

IFT Experiments in Food Science Series

Enzymes in Food Systems

Activity #3

Enzymatic Browning of Apples

A Science Unit for Secondary School Curriculum



Institute of Food Technologists
The Society for Food Science and Technology

STUDENT ACTIVITY GUIDE

Enzymatic Browning of Apples

ACTIVITY OBJECTIVE

The purpose of this experiment is to monitor the level of enzymatic browning of apple slices. This experiment will illustrate that apples contain an enzyme called polyphenol oxidase or phenolase. In the presence of oxygen from the air, this enzyme catalyzes the formation of brown pigments called melanins. Treatment of the apple slices with organic substances such as ascorbic acid, citric acid, or acetic acid will reduce the level of browning. The reduction in browning is dependent on the type of substance and its concentration. Soaking in water alone will temporarily reduce the level of browning by restricting the amount of oxygen in contact with apple tissue.

MATERIALS REQUIRED

- Fresh apple slices of approximately the same size (6 per group)
- Test solutions for dipping:
 - 0.1% Ascorbic acid
 - 0.1% Citric acid
 - 0.1% Acetic acid
 - 1.0% Acetic acid
- Beaker or cup with water
- Tongs
- Paper towels

BACKGROUND INFORMATION

When fruits or vegetables are peeled or cut, enzymes contained in the plant tissue are released. In the presence of oxygen from the air, the enzyme *polyphenol oxidase* (*phenolase*) catalyzes one step in the biochemical conversion of plant phenolic compounds to brown pigments known as *melanins*. This reaction, called enzymatic browning, occurs readily at warm temperatures when the pH is between 5.0 and 7.0.

The presence of iron or copper can increase the rate of the reaction. This can be easily observed when fruit is cut with a rusty knife or mixed in a copper bowl.

Bruising or other injury to the plant tissue disrupts the structural arrangement of constituents within the cells and allows the contents to make contact with oxygen. This may lead to browning of uncooked fruit tissue.

Enzymatic browning can be a significant problem, limiting the shelf life of many fruits and vegetables which have had little heat applied during processing. However, enzymatic browning is

not always a defect. The browning reaction contributes to the desirable color and flavor of raisins, prunes, coffee, tea, and cocoa.

Several substances have been used in the food industry to prevent browning of fruits and vegetables:

Sulfites prevent browning by releasing sulfite ions, which prevent melanin formation. These compounds were used extensively until the Food and Drug Administration received reports of adverse allergic-type reactions to foods containing sulfites. FDA requires that the presence of sulfites in foods be declared on the label when the sulfiting agents are used as a preservative regardless of the level used, or when they are used for a technical effect at a level of 10 parts per million (ppm) or more.

Ascorbic acid (vitamin C) acts as an antioxidant. Oxygen preferentially reacts with the ascorbic acid, rather than with the phenolic compounds in the fruit or vegetable. Browning does not proceed until all the ascorbic acid is used up in the reaction.

Citric acid and *acetic acid* lower the pH of the fruit tissue to retard the action of the polyphenol oxidase. If the pH is reduced below 3.0, the polyphenol oxidase will be inactivated. Citric acid also acts as a chelating agent, tying up copper ions which are necessary cofactors in the reaction.

Placing fresh fruit in a water bath will temporarily inhibit the browning reaction, since water restricts the amount of oxygen in contact with fruit tissues. Heating also prevents browning by inactivating the polyphenol oxidase. Since heat also cooks the fruit, heating cannot be used as a treatment for fruits which will be served fresh.

PROCEDURES

1. Place an untreated apple slice on a paper towel. Label the towel "Control."
2. Using tongs, dip another apple slice into one of the test solutions for 30 seconds, place it on the towel, and label the towel with the name of the solution. Rinse the tongs and repeat the same procedure for the other three solutions.
3. Soak one slice in water for 30 seconds. Place it on a towel and label the towel "Water Soak."
4. Note the time and temperature in your data table. Observe the slices every 10 minutes for one hour and record your observations. Compare your results with those obtained by the rest of the class.

KEY QUESTIONS

1. What causes browning when fresh fruits and some vegetables are peeled or cut?
2. What conditions enhance the browning process? Why?
3. How do food additives or treatment processes in use today prevent or retard browning in fruits and vegetables?
4. Why do citrus juices retard browning in fresh fruits?

Data Table

Enzymatic Browning of Apple Slices

Level of Browning*						
Time (min)	No Treatment (Control)	Ascorbic Acid (0.1%)	Citric Acid (0.1%)	Acetic Acid (0.1%)	Acetic Acid (1.0%)	Water Soak
0						
10						
20						
30						
40						
50						
60						

- * 5=Completely dark brown
- 4=Fully covered light brown
- 3=Half-covered light brown
- 2=Slight or scant brown patches
- 1=No browning present

Time started: _____

Temperature: _____