



A GUIDE TO **HARVESTING** AND **ENSURING** **APPLE QUALITY**

Author:
Prof. Dr. Sc. Tomislav Jemrić



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Multiple methods should be employed to evaluate the maturity of the apple fruit.

If, when shaking the harvested fruits, a noise is audible from a distance exceeding 1–2 m, substantial post-harvest losses might occur.

When the fruits are at an advanced stage of maturation, it is advisable to conduct the harvesting process with greater caution and at a slower pace.





Apple maturation hinges on several factors, notably the variety, orchard management practices, and weather conditions. Consequently, the timing of maturation for a particular variety within the same orchard differs every year, ranging from a few days to a couple of weeks or more.

Apples harvested prematurely are sour, lack adequate size, and lack proper coloring. Those picked too late tend to be excessively soft and prone to rapid post-harvest decay.

SIGNS OF APPLE MATURATION

Determining the maturation of fruits can be done subjectively using the senses or objectively using instruments or chemical analyses. Objective methods offer greater reliability and should be always favored.

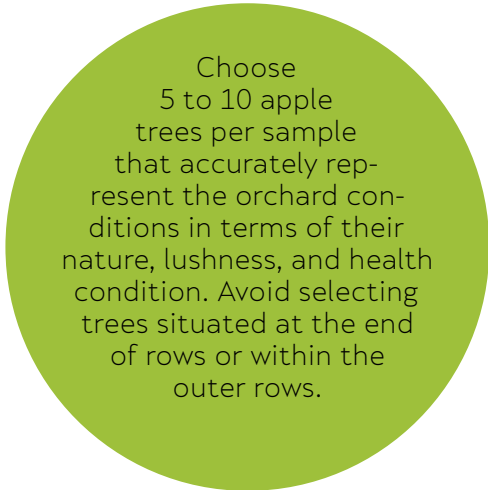
In the same orchard, apples of the same variety will not uniformly mature because of variations in health, light exposure, soil characteristics, and more. For instance, the skin of apples appears redder when maturation occurs in warm, sunny conditions with cool nights and morning dew. Apples basking in brighter sunlight mature ahead of those in shaded areas. Therefore, obtaining a proper fruit sample is crucial for accurate maturity determination.

HOW CAN WE ASSESS MATURITY THROUGH FRUIT SAMPLING?

Each fruit variety requires its sample. When a variety is grafted onto different rootstock, separate samples must be taken for each rootstock. If no significant difference was found, the single aggregate sample could be taken from both rootstocks, en-

suring an equal proportion of fruits from each rootstock.

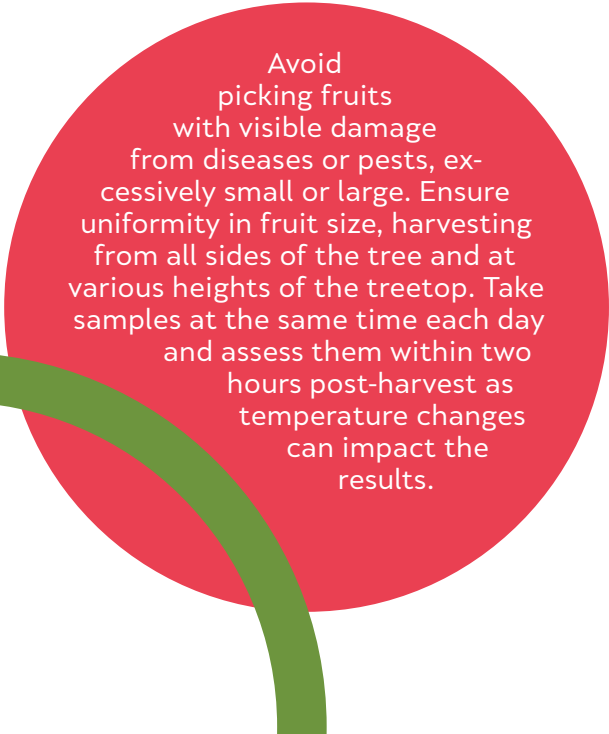
Choose 5 to 10 apple trees per sample (less if the orchard is smaller, more if the orchard is larger) that accurately represent the orchard conditions in terms of their nature, lushness, and health condition. Avoid selecting trees situated at the end of rows or within the outer rows. Mark the trees for sampling because multiple samplings will be performed. Sampling should begin approximately 4–5 weeks prior to the predicted usual harvest date. Initially, a sample should be taken once a week, and as the fruits continue to mature, the number of samples should be increased to more accurately evaluate their maturity level.



