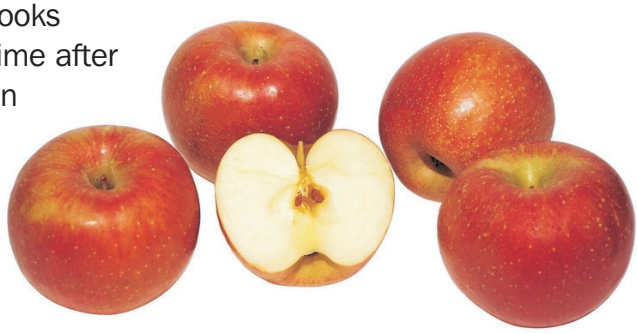
Enzymatic Browning

WE HAVE all seen that bowl of fruit that looks brown and unappetizing only a short time after it was prepared. What is this process that can turn previously delicious fruit into a brown mess in a few hours? The answer is enzymatic browning. **Enzymatic browning** is a chemical process in which plant tissues (either from fruit or vegetables) take on a brown appearance when exposed to oxygen.



Objective:

Define *enzymatic browning* and describe the effect this process has on food products.

Key Terms:

antioxidant
chelate
chelating agent
enzymatic browning
melanin
polyphenol oxidase

Enzymatic Browning

Any time a plant product is peeled, cut, bruised, or just deteriorates naturally, enzymes within the cells are released into the surrounding tissues. When enzymes within a plant cell, known as phenols, come into contact with enzymes outside the cell wall, known as phenolases, a brown pigment is produced. That brown pigment, **melanin**, occurs naturally, not only in plants, but also in animals. It is found in the pigments of human skin.

Enzymatic browning has several negative results for a food product. Browning can not only change the appearance of food but soften it, cause it to lose flavor, and limit the shelf life of the product. Think of fresh apples at the grocery store. An apple dropped or bruised during shipping develops soft, brown areas under the skin where enzymatic browning is taking place. Although the fruit may be unappealing, there is no harm in eating fruit that has begun browning. The affected pieces of fruit are usually discarded, but the rest of the apple is completely safe to eat.

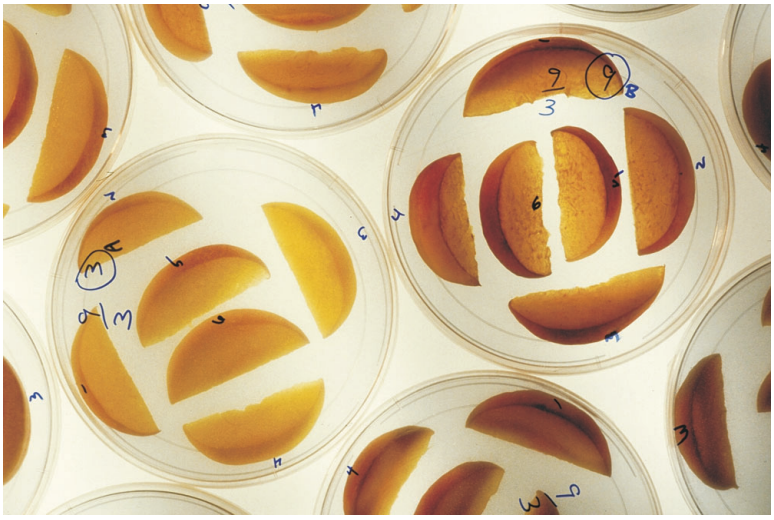


FIGURE 1. These peach slices were exposed to oxygen. The dark slices reveal enzymatic browning. The other slices were treated in an attempt to control this chemical process. (Courtesy, Agricultural Research Service, USDA)

The proper environmental conditions will also speed up the browning process. A warm temperature and a pH level between 5.0 and 7.0 have been shown to activate a natural catalyst, **polyphenol oxidase**, that speeds up browning. This enzyme contains copper that increases the oxidation of the phenol compounds, producing the brown color.

FIGURE 2. A bruised apple is undergoing enzymatic browning because tissues have been damaged.

Not all enzymatic browning is bad for food producers, though. The taste and color of some products, such as coffee, tea, raisins, and prunes, are improved through the use of enzymatic browning. Other types of browning commonly found in the food industry are maillard browning (in the case of proteins and sugars at high temperatures), caramelization (in the case of sugars at high temperatures), and lipid browning (in the case of fats at high temperatures).

METHODS TO SLOW ENZYMATIC BROWNING

Fortunately for most food producers and processors, several techniques can be used to slow or stop enzymatic browning. Some techniques may be available only to food processors and manufacturers, while others are simple enough to use in our own kitchens.

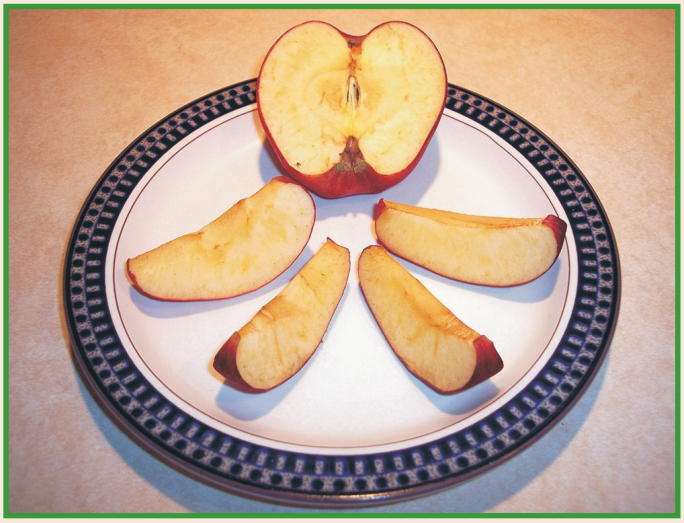
UNDER INVESTIGATION...

