OXIDATION TRANSFORMATION

Did you know that a chemical reaction occurs after fruit has been exposed to oxygen?

Once the skin on some fruit is removed, the fruit will be exposed to air, and a chemical reaction called ***enzymatic browning*** occurs. This happens because of a reaction between specific enzymes and oxygen (O_2). ***Enzymes*** are substances that can help speed up reactions. The oxidation of fruit pigments activates specific enzymes in plant tissues causing this reaction to occur. ***Oxidation*** occurs when a substance is exposed to oxygen. For fruit, oxidative browning occurs when enzymes interact with amino acids in the presence of oxygen, which then causes brown pigments to form. ***Pigments*** make up the natural coloring of plant and animal tissues.

Enzymatic or oxidative browning typically occurs at warm temperatures in slightly acidic or neutral environments. A pH between 5.0 and 7.0 would provide the perfect environment. The reaction rate can be increased by the presence of iron or copper. This reaction causes a reduction in the quality of fresh fruit and vegetables by decreasing the food's lifespan and nutritional quality; however, enzymatic browning can have its advantages. For instance, the browning reaction can contribute to the desirable color and flavor of dried fruits, like raisins and prunes.

There are various treatments that can prevent enzymatic browning. One way is by adding an acid and changing the pH. ***Acids*** cause a sour flavor in foods. To neutralize acids, ***bases*** are used. Acids and bases are categorized based on a ***pH scale***, which ranges from 0-14. Items that have a pH of 7 are considered to be neutral. Items with a pH less than 7 are acidic, and items ranging from 8-14 are basic. Lowering the pH by adding an acid prevents the enzymes from functioning properly, which stops the browning process. ***Ascorbic acid***, also called Vitamin C, is found in citrus fruits and vegetables. The

Baking soda (base) decreases the acidity of foods by increasing the pH.

addition of a base, such as baking soda, will cause the pH to increase and possibly speed up the browning process. You will observe these types of reactions in *Food Lab Explorations Part I* of this chapter.

Chemical reactions not only occur in fruit itself, but in the human body as well. ***Oxidation*** is the process in which an electron is removed from an atom. For our bodies, it is considered a normal process that cells undergo, but it can cause stress on our bodies too. This stress can lead to diseases, such as cancer and heart disease.

Antioxidants are substances that can inhibit or slow oxidation. Antioxidants can work to reduce the damaging effects of oxidation in the body. The antioxidants found in fruit will fight disease-promoting cells in your body. Vitamin C is the most common antioxidant. Citrus fruits including grapefruit, lemons, limes, oranges, and tangerines are the highest in Vitamin C. Be sure to include fruits in your diet for a good source of antioxidants! You will explore antioxidant reactions further in *Food Lab Explorations Part II* of this chapter. Try preventing enzymatic browning in your own fruits!

Include fruits in your diet as a good source of antioxidants.

Think About It

Food Explorations Lab I

1. What is the purpose of an enzyme in a chemical reaction?

_____

2. What gas is necessary for oxidation to occur? _____

3. What conditions are best for oxidative browning to occur?

_____

Food Explorations Lab II

1. What is an antioxidant? _____

2. What is another name for vitamin C? _____

3. Why are antioxidants important to our bodies?

_____

Food Explorations Lab I:

Enzymatic Reactions

STUDENT LAB INVESTIGATIONS

Name: _____

Lab Overview

There are two parts to this investigation. In Part A, you will observe and compare three types of fruit for enzymatic browning. In Part B, you will choose two substances to test for their ability to inhibit or slow enzymatic browning.

Lab Objectives

In this lab, you will learn how to…

1. Determine which types of fruit are susceptible to enzymatic browning.

2. Explore potential methods for inhibiting enzymatic browning.

Lab Safety: Before beginning ANY investigation you should put on your safety goggles and apron. It is important to avoid getting chemicals on your body. Always wash your hands following completion of an investigation. When handling food, you should also wash your hands prior to beginning an investigation.