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Pick two to three fruits from the edges of the treetop on each marked tree, as they typically mature ahead of those in the inner treetop. Avoid picking fruits with visible damage from diseases or pests, excessively small or large. Ensure uniformity in fruit size, harvesting from all sides of the tree and at various heights of the treetop. Take samples at the same time each day and assess them within two hours post-harvest as temperature changes can impact the results.



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MATURATION ASSESSMENT TESTS

The sample should first be assessed for fruit color, both primary and secondary, IAD value, fruit firmness, soluble solid content, and starch degradation intensity. Finally, a piece of each fruit should be tasted, with a small amount of water taken between each tasting to rinse the mouth and prevent any “mixing” of flavors between individual fruits.

None of the individual maturity indices adequately assess fruit maturation. Fruit ripening depends on temperature, variety, soil conditions, cultivation technology, etc. Hence, employing multiple tests is crucial to determine maturation, particularly during years with substantial deviations from the multi-year average. Over time, experience will be gained, and multi-year data monitoring will yield invaluable information, offering not just information on fruit quality but also about the success of the cultivation technology that is applied.

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COLOUR

The better quality and faster sales of red varieties are attributed to their beautiful and full color. Therefore, a higher proportion of well-colored fruits indicates better quality. In certain years characterized by extensive cloudy and cold weather, fruit color development might be weak; therefore, you should not “wait” for the fruit development because the fruits will be overmatured.

Fruits intended for long-term storage are best harvested when their primary color changes from green to yellow. Fruits intended for immediate shipment to the market or short-term storage may exhibit a colour change from yellow to cream. The most reliable color assessment is executed by applying a DA-meter (**Figure 1**), which allows measurement directly on the tree while fruits are still on the tree, so the same fruits can be measured over time, which is much more reliable.

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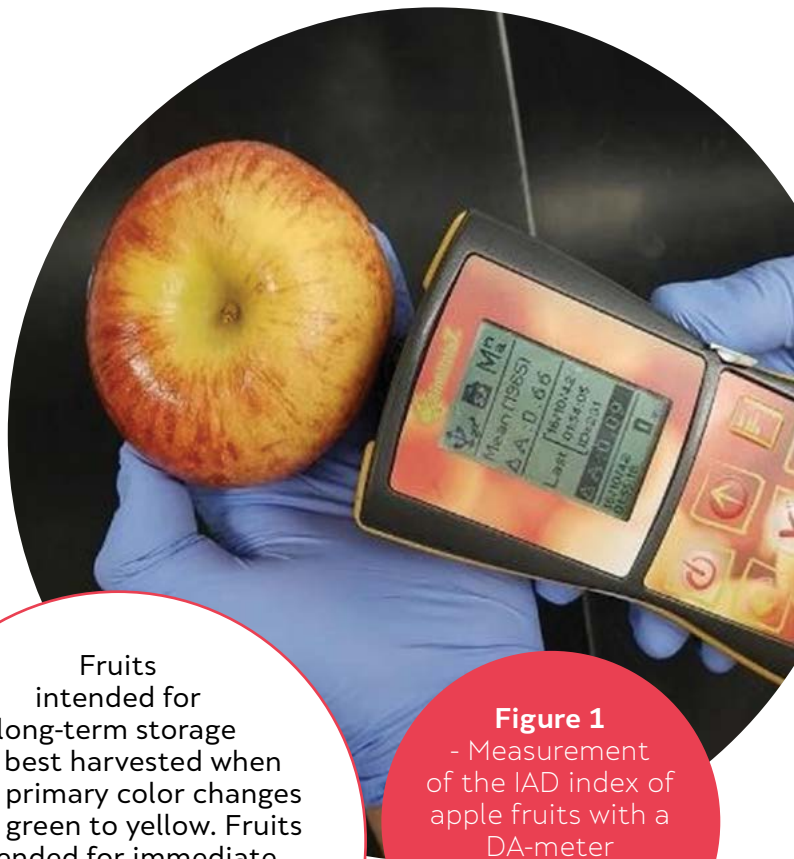