LAB CONNECTION: Enzymatic Browning

We have all experienced cutting up a fresh apple, only to find it a few minutes later brown and unappetizing. The process of enzymatic browning is a natural process that occurs as fresh fruit and other food products react with air. Scientists have discovered several techniques to slow the browning process, but ultimately nature always wins.

The consumer demand for a visually appealing product has driven the research to halt enzymatic browning. Producers and retailers realize that if a food product does not look appetizing, a consumer will not purchase it. For this reason, marketers want their products to look as fresh as possible for as long as possible.

The process of enzymatic browning can be observed in a laboratory exercise. The procedure calls for fresh apples to be sliced. Different slices are treated with ascorbic acid, acetic acid, and citric acid and left exposed to the air. By manipulating the pH level on the surface of the apple slices, the browning process can be slowed. Observations of the slices are made every 10 minutes for one hour. Other materials, such as a store-bought browning inhibitor, can be used to halt the process of enzymatic browning.



Enzymatic browning is a process that occurs as fresh fruit or vegetables are exposed to air.

Organic acids found in many foods have been shown to reduce the activity of the polyphenol oxidase enzyme. By adding natural acids, such as citric and ascorbic, to food products likely to brown, the enzymes are slowed, and browning occurs much more slowly. Many people will add a small amount of lemon juice (a strong organic acid) to fresh apple slices to keep them from browning so quickly.

Ascorbic acid is commonly used in products designed to keep fresh fruit from browning. Ascorbic acid is an **antioxidant**, a substance that slows or inhibits chemical reactions using oxygen. Oxygen present in the food source and in the surrounding air will react with the ascorbate (ascorbic acid) before reacting with phenolic compound to produce the brown coloration. This reaction will continue until the ascorbic acid is neutralized. Melanin can also be somewhat "bleached" by the ascorbic acid to hide the brown color of the fruit tissue. Ascorbic acid can be found in common "fruit fresh" additives that can be purchased at a grocery store.

Another common acid used to preserve fresh fruit is citric acid. Citric acid, such as lemon juice, acts as a **chelating agent**, or a substance that causes a metal ion (such as copper or

iron) to react with another molecule to form a chelate. A **chelate** is a chemical compound in which a metal ion is bonded to neighboring molecules in a ring structure. Citric acid inhibits the polyphenol oxidase enzyme by binding up metal ions needed for the enzyme to be active. Since the metal ion is "tied up" in the chelate, it is unavailable to cause enzymatic browning. Citric acid also lowers the pH of the food substance, also inhibiting browning. The use of lemon juice is an easy and effective way to keep fresh fruit from browning and does not negatively affect the taste of the fruit.

Acetic acid, found in vinegar, will also reduce browning by lowering the pH of a food below 3.0 (the point where the polyphenol oxidase enzyme is inactivated). Vinegar, although effective, is not commonly used as a fresh fruit preservative because it would dramatically change the taste of the fruit.

Other cost-effective methods of reducing enzymatic browning include simply the use of water. Food submerged in water is not exposed to oxygen needed for the browning reaction. Cooking foods also reduces browning, as the polyphenol enzyme is inactivated by heat. Minimizing the amount of handling will also reduce browning. The more a piece of fruit is handled, the greater the chance for a bump or bruise that will accelerate the browning process.

FIGURE 3. This product contains ascorbic acid, which will inhibit enzymatic browning for a time.

Scientists have also been working to defeat enzymatic browning. Improved cultivars of plants with increased resistance to browning are being developed. Changing storage conditions to limit oxygen exposure will also result in less browning and more appealing fruit for the consumer.

Summary:

Enzymatic browning is a chemical reaction in fresh fruit and vegetables that results in a brown coloration of food tissues. Bruising, cutting, or exposing fresh food products to oxygen can all result in the browning process. Scientists are constantly working to find ways to reduce browning in food products to make them more appealing to consumers.

Although browning has negative effects on food products, there are positives as well. Caramelization of sugar is a form of browning commonly used in candy making and desserts.

Checking Your Knowledge:

1. Describe the process of enzymatic browning in a piece of fresh fruit.
2. List four negative effects of enzymatic browning.
3. Name two ways to reduce enzymatic browning of fresh fruit.

Expanding Your Knowledge:

Design an experiment to test the degree of enzymatic browning on a type of fruit. Identify the control for the experiment; then design three treatments and compare the effects of each to the control. Discuss your findings with a classmate.

Web Links:

Wikipedia—Enzymatic Browning

http://en.wikipedia.org/wiki/Enzymatic_browning

Food Resource—Oregon State University

http://food.oregonstate.edu/flavor/phenol1.html

Agricultural Career Profiles

http://www.mycaert.com/career-profiles