporator fans set on high. In addition, the high air circulation and heavy load on the cooling unit required to remove field heat from newly-harvested fruit can dehydrate previously cooled fruit stored in the cooler. A standard room cooler is intended only to maintain the temperature of precooled fruit using a low air circulation rate. Depending on the quantity of fruit and the refrigeration capacity of the cooler, fruit from the field often take up to 24 hours or longer to reach 0^oC in a room cooler. Room cooling is generally used for produce such as potatoes or citrus fruit with low respiration rates and a relatively long shelf life.

A number of more effective methods are available to rapidly cool fruit including ice cooling, hydrocooling, and forced-air cooling. Cooling with ice usually involves spreading crushed ice over the containers of fruit using a ratio of 1 part ice to 3 - 4 parts fruit by weight. Sealed cold packs can remedy the situation, but excess condensation may be a concern. Cold packs have the benefit of being reusable. An ideal product is a reusable ice substitute such as that manufactured by Cryopak Corporation. This is a versatile product purchased in rolls which can be cut to size. The coolant in the Cryopak ice substitute is food grade material, thus eliminating any concerns with accidental leakage. In hydrocooling, fruit are showered or immersed in chilled water. These two ‘wet’ methods of cooling can be quite effective, but unless the fruit are to be frozen or processed, the excess moisture left on the fruit can contribute to the growth and spread of disease. Chlorination of hydrocooled water, while controlling the spread of microorganisms, can create worker safety and disposal problems, depending on the chlorination compound and concentration used. Although hydrocooling is very rapid, it does not lend itself well for use by producers with small operations, or for containerized fruit that are cooled after packaging.

Forced-air cooling is commonly used and recommended for small fruit crops. Forced-air cooling is considered the most efficient and effective means to cool small fruits. In forced-air cooling, cold air is forced through containers of fruit in order to remove field heat as rapidly as possible. Forced-air systems can be set up in a number of ways but all involve creating a pressure gradient across the two sides of a stack of produce. This is usually accomplished by using a fan to draw cold air through stacked containers within a cooler. Forced-air systems can utilize either horizontal or vertical air flow. Horizontal flow has the disadvantage that a large portion of the air can bypass the fruit through the head space above the fruit in the containers. In vertical flow, all the air must pass through the entire mass of fruit making this method more efficient.

In a common horizontal system, two rows of pallets of fruit are lined up starting from one wall of the cooling room. A space of 0.6 - 1 m is left between the two rows and a fan is centered on this gap placed at the end opposite the wall. The top of this space is covered with a tarp or plywood to create an enclosed tunnel. The fan will then pull air from the outside through the containers of fruit. If fewer stacks are available, one row of pallets can be arranged starting against the wall and 0.6 - 1 m out from a corner of the room; the tunnel can then be created between the stacks and the wall.

Cool air contact with all of the fruit during cooling is critical, otherwise fruit in the interior of the containers will not be properly cooled, and will continue to respire and lose quality. For forced-air cooling to be effective, fruit containers must have openings on at least 15% of their surface to permit air to pass through. The holes in the containers should not be blocked by boxes or pallets (if vertical air flow is used). To achieve the best results, the containers of fruit must be stacked and arranged to allow air to come in contact with the fruit and not bypass around. The end of the stacks must be set tightly against the wall and the pallets against each other to minimize air gaps. Closing off outside cracks between the pallets with foam rubber increases the cooling efficiency and decreases the cooling time. This system should be set up to cool fruit quickly, ideally within two hours. Cooling time will depend on the fruit temperature, the amount of fruit to be cooled at one time, fan size, and the refrigeration capacity of the cooler. If cooling is not rapid enough, a larger fan may be required. Forced-air cooling can be up to 10 times faster than room cooling.

Ideally, forced-air cooling should take place in one cooler and cold storage in another. A high refrigeration capacity is required for a forced-air system to handle the large amount of field heat to be removed. For example, 100 times more refrigeration capacity is required to cool pears in 24 hours than to keep them in cold storage for this time. Cooling rooms with large evaporators need to run less often which makes it easier to maintain a high humidity in the room. Humid air minimizes fruit moisture loss and has a greater capacity for removing heat than dry air. Cooling rooms that are used for storage require a smaller refrigeration capacity as they only need to maintain the temperature of the precooled product.