PART A: Observation of Enzymatic Browning in Fruit

MATERIALS

1 cutting board
3 plastic or blunt knives
3 paper plates (any size)
Kitchen timer or stopwatch
Fruit (¼ of an apple, ¼ of an orange, ¼ of a banana)
Paper towel or napkin
Safety goggles
Aprons (optional)

PROCEDURE

1. Prepare your fruit types. Cut the apple and orange into thirds using a different knife for each fruit. Cut the banana into small slices.

2. Separate each fruit type onto separate plates (you should have a total of three plates). Make sure the flesh of the fruit is facing upward.

3. Once your fruit samples have been prepared, you are ready to begin. Describe your *visual* observations of each fruit in Table A under "0 minutes". *DO NOT smell or taste any of the samples.*

4. Allow each fruit to sit for 10 total minutes (set your timer). While you wait, predict what you think will happen to each fruit after 10 minutes have passed and provide evidence to support your prediction. Will you observe changes in texture? Changes in color?

	After 10 minutes, I predict…	because…
the apple will…		
the orange will…		
the banana will…		

5. Describe your observations after 10 minutes in Table A. While you wait, proceed to Part B of the lab investigation.

6. Set aside one sample of apple for Part B.

Table A: Enzymatic Browning Observations

Fruit	0 minutes	10 minutes
Apple		
Orange		
Banana		

Conclusion:

1. Compare and contrast the fruits' chemical reactions.

2. Infer why this reaction is occurring in some fruit types and not others.

3. Remember to set aside the apple sample for Part B. The apple sample will serve as a *control* in the next investigation.

PART B: Methods to Decrease Enzymatic Browning

Lab Questions

Which of the following substances will decrease enzymatic browning on an apple?

Vitamin C Cream of Tartar Lemon Juice

Sugar-water Baking Soda Vinegar Salt water Water

Choose two substances from above that your group believes will decrease enzymatic browning:

1. _____ 2. _____

Complete Table B with your choices and explanations. The substances you chose as having the ability to decrease enzymatic browning should be identified under the "Identity of Substance" column below.

Table B:

	Identity of Substance	Explanation
Sample A		
Sample B		

MATERIALS

2 household substances (based on prediction)
½ teaspoon measuring spoon (if applicable, based of substances chosen above)
2 – 9 oz plastic cups
2 plastic spoons
1 paper plate (any size)
1 plastic or blunt knife
1 black permanent marker
1 beaker or measuring cup containing water
1 apple
1 kitchen timer or stopwatch
Apple sample from Part A
Safety goggles
Aprons (optional)

PROCEDURE

1. Use the marker and draw a line dividing the paper plate into two sections. Label the sections: Sample A and Sample B.

2. Label one cup Sample A and the other Sample B.

3. Obtain and prepare the two substances from your prediction using the directions provided:

Substance Preparation Procedures

- *Vitamin C Tablet:* Obtain 1 vitamin C tablet. Fill the cup ½ full of water. Crush the tablet before adding it to the water for better dissolution. Dissolve the tablet in the water.
- *Cream of Tartar:* Obtain ½ tsp. of the cream of tartar in a 9 oz cup. Fill the cup ½ full of water. Stir the mixture until the cream of tartar has completely dissolved.
- *Lemon Juice:* Fill one 9 oz cup ½ full of lemon juice.
- *Sugar-Water Solution:* Obtain ½ tsp. of sugar in a 9 oz cup. Fill the cup ½ full of water. Stir the mixture until the sugar has completely dissolved.
- *Sodium-Bicarbonate Solution (baking soda):* Obtain 3 ½ tsp. of baking soda in a 9 oz cup. Fill the cup ½ full of water. Stir the mixture until the baking soda has completely dissolved.
- *Vinegar:* Fill a 9 oz cup ½ full of vinegar.
- *Salt Solution:* Obtain ½ tsp. of salt in a 9 oz cup. Fill the cup ½ full of water. Stir the mixture until the salt has completely dissolved.
- *Water:* Fill a 9 oz cup ½ full of water.

4. Obtain and prepare your apple by cutting it in half. Place ½ of the apple in each of the two sections on your labeled plate. Make sure the flesh of the fruit is facing upward.

