



THE FIRST CUT DEFINES GRAPE SHELF LIFE: HOW HARVESTING TOOLS SHAPE POSTHARVEST QUALITY

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Abstract

Harvesting is the first and one of the most critical postharvest operations for grapes. Due to thin epidermis, high surface-to-volume ratio and delicate waxy bloom, fruits are highly sensitive to mechanical injury. The choice and handling of harvesting tools directly influence postharvest quality by affecting berry integrity, stem tissue continuity, wound-induced physiological responses and susceptibility to latent infections such as *Botrytis cinerea*. Minor injuries during harvest can accelerate water loss, respiration, rachis browning, berry shatter and decay, thereby significantly shortening shelf life. Hand tools like secateurs and clippers, when properly maintained and sanitised, preserve fruit-stem integrity, while harvesting knives and mechanical harvesters may introduce varying degrees of damage depending on usage and precision. Emerging smart harvesting technologies, including force-controlled and sensor-assisted tools, offer improved precision, reduce physiological stress and enhance uniformity in ripening, ultimately extending postharvest shelf life.

Keywords: Grapes, harvesting, postharvest, quality, shelf life

Introduction

Harvesting tools are a component of postharvest technologies, not merely labour aids. Harvesting time represents the final stage of fruit development and plays a crucial role in

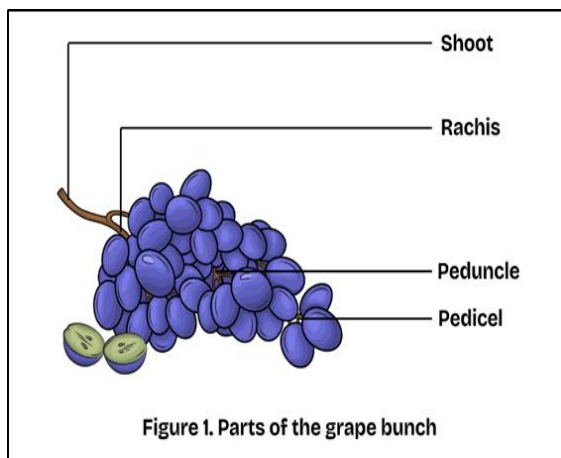
determining the overall quality of the fruit. Harvesting is the first postharvest operation, where the choice of harvesting tool critically influences the extent of mechanical injury, the activation of wound-induced physiological responses, and the magnitude of stress-related ethylene production. The physiological events strongly affect the susceptibility of fruits, particularly grapes, to latent infections that may remain undetected at harvest but develop rapidly during storage and distribution. Even microscopic damage caused by blunt, contaminated or improperly used harvesting tools can disrupt tissue integrity, accelerate senescence and dramatically shorten shelf life.

Grapes – Extremely Tool Sensitive

Grapes are among the most delicate of fresh fruits, largely due to their thin epidermis, high surface-to-volume ratio and the presence of a natural waxy bloom on the berry surface. This epicuticular wax plays a crucial role in limiting water loss and protecting berries from microbial invasion. During harvest, even minor mechanical injuries like abrasions, punctures or compression caused by inappropriate tools can disrupt this protective barrier. Once compromised, grapes rapidly lose moisture, respiration rates increase and the risk of decay rises sharply. As a result, harvesting tools become a decisive postharvest factor, often determining whether grapes retain their quality or deteriorate quickly during storage and distribution.

Anatomy of a Grape Bunch

A grape bunch is a highly integrated structure in which berries remain physiologically connected to the plant through the peduncle, rachis and pedicels even after harvest. These stem tissues play a vital role in maintaining water balance, nutrient movement and overall bunch freshness. Any damage to the rachis or pedicel during harvesting disrupts vascular continuity, leading to rapid dehydration, accelerated rachis browning and weakened berry attachment. Because grapes do not possess a protective peel like many other fruits, injuries to the stem tissues often have a greater impact on postharvest quality than direct berry damage. Preserving fruit–stem integrity at harvest is therefore critical for maintaining grape freshness during storage and distribution.



Harvest Management

As grapes are non-climacteric fruits, achieving proper ripening is essential both for marketing them as fresh fruit and for producing high-quality grape-derived products. Ripening is a dynamic, temporal process influenced not only by climate but also by vineyard location and grape variety. It is a complex phenomenon that cannot be captured by a single parameter; rather, it involves coordinated changes in the levels of sugars, acids, phenolics, and other bioactive compounds within the berries. The berries are

typically harvested when they reach the desired balance of sugar, flavour and colour. In unripe berries, glucose predominates, but as the fruit ripens, glucose and fructose accumulate in roughly equal amounts, forming a 1:1 ratio. The timing of harvest varies depending on the variety and intended use, whether for wine, table grapes, or raisins. Grapes are usually hand-harvested, with clusters carefully cut from the vine and handled gently to prevent bruising or other damage that could compromise quality and shelf life.

