

Understanding of Enzymatic Browning Effect in Fresh Vegetables and Fruits

Alok Kumar¹, Abhinav Kumar Yadav² and Satya Prakash³

¹M.Sc. Agricultural Extension Education, Dr. Rajendra Prasad Central Agricultural University, Pusa

²M.Sc. (Agronomy) DAV University, Jalandhar

³Associate Professor cum Senior Scientist Agricultural Extension Education, Dr. Rajendra Prasad Central Agricultural University, Pusa

Corresponding Author:

Abstract

Enzymatic browning is a chemical reaction that occurs when certain fruits and vegetables are cut, bruised, or otherwise damaged, leading to the exposure of their internal tissues to oxygen. This process is primarily driven by an enzyme called polyphenol oxidase (PPO), which catalyses the oxidation of phenolic compounds present in plant tissues, resulting in the formation of brown pigments.

Introduction

The browning effect in fresh vegetables and fruits is primarily caused by a chemical reaction called enzymatic browning, which occurs when certain enzymes in the produce come into contact with oxygen in the air. This reaction results in the formation of brown pigments, usually melanin's, that can affect the appearance and sometimes the flavours of the food. Browning is a process in which the food turns brown due to the chemical reactions taking place within the food. It may be desirable or undesirable.

This browning occurs when crop polyphenols, or phenolic molecules, are oxidized by specific enzymes in the presence of oxygen, leading to the formation of quinones, which subsequently undergo chemical polymerization, resulting in a brown coloration (Parveen et al., 2010; Sui et al., 2023).

Here are some examples of the browning effect on different vegetables and fruits:

- Apples, pears, bananas, and avocados:** When their flesh is exposed to air, they turn brown due to enzymatic activity.
- Potatoes:** When cut or peeled, they often turn brown or gray.
- Lettuce and other leafy greens:** These can develop brown spots or edges after being cut or bruised.

The variation in colour is from light cream to black colour. The flavours may vary from mild to very bitter flavour.

Browning specifically falls into 2 main categories:

- **Enzymatic Browning**
- **Non-Enzymic Browning**

Enzymatic Browning: Enzymatic browning is a chemical reaction that occurs when certain fruits and vegetables are cut, bruised, or otherwise damaged, leading to the exposure of their internal tissues to oxygen. This process is primarily driven by an enzyme called polyphenol oxidase (PPO), which catalyses the oxidation of phenolic compounds present in plant tissues, resulting in the formation of brown pigments.

It is most common in fresh produce, particularly fruits and vegetables with high phenolic content. While enzymatic browning doesn't typically affect the safety of the food, it can reduce the aesthetic appeal and sometimes the flavour. Various methods, including acid treatments, refrigeration, and blanching, can be used to reduce or prevent enzymatic browning in fresh produce.

How Enzymatic Browning Happens

- Cell Damage:** When fruits or vegetables are cut, bruised, or peeled, the cells are damaged, and enzymes like polyphenol oxidase (PPO) are released from the cell vacuoles into the cytoplasm.
- Oxidation of Phenolic Compounds:** The PPO enzyme interacts with **phenolic compounds** (such as catechins, chlorogenic acid, or tyrosine) found in the plant tissue. These phenolic compounds, when exposed to oxygen in the air, are oxidized into **quinones**.
- Formation of Brown Pigments:** Quinones are highly reactive and can polymerize (bind together) to form **melanin**, which are brown-coloured pigments that contribute to the browning of the fruit or vegetable.
- Browning Process:** As the quinones react and polymerize, they create the brown colour associated with the browning of the produce. This process can continue over time, causing the fruit or vegetable to become increasingly brown and less visually appealing.

Enzymatic browning is common in

- **Fruits:** Apples, bananas, pears, avocados, peaches, and apricots are all prone to enzymatic browning when cut or bruised.
- **Vegetables:** Potatoes, eggplants, and mushrooms also undergo enzymatic browning when exposed to air.

Factors Affecting Enzymatic Browning

1. **Oxygen:** Oxygen is necessary for the oxidation of phenolic compounds. When produce is exposed to air, the reaction is accelerated.
2. **Temperature:** The activity of polyphenol oxidase is higher at warmer temperatures. Lowering the temperature (e.g., by refrigerating) can slow down the reaction. However, refrigeration does not stop the process entirely.
3. **pH:** The reaction is more efficient at a neutral or slightly alkaline pH (around 6-7). Acidic environments (like lemon juice or vinegar) can slow down or inhibit the reaction by reducing the activity of PPO.
4. **Time:** The longer the produce is exposed to air or stored after being damaged, the more browning will occur.

Enzymatic Browning in Cooking and Food Preservation

- **Canning and Freezing:** When fruits and vegetables are preserved through canning or freezing, they are typically blanched first to deactivate the enzymes that cause browning. This helps maintain the colour, texture, and overall quality of the food.
- **Cooking:** Cooking fruits and vegetables (e.g., in baking, sauteing, or boiling) denatures the polyphenol oxidase enzyme, stopping the browning process.

Methods to prevent or slow down enzymatic browning

1. **Use of Acids:** Applying acidic substances like **lemon juice**, **citric acid**, or **ascorbic acid** (vitamin C) can reduce PPO activity and slow down browning. This is why lemon juice is often used to coat cut fruits like apples and avocados.

2. **Blanching:** Briefly dipping vegetables like potatoes, carrots, and broccoli in boiling water or steam for a few minutes can deactivate the enzymes responsible for browning.
3. **Cold Storage:** Refrigeration slows down enzyme activity, helping to keep browning at bay, although it doesn't stop it completely. Freezing also slows or halts the process, but some fruits and vegetables may lose texture or flavour when frozen.
4. **Anti-Browning Agents:** Commercial products that contain sulphites, such as **sodium bisulphite**, can be used to prevent browning, especially in the food industry. These agents work by reducing the quinones back to their phenolic form, preventing them from forming brown pigments.
5. **Vacuum Sealing:** Reducing oxygen exposure by vacuum sealing or storing produce in airtight containers can also slow down the enzymatic browning process.
6. **Use of Sugar Syrups or Citric Acid:** In some cases, placing cut fruit into sugar syrup or a mixture of water and citric acid can also prevent enzymatic browning.

Conclusion

In conclusion, enzymatic browning is a chemical reaction that occurs when phenolic compounds in fruits and vegetables are exposed to oxygen, facilitated by the enzyme polyphenol oxidase (PPO). This reaction results in the formation of brown pigments, which can negatively affect the appearance, texture, and nutritional quality of the food. Factors such as pH, temperature, and oxygen availability can influence the rate of browning. While enzymatic browning is an inevitable process in many fruits and vegetables, various methods such as applying acid solutions (e.g., lemon juice), blanching, refrigeration, or using antioxidant treatments can help slow or prevent it. Understanding enzymatic browning is important in food preservation and processing to maintain the quality and visual appeal of fresh produce.