5. Dip each fruit sample into the cup with the same label. For instance, the apple on the plate labeled *Sample A* should be dipped into the cup labeled *Sample A*.

6. Allow the apple samples to sit for a total of 15-20 minutes (set your timer). While you wait, start Food Explorations Part II. Record your observations after 10 minutes and 20 minutes in Table C.

Table C: Color Change Observations

Sample	10 minutes	20 minutes
Sample A		
Sample B		

Conclusion:

1. Including the control (apple half from Part A), order each sample from greatest to least amount of enzymatic browning.

   Greatest: _____

   _____

   Least: _____

2. Compare and contrast the effectiveness of the substances you tested on inhibiting enzymatic browning.

3. As a class, discuss the list of substances used and complete the chart below:

Substance	Browning (Yes, None, Some)
Vitamin C	
Cream of Tartar	
Lemon Juice	
Sugar-water solution	
Baking Soda	
Vinegar	
Salt water	
Water	

4. Consider the properties of the substances tested including acidic and basic properties. How might these properties impact the ability to decrease enzymatic browning?

5. When making a fruit salad that includes apples and bananas, it is desirable to reduce the enzymatic browning of each fruit. Suggest a substance that could be used in the recipe for this purpose.

Food Explorations Part II:

Hidden Antioxidants

STUDENT LAB INVESTIGATIONS

Name: _____

Lab Overview

In this investigation, you will prepare four solutions and test them with an indicator to determine their antioxidant properties.

Lab Objectives

In this lab, you will learn how to…

1. Identify substances with antioxidant properties.

2. Describe health benefits of antioxidants.

Lab Safety: Before beginning ANY investigation you should put on your safety goggles and apron. It is important to avoid getting chemicals on your body. Always wash your hands following completion of an investigation. When handling food, you should also wash your hands prior to beginning an investigation.

Lab Questions

Which of the following substances are antioxidants? (Circle your answer)

Vitamin C Cream of Tartar Lemon Juice Vinegar

Predictions: I predict the following substances are antioxidants.

_____ and _____ because…

Observations of Antioxidants

MATERIALS

1 acidic substance
1 beaker or measuring cup containing water (350mL or 1 cup)
1 – 9 oz plastic cup
1 black permanent marker
1 medicine dropper
1 plastic spoon
1 medicine cup or small cup containing colored iodine
½ teaspoon
Safety goggles
Aprons (optional)

PROCEDURE

1. Choose one of the acidic substances identified in your prediction above. Use the marker to label the plastic cup with the name of your chosen acid sample (e.g. vitamin C).

2. Prepare your substance using the directions provided below:

Substance Preparation Procedures

- Vitamin C Tablet: Obtain 1 vitamin C tablet. Fill the cup ½ full of water. Crush the tablet and dissolve it in the water.
- Cream of Tartar: Obtain ½ tsp. of cream of tartar in a 9 oz cup. Fill the cup ½ full of water. Stir the mixture until the cream of tartar has completely dissolved.
- Lemon Juice: Fill one 9 oz cup ½ full of lemon juice.
- Vinegar: Fill one 9 oz cup ½ full of vinegar.

3. Describe your *visual* observations of your chosen acid sample before reacting with iodine in Table A.

4. To test for antioxidant properties of each acid substance, use the medicine dropper to add 12-15 drops (do not exceed) of iodine to each sample. Describe your *visual* observations of your chosen acid sample's reaction with iodine in Table A. A solution *with* antioxidant properties will not change color. A solution *without* antioxidant properties will have a brown tint.

5. Share your data with the other groups in your class to complete Table A.

Table A: Substance Observations

Substance	BEFORE Reacting with Iodine	AFTER Reacting with Iodine	Antioxidant Properties?
Vitamin C Tablet Solution			YES NO
Cream of Tartar Solution			YES NO
Lemon Juice			YES NO
Vinegar			YES NO

Conclusion:

1. Compare and contrast the four acid samples and their chemical reactions.

2. Which acid substances had antioxidant properties? Compare your results to your predictions and explain any similarities and differences.