Hand Pulling vs Cutting

In grape harvesting, the method of detachment is just as important as the tool itself. Hand pulling of bunches often results in tearing of the peduncle. It causes damage to the rachis, disrupting vascular continuity and creating uneven wound surfaces. This mechanical stress accelerates water loss, increases respiration and weakens berry attachment, leading to higher levels of berry shatter during handling and storage. In contrast, harvesting grapes by clean cutting preserves the structural integrity of the rachis, allowing more uniform wound healing and reducing physiological stress. Cut bunches maintain freshness longer and show lower susceptibility to postharvest decay, particularly under cold storage conditions.

Harvesting Tools Used in Grape Harvesting

Grape harvesting relies on specialised tools designed to detach bunches with minimal mechanical stress while preserving the integrity of both berries and stem tissues. Because grapes are highly sensitive to physical injury, the choice and condition of harvesting tools play a crucial role in maintaining postharvest quality.

1. Secateurs and hand clippers

Secateurs and hand clippers are the primary tools used for harvesting table grapes, valued for their precision and ease of handling.

When kept sharp and properly aligned, these tools produce clean cuts at the peduncle, minimising vascular damage and allowing the fruit to heal quickly. Stainless steel clippers are especially preferred because they resist corrosion, maintain sharpness longer and are easy to sanitise, reducing the likelihood of transferring pathogens from one bunch to another. Careful use of these tools ensures that both berries and stem tissues remain intact, helping to preserve freshness and extend postharvest shelf life.

2. Harvesting knives

Harvesting knives are sometimes employed, especially in traditional grape-growing systems. However, uneven or forceful cuts can easily injure the rachis and adjacent berries, increasing the risk of dehydration, bruising, and postharvest decay. For high-quality table grapes, knives are generally less suitable unless used with exceptional care and precision, as even minor damage can compromise fruit integrity and shorten shelf life.

3. Mechanical grape harvesters

Mechanical grape harvesters use shaking or vibratory mechanisms to detach berries and are widely employed in vineyards producing wine grapes. Minor berry damage is generally acceptable. These machines offer the advantage of significantly reducing labour costs and speeding up the harvest. However, vigorous action can cause berry detachment, microcracks in the skin and loss of the protective epicuticular wax, all of which reduce fruit quality. For fresh-market table grapes, where appearance, firmness and shelf life are critical, mechanical harvesters are less suitable unless additional care is taken during handling and postharvest management.

Types of Mechanical Grape Harvesters

- **Trailed Harvesters:** Trailed harvesters rely on an external power source, such as a tractor, making them a cost-effective option for

growers who already own one. They can be equipped with either canopy or trunk shaker heads to suit different vineyard designs. However, they may cause more damage to vines and trellises. So, careful operation is required, especially on sloped terrain.

- **Self-Propelled Harvesters:** Self-propelled harvesters have their own engine and are equipped with a shaking system, collecting and transport mechanisms and cleaning units. They are widely used in major wine-producing countries, allowing large areas to be harvested efficiently while reducing labour requirements.
- **Autonomous and Robotic Harvesters:** These modern machines are designed to operate independently and adapt to different grape sizes and shapes. They offer precise harvesting while reducing labour needs, making them ideal for high-tech, modern vineyards.



4. Collection Aids

In addition to cutting tools, collection aids such as padded harvesting trays, shallow crates and smooth-surfaced bins are essential for maintaining grape quality during harvest. Even when precise cutting tools are used, poorly designed or overfilled containers can introduce compression and impact injuries, leading to bruising, juice leakage and increased

susceptibility to decay. Properly designed collection aids help cushion the fruit, preserve the integrity of the berries and rachis, and ensure that the care taken at the point of harvest is not lost before grapes reach storage or transport.

Tool Hygiene and Disease Transmission

Harvesting tools can serve as silent carriers of pathogens, turning every cut into a potential infection site. In grapes, fresh cuts made by unclean secateurs, knives or clippers create direct "infection courts" where fungal spores, particularly *Botrytis cinerea*, can enter. Even when infections are not immediately visible, latent infections may develop during cold storage, causing sudden outbreaks of decay that compromise entire bunches. These hidden infections not only accelerate postharvest losses but also reduce export quality and shelf life. Maintaining strict tool sanitation by cleaning and disinfecting blades between cuts can be more effective at limiting disease spread than some postharvest fungicide treatments.

Emerging Smart Harvesting Tools for Grapes

Recent technological advances have introduced smart harvesting tools that prioritise fruit quality and minimise postharvest losses. Force-controlled cutting tools apply just the right amount of pressure during detachment, reducing damage to the rachis and berries. Sensor-assisted harvesting systems help determine the optimal timing of harvest, avoiding over-mature berries that are more susceptible to softening and decay. Meanwhile, ergonomically designed clippers ensure consistent, clean cuts and limit uneven tissue injury. Together, these innovations result in more uniform ripening, reduced decay and improved performance during cold storage, making them particularly valuable for high-quality table grapes destined for domestic and export markets.

Conclusion

The quality and shelf life of grapes are profoundly influenced by the choice and handling of harvesting tools. Even minor injuries to the rachis or berries can trigger a cascade of physiological changes ranging from increased respiration and rapid water loss to rachis browning, berry shatter and fungal decay. Importantly, these changes often begin in the vineyard, long before grapes reach the packhouse. Careful selection of tools, proper handling techniques, and attention to hygiene can therefore prevent early damage, maintain fruit integrity and significantly extend postharvest life.

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