Investigating different browning reactions

Education in Chemistry
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This activity investigates some of the factors involved in the browning reactions of fruit and the Maillard reaction.

What causes cut apples to go brown: enzymes or microbes?

Apples, avocadoes and potatoes all change colour when peeled or cut and left to stand.

A student wanted to investigate if microbes or enzymes caused cut apples to go brown. This is the method the student used first:

1. Take three pieces of apple.
2. Crush one piece.
3. Break one piece in two.
4. Cut one piece in two.
5. Observe the rate of browning in the three pieces.

The quickest to turn brown was the crushed piece and the slowest to turn brown was the one broken in two.

1.1 Suggest reasons for the different browning speeds.

1.2 Explain whether enzymes or microbes are more likely to be found inside the fruit.

In the next experiment, the student used a solution of phenol that would kill microbes but not affect enzymes. This is the method the student used:

1. Cut an apple in half.
2. Soak one half of it in a phenol solution for one minute.
3. Soak the other half in distilled water for one minute.
4. Remove the apples from the solutions and stand in air.
5. Observe the browning rate.

1.3 Draw the structure of phenol.

1.4 Why did the student soak one half of the apple in distilled water and one half in phenol solution?

1.5 The student observed that the rate of browning was the same in both halves of the apple. Explain what the student can conclude from these results.

1.6 The student wanted to investigate the effect of temperature on the rate of browning in an apple using the following temperatures: 20˚C, 40˚C, 60˚C, 80˚C and 100˚C. Plan a method the student could use, giving the control variables.

1.7 The student found the apple at 40˚C browned the fastest and that the apples did not turn brown at any temperatures greater than 60˚C. Explain how these results support the hypothesis that enzymes cause browning in apples.

1.8 Explain how the results for the experiment investigating the effect of temperature would differ if microbes caused the browning reaction.

1.9 The reaction turning the apples brown is an oxidation reaction. Suggest how the student could investigate the hypothesis that oxygen from the air is necessary for the browning reaction.

How to stop apples and potatoes from going brown

2.1 Freshly cut potatoes can be prevented from browning by 'blanching' them. (This can be done by placing them in boiling water for one minute.) Explain how blanching stops the potatoes from browning.

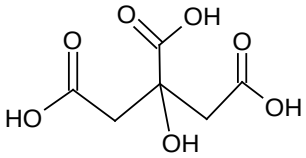
A student conducted an investigation using acids to stop the browning reactions. They used:

- 0.1 mol dm^{-3} hydrochloric acid
- 0.1 mol dm^{-3} citric acid
- 0.1 mol dm^{-3} ethanoic acid

All of the acids stopped the browning reaction in the apples.

2.2 Explain why acid solutions can stop the browning reaction.

2.3 Each of the three acids used had a different pH. Suggest the order of decreasing pH for the three acids and explain your reasoning. The structure of citric acid is provided below.



2.4 Which of the above acids would be most suitable to add to a fruit salad to stop the fruit browning?

Investigating the Maillard reaction

The Maillard reaction causes foods like meat and onions to go brown when cooked.

3.1 Two functional groups react together at the start of the Maillard reaction. What are these functional groups and what type of natural molecules are they found in?

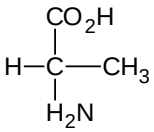
3.2 A student investigated the following four mixtures to compare the extent of browning due to the Maillard reaction.

A. Solution of alanine at pH 2 and glucose
B. Solution of alanine at pH 11 and glucose
C. Solution of lysine at pH 2 and glucose
D. Solution of lysine at pH 11 and glucose

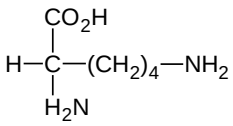
Each mixture was heated at 140˚C for 10 minutes. Mixtures **A** and **C** did not change colour. Mixture **B** turned light brown and mixture **D** turned dark brown. Explain the results.

- Refer to the formulae of the amino acids at the different levels of pH.
- Refer to the likely first step of the mechanism in the Maillard reaction.

The structures of alanine and lysine are given below.



alanine



lysine