Ripening Avocados

Phenomenon/Problem:

Avocados are often purchased when they are firm, then left on a kitchen counter to ripen over several days. During that time, the fruit undergoes noticeable changes. It becomes softer, develops a richer flavor, and reaches a texture many people associate with being ready to eat.

An avocado left on a counter may soften in a few days, while another in the refrigerator remains firm for much longer. Some storage methods appear to speed up ripening, while others seem to slow it down. These differences can occur even when the avocados come from the same tree and begin at similar stages of development.

What is happening inside an avocado after it has been picked? Although the fruit is no longer attached to the plant, it continues to change in predictable ways. Understanding why these changes occur requires investigating the biological and chemical processes that control fruit ripening.

Essential Questions:

- Why do avocados stored under different conditions ripen at different rates?
- What causes an avocado to continue changing after it has been picked?
- Why does placing an avocado near a banana speed up ripening?
- How do chemical reactions within cells change the texture, flavor, and aroma of fruit?
- How do changes at the cellular level lead to the observable characteristics of ripe fruit?

Stimuli: How will students experience and/or observe the phenomenon/problem?

A group of students obtained four avocados that appeared to be at a similar stage of development. To investigate how different conditions might affect ripening, they compared each avocado in a different location.

- Avocado A: Left attached to the tree
- Avocado B: Picked and left on a kitchen counter
- Avocado C: Picked and placed in a paper bag with a banana
- Avocado D: Picked and stored in a refrigerator



At the end of the week, the avocados looked very different from one another.

- One avocado showed no signs of ripening at all.
- One avocado had become very soft and appeared fully ripe.
- One avocado had ripened after a few days.
- One avocado had changed very little and remained mostly firm.

Although all four avocados started in a similar condition, the rate at which they ripened differed dramatically.

Related Phenomena/Problems:

- Why do different fruits ripen differently?
- Why do bananas stored together tend to ripen more quickly than bananas stored separately?
- Why do tomatoes picked while green continue to turn red after harvest?
- Why do some fruits continue ripening after they are picked, while others do not?
- Why does fruit stored in a refrigerator often stay firm longer than fruit left on a kitchen counter?
- Why does a bruised fruit often ripen or spoil faster than an undamaged fruit?
- Do different varieties of avocados ripen differently?

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Considerations for Instructional Design:

- Have students develop initial explanations as to why avocados stored in different conditions may ripen at different rates.
- Have students make predictions about how changing environmental conditions, such as temperature or proximity to other fruits, may affect the rate of avocado ripening.
- Engage students in analyzing patterns in observations or data collected from avocados ripening under different conditions.
- Have students develop and revise models that trace how matter is transformed during the ripening process.
- Have students develop and compare models of the ripening of avocados with other fruits, such as bananas, tomatoes, or apples, to identify common patterns and possible explanations.
- Have students use evidence from investigations, readings, or datasets to construct explanations for why some storage conditions accelerate ripening while others slow it.
- Engage students in developing a systems model that includes the avocado, the surrounding environment, ethylene, temperature, and other factors influencing ripening.

Explanation:

Although an avocado has been removed from the tree, it is still living tissue. Avocado cells continue carrying out metabolic activities after the fruit is removed from the tree. As ripening occurs, numerous chemical reactions continue within the fruit's tissues, causing changes in texture, aroma, flavor, and appearance. Avocados on the tree produce only very small amounts of ethylene and remain in an unripe state until harvest occurs. Once the fruit is picked, physiological changes allow ripening processes to begin.



Ethylene

A key factor controlling avocado ripening is ethylene, a naturally occurring plant hormone. Ethylene is a simple hydrocarbon gas (C_2H_4), but it functions as a powerful chemical signal in many fruits and plants.

While an avocado remains attached to the tree, the fruit's ethylene production remains low. After harvest, the activity of enzymes involved in ethylene biosynthesis increases. One important molecule, called ACC (1-aminocyclopropane-1-carboxylic acid), begins to accumulate. ACC is then converted into ethylene by additional enzymes, causing ethylene concentrations within the fruit to rise.

Once ethylene is produced, it is detected by receptors in avocado cells. These receptors initiate signaling pathways that alter gene expression within the fruit. In response, cells begin producing proteins and enzymes associated with ripening. In essence, ethylene acts as a molecular message telling the fruit that it is time to begin the ripening process.

