Stopping Apples from Browning

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Abstract

This report demonstrates an experiment to understand the effect of the pH of a solution on the browning of apple slices. It focuses primarily on investigating the effect of decreased pH level on lowering the enzymatic browning of freshly cut apple slices. During the experiment, the apple slices (from the same apple) are dipped into different solutions of lemon juice, orange juice, vinegar, and tap water. The amount of browning of each slice is recorded over a period. The apple slice left in lemon juice shows the minimum amount of browning and the apple slice left in water shows the maximum amount of browning. The result indicates that the browning of apple slice is dependent on the pH of the environment and the least browning occurs at an optimum pH level.

Introduction

The purpose of this lab is to determine which pH level is most effective at reducing the browning of apple. It is a well-known fact that after slicing the apple into pieces and leaving it out, the slices will start to attain a brown color. This is due to the effect of pH. pH is the measurement of hydrogen ion concentration or level of acidity in a solution [1].

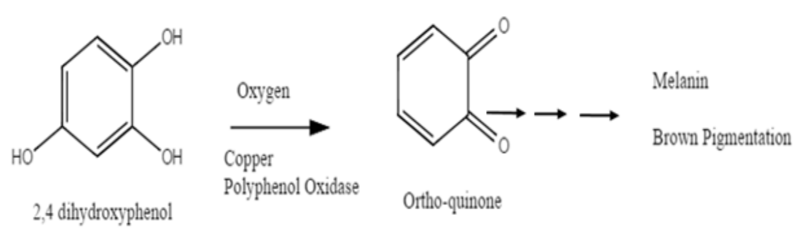
The purpose of this experiment is to determine the effect of pH of a solution on the browning of freshly cut apple slices; specifically, at which pH level the least browning will take place. Certain fruits when sliced open and exposed to air, the fruit slices turn brown.

The browning of fruit is known as enzymatic browning [2]. Enzymatic browning occurs as the oxygen, present in the air and an enzyme present within the fruits comes into contact. This enzyme is called Polyphenyl Oxidase. When the fruit is sliced open, the enzyme polyphenyl Oxidase comes into contact with oxygen from air and becomes activated [3].

Oxygen + Polyphenol Oxidase → activated Polyphenol Oxidase

The activated Polyphenyl oxidase converts polyphenol and oxygen into melanin and others and leads to the browning of the fruit. Polyphenol oxidase and polyphenol are released when the fruit cells are cut [4]. The enzymatic browning is optimum at pH 5-7[5].

Figure 1 The reaction between Oxygen and dihydroxy phenol in presence of Polyphenyl oxidase leading to enzymatic browning



Here we see Polyphenol gets activated by oxygen (in air) and starts the enzymatic reaction that turns the exposed fruit's surface brown.**[4]**

The enzymatic browning can be slowed down by using antioxidants [4] or PPO inhibitors [1]. These antioxidants react with oxygen and act as a barrier between oxygen and Polyphenol oxidase. As a result, the enzyme Polyphenol oxidase is not activated, and the browning doesn't take place or is slowed down. Citric acid and other acidic solution tend to react with oxygen and act as antioxidants [6].

It is crucial to know how to reduce the enzymatic browning of fruits because the study shows that enzymatic browning reduces the nutritional value of fruits [1]. Therefore, the audience will be able to understand why the browning takes places and will be informed on what steps to take to reduce the browning.

In this experiment, the independent variables are tested against the dependent variables. The independent variables used in this experiment are solutions of different pH, Lemon juice, orange juice, vinegar, and tap water. The dependent variable is the amount of browning that takes place on the surface of the apple slices. Some constant variables are maintained throughout the experiment to increase the accuracy of the experiment. This includes:

1. same room temperature
2. same size of apple slices used in the experiment, amount
3. the concentration of the solution is kept the same
4. time length, the apples are dipped in the solutions, are kept same.

We will be placing the slices apples into different solutions with varying pH levels, mostly acidic (<7), see the correlation between pH level and the level of browning.

We hypothesize that the solution with the lowest pH level (more acidic) will show a lower rate of enzymatic browning of apple slices because, the pH of the solution with the fruit in it has to be at a certain range for the Polyphenol to be activated when it comes in contact with oxygen, and that range is 5-7 [4]. Therefore, pH level lower than 5 will reduce the browning by preventing the Polyphenol from being activated. Furthermore, if we lower the pH as low as possible, it might denature the enzyme, causing the browning at all. Therefore, since lemon juice is the solution with the lowest pH level in this experiment, we hypothesize that the least browning will take place when the apple slices are dipped into the lemon juice.

Objectives

This experiment is done to test the effect of the pH of a solution on the browning of apple slices. The effect of decreased pH level on lowering the enzymatic browning of freshly cut apple slices is probed. There is a control sample, where the slices are left by themselves to further prove that lowered pH levels, do in fact, lower the chance of browning. The pH of the different solutions (independent variable) is recorded. Moreover, the amount of browning of the apple slices (dependent variable) in different solutions is also recorded.

Materials

- 5 apples of approximately same size and color
- Tongs
- Cutting knife and cutting board
- Lemon juice (100 ml 10 percent solution)
- Orange juice (100ml 10 percent solution)
- Tap water (100 ml)
- Vinegar (100 ml 10 percent solution)
- 5 small beakers
- A pH meter

Procedure

1. Take the four beakers and label each one A, B, C, D, and E, respectively. Then pour 25 ml of lemon juice in beaker A, 25 ml of orange juice in beaker B, 25 ml of tap water in beaker C, 25 ml of vinegar in beaker D, and leave beaker E empty for the control.