Figure 1
- Measurement of the IAD index of apple fruits with a DA-meter

Source: Dr. Macarena Farcuh, University of Maryland

Link: <https://extension.umd.edu/resource/how-can-growers-determine-apple-fruit-maturityand-optimal-harvest-dates-fs-1180>

As fruits mature, their IAD values decrease. Each apple variety possesses distinct IAD characteristics. An IAD ranging between 0.60 and 0.70 is advised for long-term storage of apples, whereas fruits with an IAD of 0.35 are better suited for short-term storage.

FIRMNESS

A penetrometer with a plunger measuring 11.2 mm in diameter is used to measure the firmness of apples (**Figure 2**). To prepare for measurement, remove part of the skin with the razor that comes with the instrument from each of the four opposite sides at the fruit's midpoint (referred to as the "equator"). Then, apply uniform pressure with the plunger tip onto the peeled area of the fruit up to the groove marked on the plunger. Pushing the plunger at an even speed should take approximately 2 s. Record the average value for each fruit and calculate the overall average for the entire sample.

It is crucial to ensure uniformity in the size and health of the fruits, avoiding any signs of physiological disorders, to prevent inaccurate readings. For apples intended for extended storage (beyond three months), harvesting when they reach firmness of at least 7 kg/cm² is recommended. Conversely, apples designated for shorter storage periods can have firmness ranging between 6 and 7 kg/cm².



Figure - 2
- Measuring
the hardness of
apple fruits with a
penetrometer

Source: Dr. Macarena
Farcuh, University of
Maryland

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THE STRENGTH OF THE STARCH CONVERSION

During apple maturation, starch is converted into simpler sugars. This transformation can be monitored using a straightforward test by immersing sliced fruits in a solution containing iodine and potassium iodide. You can either purchase a pre-made iodine solution or prepare one by mixing 10 g of potassium iodide and 2.5 g of iodine crystals in 1 L of water (stir thoroughly until the crystals dissolve completely over few hours). Properly store the iodine solution in a labeled opaque container or wrap it in aluminum foil to prevent fading when exposed to light. The container's cap should not be metallic to avoid potential damage. Because of its high toxicity, contact with the solution must be avoided at all costs. Always wear gloves to prevent skin contact and do not use the tested apples for composting or animal feed.

To conduct the starch- iodine test, slice the fruit horizontally across its equator to create two halves. Take one half with the stem and reserve the other half for the taste test. Holding the halved fruit by its stem, briefly immerse half of the fruit in the iodine solution, drain it, and turn it upside down to observe any alterations. The reading is taken after at least 2 min to allow ample time for the starch to interact with the iodine.

Figure 3 - The appearance of apple fruit halves after the iodine starch test (Top row: the first fruit is fully ripe for consumption, the adjacent fruit is suitable to be stored for a long-term refrigeration; Bottom row: the first fruit is in the stage just before it becomes suitable for refrigeration storage, the second fruit is fully unripe)

Source: Dr. Macarena Farcuh,
University of Maryland

In general, for harvesting apples for storage, values falling within the range of 4 to 7 on a scale of 1 to 10 are suggested, whereas higher values are preferred for immediate sale as fresh produce.

The degradation pattern of starch differs for each variety of apple. For instance, 'Golden Delicious', 'Gala', and 'Fuji' varieties do not lose starch in a uniform pattern, whereas apples like 'Red Delicious' lose starch in a moderately even ring.