Growers with small orchards and only one walk-in cooler may be able to improvise. The forced-air system can be set up at one end of the cooler and storage at another. However, the refrigeration capacity of the cooler must be sufficient to remove the field heat, otherwise the room temperature will warm, lengthen the cooling time and cause condensation to form on already cooled fruit. The forced-air system should be set up under the evaporator coils and the already cooled fruit stored at the opposite end of the cooler. This allows the cold air from the evaporators to contact the cold produce first (as the air flows over the tunnel of fruit to be cooled), otherwise the cold air would first contact the hot produce, warm up, and then would come in contact with the cold produce, causing undesirable condensation. Stored fruit should be arranged in such a way to allow for good air flow within the cooler.

A simple form of a forced-air system can be adopted by producers with small operations, who do not have the fruit volume for the typical set up. Recently-picked containers of fruit can be set into a cardboard box which is opened at both ends. A household fan is then placed at one end of the box pointing outward to draw air through the containers of fruit. Alternatively, the top and sides of a row of stacked trays of fruit can be wrapped in plastic leaving the narrower ends open. A fan can be positioned at the narrow end of the row to draw air through the stack of fruit.

The absence of water in forced-air cooling avoids the spread and growth of mold and bacteria which can be a problem when using ice or hydrocooling. However, the disadvantage of forced-air cooling is that it can cause dehydration of the fruit. If the forced-air cooling unit is within a cooler that is also used for storage, the high air flow through the cooler can result in excessive moisture loss from previously cooled fruit unless they are covered with plastic. The fruit will constantly lose water to any atmosphere that is drier than the interior of the fruit. To minimize water loss from the fruit during forced-air cooling, the humidity should be maintained at 90-95% within the cooler. Some growers have found that wetting the walls and floors of the cooler is effective in maintaining a high humidity. A cool mist humidifier or some other form of humidification may need to be installed. Once the fruit are cool, containers or flats can be wrapped in plastic to reduce moisture loss from the fruit during storage and to prevent condensation forming on the fruit when removed to warmer temperatures.

Cooled fruit should be kept cold through all subsequent processes including transportation and storage. If the fruit are brought into a warm environment after cooling, condensation will form on the fruit, unless the containers are covered with plastic. Thus it is important to avoid warming of packaged fruit until the fruit reach the retail counter. Because it is difficult to avoid warming and cooling of the fruit during the transportation and marketing process, some blueberry growers only cool their fruit to 5°C so that condensation will more likely be prevented; however this will also shorten the shelf life. The plastic wrap covering the fruit can be removed after the fruit have warmed on the retail counter; any condensation will have formed on the plastic wrap rather than the produce.

Refrigerated transport is intended only to maintain the temperature of the cooled fruit and is not designed to remove field heat from the fruit. Transport trailers should be cooled prior to loading the fruit. Containers or pallets of fruit should be arranged in the trailer away from the side walls, allowing for good air circulation around the stacks of containers. The time of loading and unloading of the fruit, as well as time in transit, should be kept to a minimum.

All postharvest handling and cooling systems must be appropriate in size, cost and performance to suit the grower. The systems should also be adaptable for future expansion to support increasing production. Each step in the process, from harvesting, to cooling, and to storage, should be designed to work together. For example, the capacity of the handling and cooling systems must match the capacity of the harvester. Proper handling, cooling, storage and transport of the fruit all contribute to ensuring that a good quality product reaches the consumer.

Cleaning & Sorting Fruit

Cleaning fruit is a slow, messy job, and the primary bottleneck to getting the harvested fruit to market. The maintenance of consistent fruit quality is important.

The cleaning and sorting line should be as cold as is practical. Cooling costs will be reduced if fruit go through the cleaning and sorting process prior to rapid cooling. However, this should only be done if the fruit can make it from the field, through the sorting and grading process, into containers, and rapidly cooled within 3 - 4 hours of harvest. Fruit can benefit from rapid and immediate cooling even if some rewarming occurs during subsequent handling.

