The Effects of Acids and Bases on the Browning of Apples

Purpose of the Experiment

When you cut an apple, the exposed surface starts to react with oxygen in the air.

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Apples and other fruit will turn brown when they are cut and the enzyme contained in the fruit (tyrosinase) and other substances (iron-containing phenols) are exposed to oxygen in the air (for more information, read this FAQ on apple browning).

The purpose of this chemistry laboratory exercise is to observe the effects of acids and bases on the rate of browning of apples when they are cut and the enzymes inside them are exposed to oxygen.

A possible hypothesis for this experiment would be:

Acidity (pH) of a surface treatment does not effect the rate of the enzymatic browning reaction of cut apples.

Gather Materials

The following materials are needed for this exercise:

- Five slices of apple (or pear, banana, potato, or peach)
- Five plastic cups or other clear containers
- Vinegar (or dilute acetic acid)
- Lemon juice
- Solution of baking soda (sodium bicarbonate) and water (you want to dissolve the baking soda. Make the solution by adding water to your baking soda until it dissolves.)
- Solution of milk of magnesia and water (ratio isn't particularly important - you could make a mixture of one part water one part milk of magnesia. You just want the milk of magnesia to flow more readily.)
- Water
- Graduated cylinder or measuring cups

Procedure - Day One

1. Label the cups:
    - Vinegar
    - Lemon Juice
    - Baking Soda Solution
    - Milk of Magnesia Solution
    - Water
2. Add a slice of apple to each cup.
3. Pour 50 ml or 1/4 cup of a substance over the apple in its labeled cup. You may want to swirl the liquid around the cup to make sure the apple slice is completely coated.
4. Make note of the appearance of the apple slices immediately following treatment.
5. Set aside the apple slices for a day.

Procedure and Data - Day Two

1. Observe the apple slices and record your observations. It may be helpful to make a table listing the apple slice treatment in one column and the appearance of the apples in the other column. Record whatever you observe, such as extent of browning (e.g., white, lightly brown, very brown, pink), texture of the apple (dry? slimy?), and any other characteristics (smooth, wrinkled, odor, etc.)
2. If you can, you may want to take a photograph of your apple slices to support your observations and for future reference.
3. You may dispose of your apples and cups once you have recorded the data.

Results

What does your data mean? Do all of your apple slices look the same? Are some different from others? If the slices look the same, this would indicate that the acidity of the treatment had no effect on the enzymatic browning reaction in the apples. On the other hand, if the apple slices look different from each other, this would indicate something in the coatings affected the reaction. First determine whether or not the chemicals in the coatings were capable of affecting the browning reaction.

Even if the reaction was affected, this does not necessarily mean the acidity of the coatings influenced the reaction. For example, if the lemon juice-treated apple was white and the vinegar-treated apple was brown (both treatments are acids), this would be a clue that something more than acidity affected browning. However, if the acid-treated apples (vinegar, lemon juice) were more/less brown than the neutral apple (water) and/or the base-treated apples (baking soda, milk of magnesia), then your results may indicate acidity affected the browning reaction.

Conclusions

You want your hypothesis to be a null hypothesis or no-difference hypothesis because it is easier to test whether or not a treatment has an effect than it is to try to assess what that effect is. Was the hypothesis supported or not? If the rate of browning was not the same for the apples *and* the rate of browning was different for the acid-treated apples compared with the base-treated apples, then this would indicate that the pH (acidity, basicity) of the treatment *did* affect the rate of the enzymatic browning reaction. In this case, the hypothesis is not supported. If an effect was observed (results), draw a conclusion about the type of chemical (acid? base?) capable of inactivating the enzymatic reaction.

Additional Questions

Here are some additional questions you may wish to answer upon completing this exercise:

1. Based on your results, what substances in each apple treatment affected the enzyme activity responsible for the browning of the apples? Which substances did not appear to affect the enzyme activity?
2. Vinegar and lemon juice contain acids. Baking soda and milk of magnesia are bases. Water is neutral, neither an acid nor a base. From these results, can you conclude whether acids, pH neutral substances, and/or bases were able to reduce the activity of this enzyme (tyrosinase)? Can you think of a reason why some chemicals affected the enzyme while others didn't?
3. Enzymes speed the rate of chemical reactions. However, the reaction may still be able to proceed without the enzyme, just more slowly. Design an experiment to determine whether or not the apples in which the enzymes have been inactivated will still turn brown within 24 hours.

http://chemistry.about.com/od/demonstrationsexperiments/ss/appleenzyme.htm