Ripening Involves Major Changes in Matter and Energy

Avocados are climacteric fruits, meaning they experience a rapid increase in both respiration and ethylene production during ripening. As ethylene levels rise, cellular respiration also increases. During respiration, cells break down molecules and transfer energy that can be used to power biological processes.

This increase in metabolic activity provides the energy required for the many biochemical changes occurring within the fruit. Molecules already present in the avocado are broken apart and recombined into new substances. Flavor compounds, aroma compounds, pigments, and other molecules are produced or modified as ripening progresses.

One of the most noticeable signs of ripening is softening. This change occurs because enzymes activated during ripening begin modifying the structure of the fruit's tissues. Plant cell walls contain substances such as cellulose and pectin that provide strength and rigidity. During ripening, enzymes including cellulases and polygalacturonases break down these

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structural components. As these materials are altered, cells become less tightly connected and tissues lose their firmness. The result is the soft texture associated with a ripe avocado.

Changes to Ripening

Ethylene is a gas, which means it can move through the air and affect neighboring fruits. Bananas are also climacteric fruits and produce substantial amounts of ethylene as they ripen. When an avocado is placed in a paper bag with a banana, ethylene released by the banana accumulates around the avocado. Higher ethylene concentrations expose the avocado's cells to stronger ripening signals, causing ripening processes to begin sooner or proceed more rapidly. The paper bag further enhances this effect because it traps ethylene gas near the fruits rather than allowing it to disperse into the surrounding environment.

The biological processes involved in ripening depend on enzymes, and enzyme activity is strongly influenced by temperature. Lower temperatures reduce the rate of chemical reactions occurring inside the fruit. When an avocado is stored in a refrigerator, respiration slows, metabolic activity decreases, and ripening-related enzymes work more slowly. Ethylene-mediated responses still occur, but they proceed at a reduced rate. As a result, the avocado remains firm much longer than one stored at room temperature.

The four avocados in the phenomenon ripen at different rates because the biological conditions surrounding each fruit influence ethylene production and the chemical reactions associated with ripening. Avocados attached to the tree produce very little ethylene and remain largely unripe. Harvested avocados begin producing ethylene and initiate ripening. Additional ethylene from a nearby banana accelerates these processes, while refrigeration slows the enzyme activity and metabolic reactions required for ripening.

Growers and distributors also make decisions that influence when avocados ripen. Before harvest, growers may use dry matter testing, which measures how much of the fruit remains after water is removed, to determine whether avocados have reached sufficient maturity for harvest. After harvest, handlers balance transportation time, storage temperature, fruit quality, and the risk of chilling injury. Avocados are often stored under carefully controlled conditions that slow respiration and delay ripening during transportation. When fruit is needed for sale, some facilities place avocados in commercial ripening rooms where temperature, humidity, and ethylene exposure are managed to promote uniform ripening before the fruit reaches grocery stores.

Student and teacher questions about this phenomenon/problem that could be instructionally productive:

- Why would four avocados in different conditions ripen at different rates?
- What happens inside the avocado as it ripens?
- What factors in the environment influence how quickly an avocado ripens?
- What causes the color, texture, smell, and flavor of an avocado to change?
- Does an avocado gain or lose matter as it ripens?
- Does an avocado need oxygen to ripen?
- What role do enzymes play in ripening fruit?
- What might growers, distributors, grocery stores, and consumers want to influence when avocados ripen?

Explaining the phenomenon/problem or related phenomena could lead students toward developing the following DCIs:

HS-LS1.A:

- Systems of specialized cells within organisms help them perform the essential functions of life.

HS-LS1.C:

- As matter and energy flow through different organizational levels of living systems, chemical elements are recombined in different ways to form different products.

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- As a result of these chemical reactions, energy is transferred from one system of interacting molecules to another. Cellular respiration is a chemical process in which the bonds of food molecules and oxygen molecules are broken and new compounds are formed that can transport energy to muscles. Cellular respiration also releases the energy needed to maintain body temperature despite ongoing energy transfer to the surrounding environment.

Notes about relevance and authenticity (funds of knowledge, interests, identity)
Why might students be engaged?

- Connects to a food they may have eaten, purchased, prepared, or observed ripening at home.
- Can be applied at home in how they decide to store an avocado.
- Provides an authentic context for exploring how chemical signals influence the behavior of living cells and organisms and being able to visually see those changes.
- Connects concepts from biology and chemistry to their food.
- Connects students to the larger food system and how food is transported to their home.

Resources/References

https://ishs.org/ishs-article/179_132/

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