The process of cleaning is far slower than harvesting. Two to three cleaning tables will be required to keep up with a mechanical harvester. If fruit are hand-picked, the pickers can be trained to pick only those fruit that appear to be marketable. Machine-harvested fruit need to be cleaned of leaves and twigs. Regardless of the method of harvest, the fruit will need to be examined on some form of conveyor system in order to cull green and red fruit, leaves, fruit stalks, diseased or damaged fruit, and overripe or mushy fruit (refer to Figure 5.4, Plate 5 in factsheet 14.1 on harvesting saskatoons).

Machines used for cleaning and sorting should be made of stainless steel, should have a variable speed fan, an adjustable air flow, a white conveyor belt, and troughs for culled fruit.

An airdraft berry cleaner equipped with a sorting table (Figures 1 & 2) can be purchased from Hometown Machines (Sundre, AB) at a cost of approximately $9,000. With three persons on both sides of the sorting table (3.7 m (12 ft) long, 1.8 m (6 ft) high, and 0.8 m (30 in) wide), 20 kg of fruit can be sorted in less than 30 minutes. A similar cleaner equipped with a 3.1 m (10 ft) sorting table can be obtained from BEI

(South Haven, MI) at a cost of approximately US$9,000.

Figure 1. Top view of an airdraft berry cleaner.

Figure 2. Sorting table.

Washing Fruit

Unless the fruit are to be frozen or immediately processed, washing of fresh fruit is not advisable, as any excess moisture remaining on the fruit can contribute to the spread and development of disease. Consumers are accustomed to washing fresh produce prior to eating.

Fruit intended for frozen storage or processing needs to be washed prior to freezing. The reason is that most secondary processors do not wash fruit prior to processing. Therefore, it is important that primary processing should include a washing step. However, for small operations, washing fruit does not appear practical. The water used for washing must be potable (i.e. free of toxic chemicals and not contaminated with micro-organisms).

Washing removes dirt and chemical residues from fruit surfaces. After washing, the excess moisture on fruit surfaces needs to be removed prior to freezing. Drying is therefore necessary; drying avoids clumping of fruit during freezing.

A washing/drying unit can be purchased from BEI at a cost of approximately US$9000. This unit is 3.1 m (10 ft) long, 1.5 m (5 ft) high, and 0.8 m (30 in) wide (Figure 3). Machines used for washing and drying should be made of stainless steel, should have a variable speed motor, a stainless steel mesh conveyor belt and troughs to remove culled fruit during final inspection. A longer conveyor belt allows for more effective drying.

It is important to remember to routinely clean harvesting equipment, coolers and processing facilities. This is necessary to avoid contaminating clean fruit and to ensure optimum quality of stored fruit. Growers must also be aware that care must be taken to ensure good sanitary practices when handling fruit. Good sanitary conditions must also be provided in the work place. Some potential ways in which fruit can become contaminated by people is by touching other body surfaces (such as skin, hair, nose, mouth), coughing, sneezing, using toilet facilities, or any other activity in which hands become soiled.

Figure 3. Primary processing line showing airdraft cleaner and washing/drying unit.

If the fruit are bagged, the bags should not be tied shut with a twist tie because these can get mixed in with the fruit. It is better to tie the actual bag, or use brightly-colored string. Figures 5.5 and 5.6 (refer to Plate 5 in factsheet 14.1 on harvesting saskatoons) illustrate two methods of packaging and marketing fresh saskatoons, including freezing and fresh-packaging the fruit.

Optimal fruit quality (i.e. flavour, colour, texture and nutritive value), fruit size and fruit weight are important characteristics for marketing fresh fruit. These quality characteristics can be attained by harvesting fruit at full maturity (purple fruit) and by proper handling of fruit after harvest. Good temperature management during harvesting and at post-harvest is critical for maintaining quality and prolonging shelf life, and can be achieved by harvesting in the cool hours of the day (early in the morning or late in the evening), promptly cooling fruit to remove field heat, promptly cleaning fruit to remove diseased and damaged fruit, and holding fruit at or near the optimum storage temperature during transportation and primary processing.