2. Measure the pH reading of each beaker's solution by using a pH meter and then record in Table 1 accordingly.

3. Take one of the apples and slice into 5 equal pieces with a knife. Next, by using a tong, place one slice of apple in the solution of each of beaker.

4. For the latter half of the experiment, take the apple slices out of the solutions to check the browning in intervals of five minutes and dip back in the respective solution. Continue this process for 30 minutes. Record the browning of the apple in Table 1 according to the scale below:

No presence of brown color =0

Very little browning =1

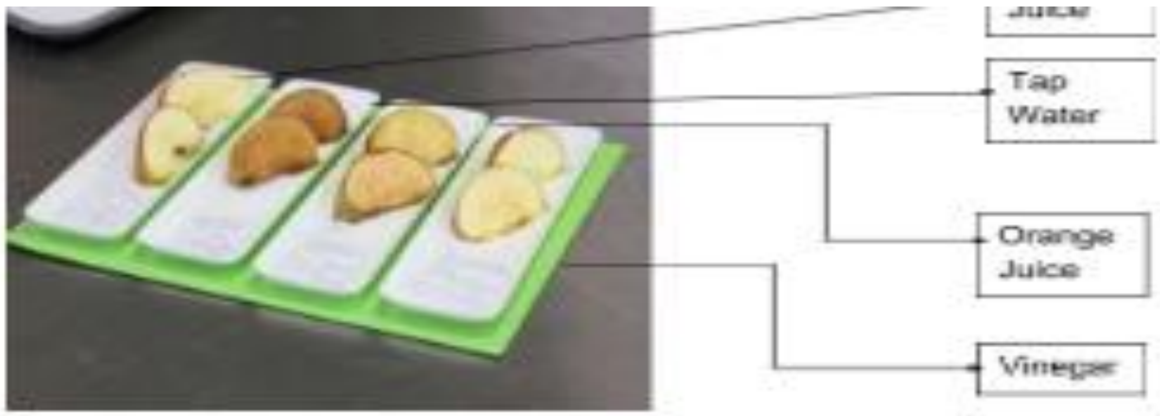
normal browning =2

significant browning =3

Dark brown =4

The steps were repeated for the remaining 4 apples and their data were recorded in Table 1.

Figure 2: The Apple slices after being dipped in solutions of varying pH levels



The image shows the apple slices after they are dipped into four different solutions of Lemon juice, orange juice and vinegar with varying pH [7]. The apple slices embody varying degree of browning.

Results

The apple slice that is kept in the empty beaker (beaker E), the control, shows complete dark browning (4). The apple slice that is kept in tap water(C) shows significant browning (3) but lower than the apple slices that is put in the empty beaker. The apple slice that is kept in orange juice (B) shows very little browning (1.5) even lower than sample C (Tap water). The apple slice dipped in vinegar (sample D) shows very little browning (1) and slightly lower than sample B (orange juice). The apple slice dipped in lemon juice (sample A) shows no browning (0) after 30 minutes.

Table 1: Table shows the data collected from repeating the experiment five times

	Independent variables				
	Lemon Juice	Orange juice	Tap water	Vinegar	Control

	Sample A	Sample B	Sample C	Sample D	Sample E
Experiment 1	0	2.0	3.0	1.5	4.0
Experiment 2	0	1.25	4.0	0.75	4.25
Experiment 3	0	1.25	2.5	0.75	3.75
Experiment 4	0	1.75	3.25	1.25	4.5
Experiment 5	0	1.25	2.75	0.75	3.5
Average	0	1.50	3.0	1.0	4.0

The amount of browning of apple slices in different solution with varying pH are recorded according to the scale and average reading is taken from the values obtained by repeating the experiment five times.

Analysis

The hypothesis of the experiment is the that solutions with lower pH slow down enzymatic browning. The data shown in Table 1 support the hypothesis. Table 1 indicates that the pH of lemon juice is lowest (2.0) and when the sample is dipped into the solution of lemon juice no browning takes place. As for the explanation, as to why no browning occurred in the lemon juice, it is due to the presence of citric acid. This citric acid acts as an antioxidant agent and acts as a barrier between the polyphenol oxidase and oxygen [2]. Thus, it shows hardly any browning effect. The pH of vinegar is 2.4 due to the presence of acetic acid and thus it shows very little browning. The pH of orange juice is around 3.5 due to the presence of ascorbic acid. Ascorbic acid acts as a barrier between oxygen and Polyphenol Oxidase and thus shows slight browning only. The pH of Tap water is around 8. The optimum working environment for Polyphenol oxidase is from 5-7. As the pH is slightly higher than optimum pH, water shows significant browning. The apple slice that is kept as control shows the most browning as it's in direct contact with air and also the pH is optimum for the reaction to take place. Thus, the result obtained from the experiment shows that the browning effect of the apple slices are slowed down or prevented as the pH of the solution reduces.

However, there are limits and sources that may cause an error in the data. First of all, the apples that are used, though they are very close in resemblance and size, they have distinct DNA or molecules. Furthermore, the solution used in this experiment are not pure. For example, the lemon juice and the orange juice have a certain amount of added sugar in them which may cause some discrepancy in data. Plus, as aforementioned, since the reaction takes place at a molecular/microscopic level, the microscopic factors; i.e., the air and temperature are taken into consideration. Moreover, the data and conclusion produced by this experiment are only applicable to the specific solutions and the specific apples that are used. The results and the conclusions cannot be applied to all the enzymatic browning reactions.

To improve the experiment it is recommended to use pure solution. Moreover, Added sugar in lemon juice and apple juice are to be removed.

Reference list

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