The common starch index rating system uses a scale from 1 to 10, where 1 signifies complete starch presence (all blue-black), and a rating of 10 indicates no starch remaining (no stain) (see **Figure 3**).

Every halved apple, with the stem, from the sample is compared to the scale images and the value on the scale that most closely resembles the observed half is chosen. The average value for the sample is then calculated and rounded to one decimal place.

The ideal levels of starch degradation intensity vary depending on the apple variety and the index ranking system applied. In general, for harvesting apples for storage, values falling within the range of 4 to 7 on a scale of 1 to 10 are suggested, whereas higher values are preferred for immediate sale as fresh produce. Each apple variety has unique characteristics in this regard.



SOLUBLE SOLIDS CONCENTRATION (SSC) OR CHANGES IN SUGAR CONTENT

As apples mature, their soluble solid concentration increases, which is measured using a refractometer.

Refractometers come in two variants: optical and digital (**Figure 4**). In recent times, digital refractometers have gained popularity because of their user-friendly nature, and certain models even measure the acid content of fruits.

To measure, a small amount of juice is placed on the prism of an optical refractometer or in the sample well of a digital refractometer, and then a reading is taken. Working on a digital instrument proves simpler because there is no need to readjust values due to temperature fluctuations. Measuring the value of the collected juice after testing the entire sample is sufficient.

Before measuring, calibrate the refractometer by setting it to zero after pouring distilled water into the well. An additional check was performed by measuring the 10% sucrose solution. After each juice sample, the surface of the prism should be rinsed with distilled water and carefully wiped with soft tissue to prevent false read-



Figure 4
- Optical refractometer (left) and digital refractometer (right)

Source: Dr. Macarena Farquh, University of Maryland

Link: <https://extension.umd.edu/resource/how-can-growers-determine-apple-fruit-maturity-and-optimal-harvest-dates-fs-1180>

The quantity of soluble solids fluctuates significantly based on the year and the orchard's prevailing conditions. Good quality of apples is achieved when the fruits have 12%–14% soluble solids

ings due to sample mixing. In years with high temperatures and strong sunlight, we will get higher values of soluble solids, and in years with a rainfall abundance, as well as in orchards with irrigation or those that are overloaded with fruits, the values will be lower. Fruits from the outer part of the treetop had higher values than those from the inner parts of the treetop. In general, higher values indicate better fruit quality. Good quality of apples is achieved when the fruits have 12%–14% soluble solids.



Figure 5 –
Proper apple
picking

If the sound of fruits colliding can be heard from a meter or two away, the emptying of the harvest apple-picking bag has been mishandled and it is necessary to warn the pickers immediately.

It is advisable to harvest either in the morning or early evening if temperatures soar at midday. This is particularly true for summer apple varieties, which are poorly stored, prompting swift shipment to markets.

HARVESTING – THE FIRST STEP IN SUCCESSFUL STORAGE

The apples intended for consumption are handpicked (**Figure 5**). To pick them, carefully hold the fruit and gently lift it upward while rotating it to detach the stem. Carefully place the harvested apple into the harvest apple-picking bag.

After the harvest apple-picking bag is full, it should be carefully shaken in the box-pallet, ensuring that the fruits do not drop from a height greater than 30 cm. If the sound of fruits colliding can be heard from a meter or two away, the emptying of the harvest apple-picking bag has been mishandled and it is necessary to warn the pickers immediately.

When the harvest is delayed and the fruits become overly soft, extra caution is crucial. At this stage, the harvesting process should slow down, and it is advisable to decrease the expected yield per worker. Otherwise, a considerable number of fruits may be damaged, resulting in large post-harvest losses due to rot.

POST-HARVEST MANAGEMENT OF FRUITS

After harvesting, promptly relocate the fruits away from direct sunlight. Makeshift overhangs or other shaded areas in the orchard can be used.

TRANSPORTATION

Fruit transportation from the orchard requires meticulous organization, preferably using refrigerated trucks. If unavailable, tarpaulin-covered trucks can be used; transportation to cold storage must be swift.