Storage Of Fresh Fruit

Fresh saskatoons in marketable condition can be stored for a minimum period of two weeks using modified atmosphere packaging (MAP). Modified atmosphere packaging is a storage method that involves wrapping fruit with plastic. The plastic packaging modifies the atmosphere around the fruit by decreasing oxygen levels from 21% (atmospheric level) to 1 to 2%, and increasing carbon dioxide levels from 0.03% (atmospheric level) to well above 5%. By altering the atmospheric composition around the fruit, respiration and other chemical processes associated with fruit deterioration are substantially slowed down. Modified atmosphere packaging also creates high humidity around the fruit, thus preventing dehydration, and decreases the activities of decay organisms. The consequence is that fruit quality is maintained and shelf life extended. It is important to note that modified atmosphere packaging is only effective if fruit are stored at low temperatures. For saskatoon fruit, the optimum storage temperature is 0˚C.

Fruit destined for retail markets can be stored in half-pint plastic containers (typically used for packaging strawberries and blueberries) which are placed in cardboard boxes. The cardboard boxes must be wrapped in plastic and heat-sealed. This is necessary to effectively modify the atmosphere around the fruit in order to maintain a high relative humidity (85-90%), and to slow the growth of micro-organisms.

Modified atmosphere packaging can be obtained from Unisource Canada, Saskatoon or Regina, SK (code 039029), or from Winpak Ltd.,Winnipeg, MB, as roll stock (PAE 2060 L) or as a stock pouch (VAK 3 L).

Modified atmosphere packaging allows a minimum storage period of two weeks. This is sufficient time to transport fruit from the processing centre to retail markets. Several market avenues currently exist for fresh fruit but the major limitation is a consistent fruit supply. It is important to remember to transport fruit in a cool environment. This is necessary precaution to continue maintaining fruit quality and prolonging shelf life.

Pallet loads of fruit, stacked in two or three Fish ‘N Farm trays, can be stored for at least one week by wrapping the pallet with plastic and heat-sealing. Fruit can then be stored at 0˚C. No more than three trays should be stacked on a pallet. More trays allows the accumulation of excess moisture in the lower trays, which could increase the susceptibility of the fruit to disease.

Frozen Storage

For optimum freezing quality, fruit must be frozen as quickly as possible. A blast freezer or a cryogenic freezer (to produce individually quick frozen, or IQF, fruit) can be used. Although a cryogenic freezer is faster at freezing fruit than a blast freezer, the costs of operating are much higher.

For blast freezing, the fruit are placed in Fish ‘N farm trays and frozen. These trays are effective for freezing because the slots at the sides and bottom allow for rapid air movement which hasten the freezing process. Trays can be stacked to create freezer space. After freezing is completed (usually within 2 to 3 hours depending on the freezer temperature), the trays containing the fruit are wrapped with plastic. Wrapping minimizes freezer damage and maintains frozen fruit quality. The frozen fruit should be stored at -20˚C to -40˚C. Lower temperatures are more effective for prolonged storage. For cryogenic freezing, after the freezing operation is completed, the fruit are wrapped with plastic and stored at -20˚C to -40˚C. As a general rule, temperature fluctuations in the freezer should be minimized to ensure good fruit colour, texture and flavour. Household deep-freezers should not be used. These freezers are not equipped for freezing large quantities of fruit, are characterized by large temperature fluctuations, and decrease fruit quality.

Research conducted at the University of Manitoba has shown that saskatoon fruit can be frozen within 1 hour to -10˚C using an on-farm blast freezer. The temperature of the freezer was -30˚C ; the temperature of the incoming fruit was 5˚C. The prototype freezer consisted of a compressor, and an evaporator with a fan enclosed in an insulated chamber (2.4 m (8 ft) wide x 2.4 m (8 ft) long and 3.1m (10 ft) high). During the operation of this freezer, air circulating from fans draws heat away from stacked trays of fruit. The capacity of the blast freezer was 600 kg and the trays used were Fish ‘N Farm trays.

Further Reading

Mitchell, F.G. 1992. Cooling Horticultural Commodities. I. The Need for Cooling. pp. 53-56 in Kader, A.A. (ed.). Postharvest Technology of Horticultural Crops. University of California, Division of Agriculture and Natural Resources. Publication 3311.

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