FACTORS INFLUENCING POST- HARVEST QUALITY

Variety - Each variety has unique requirements that you need to know and adapt to

Maturity - Underripe and overripe fruits experience poorer preservation, resulting in substantial post-harvest losses.

Temperature control - Start temperature control during harvest and continue until the fruits are stored in the cold store.

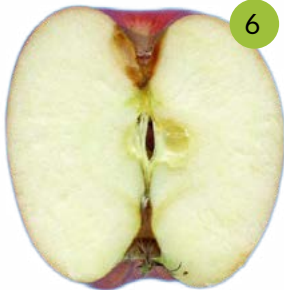
Storage duration – Storage duration is affected by fruit variety, maturity, and quality (for long-term storage, only the crispiest fruits harvested at the optimal time of maturity are selected).

Methods of fruit storage – Fruit refrigeration with a controlled atmosphere (CA) is ideal. However, certain cultivars like 'Braeburn' and 'Fuji' might not thrive in high carbon dioxide environments, so avoiding storage in CA is what you should do.

During storage, fruit quality control should be performed regularly. Even the slightest signs of decay warrant prompt shipment to the market to mitigate losses.



FRUIT DEFECTS AND DAMAGES



6

Picture 6

- Petiole cavity rot

Source: OECD (2021), Apples, International Standards for Fruit and Vegetables, OECD Publishing, Paris,

<https://doi.org/10.1787/12ebba9f-en-fr>



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Picture 7 - Bitter pits

Source: OECD (2021), Apples, International Standards for Fruit and Vegetables, OECD Publishing, Paris,

<https://doi.org/10.1787/12ebba9f-en-fr>



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Picture 8

- Jonathan's spot

Source: OECD (2021), Apples, International Standards for Fruit and Vegetables, OECD Publishing, Paris

<https://doi.org/10.1787/12ebba9f-en-fr>



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Picture 9

- Lenticel spots

Source: OECD (2021), Apples, International Standards for Fruit and Vegetables, OECD Publishing, Paris,

<https://doi.org/10.1787/12ebba9f-en-fr>



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Picture 10

- Glassiness/
watercore of fruits

Source: OECD (2021), Apples, International Standards for Fruit and Vegetables, OECD Publishing, Paris

<https://doi.org/10.1787/12ebba9f-en-fr>



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Picture 11

- Seed cavity rot

Source: OECD (2021), Apples, International Standards for Fruit and Vegetables, OECD Publishing, Paris

<https://doi.org/10.1787/12ebba9f-en-fr>



Picture 12

- Sunburns/sunscalds in apples

Source: OECD (2021), Apples, International Standards for Fruit and Vegetables, OECD Publishing, Paris,

<https://doi.org/10.1787/12ebba9f-en-fr>

Picture 13

- Crushing of the fruit

Source: OECD (2021), Apples, International Standards for Fruit and Vegetables, OECD Publishing, Paris,

<https://doi.org/10.1787/12ebba9f-en-fr>



Picture 14 - Hail damaged apples

Source: OECD (2021), Apples, International Standards for Fruit and Vegetables, OECD Publishing, Paris,

<https://doi.org/10.1787/12ebba9f-en-fr>



Picture 15 - Fruit damage caused by fruit scab (*Venturia inaequalis* (Cooke) G. Winter

Anamorf *Spiloceapomi* Fr. syn. *xFusicladium dendriticum*)

Source: OECD (2021), Apples, International Standards for Fruit and Vegetables, OECD Publishing, Paris,

<https://doi.org/10.1787/12ebba9f-en-fr>



Picture 16 - Fruit damage by caterpillars of the apple borer (*Cydia pomonella* (Linnaeus, 1758))

Source: OECD (2021), Apples, International Standards for Fruit and Vegetables, OECD Publishing, Paris

<https://doi.org/10.1787/12ebba9f-en-fr>



Picture 17

- Shrivelling of the skin of the fruit

Source: OECD (2021), Apples, International Standards for Fruit and Vegetables, OECD Publishing, Paris

<https://doi.org/10.1787/12ebba9f-en-fr>