3. Explain why the orange in **Part I: Enzymatic Reactions** investigation did not turn brown?

4. All the substances tested in this investigation were acids. Infer why they are not all antioxidants.

5. Lemon juice (pH 2) is more acidic than vinegar (pH 3). Vitamin C has a slightly lower pH than vinegar. Some fruit salad recipes have yogurt as an ingredient. Yogurt contains lactic acid (pH 2.4). Will the yogurt act as an antioxidant? Explain.

6. As a class, discuss antioxidant properties and the potential benefits to your health.

Investigating Your Health:

Amazing Antioxidants

Name: _____

Objective: Investigate fruits by comparing the nutrients of frozen, dried, and canned fruit. Develop or research recipes to learn about ways you can add more fruit to your diet.

Antioxidants are vitamins and other nutrients that protect your body from harmful molecules that are found in the environment or created by the body. These substances can contribute to cancer and heart disease. Your body can protect itself against these molecules to an extent; however, it isn't completely effective in destroying them. Therefore, eating fruits high in antioxidants will help your body destroy these harmful substances. Vitamins A, C, E, and the mineral zinc are common antioxidants in our diet. Vitamin C is the most common antioxidant, and is needed to heal cuts and protect bones and teeth. Citrus fruits including grapefruit, lemon, lime, orange, and tangerine are the highest in Vitamin C. Vitamin A is found in colorful fruits, like apricots and cantaloupe. Vitamin A helps your eyes. Vitamin E and zinc help your immune system and can be found in many different foods. The mineral selenium and the phytochemicals lycopene, lutein, and beta-carotene are also antioxidants.

As with vegetables, you should eat 1 ½ cups of fruit every day. For example, you can drink ½-cup of orange with breakfast and eat 1 banana for a snack in the afternoon to meet this recommendation. Most of us do not eat enough fruits. It's easy to add fruits to your diet. Instead of eating potato chips as a snack, eat a piece of fruit like an apple, orange, or banana. You can keep it in your backpack and eat it when you are hungry. You could also have a fruit salad for dessert or add fruit to your cereal in the morning. Try to eat dried fruit instead of candy. They're just as sweet and good for you too! Use the *Try This at Home* recipe to make a fruit snack!

PART A: Antioxidants in Fruit

1. Go to the grocery store and look at the Nutrition Facts label on one frozen, one dried, and one canned fruit. Try to find the same fruit for each kind. If you are unable to go to the grocery store, use the handout provided by your teacher or access the nutrient database on USDA's website. Complete the Nutrition Facts Labels below.

USDA Nutrient Database: http://ndb.nal.usda.gov/ndb/search/list

Frozen Fruit:	**Dried Fruit:**	**Canned Fruit:**
_____	_____	_____

Nutrition Facts		**Nutrition Facts**		**Nutrition Facts**	
Serving Size	_____	**Serving Size**	_____	**Serving Size**	_____
Calories	_____	**Calories**	_____	**Calories**	_____
Total Fat	_____	**Total Fat**	_____	**Total Fat**	_____
Sodium	_____	**Sodium**	_____	**Sodium**	_____
Total Carbohydrates	_____	**Total Carbohydrates**	_____	**Total Carbohydrates**	_____
Dietary Fiber	_____	Dietary Fiber	_____	Dietary Fiber	_____
Sugars	_____	Sugars	_____	Sugars	_____
Protein	_____	**Protein**	_____	**Protein**	_____
Vitamin A ____%	Vitamin C ____%	Vitamin A ____%	Vitamin C ____%	Vitamin A ____%	Vitamin C ____%
Vitamin E ____%	Calcium ____%	Vitamin E ____%	Calcium ____%	Vitamin E ____%	Calcium ____%
Iron ____%	Thiamin ____%	Iron ____%	Thiamin ____%	Iron ____%	Thiamin ____%
Niacin ____%	Folate ____%	Niacin ____%	Folate ____%	Niacin ____%	Folate ____%
Vitamin B_{12} ____%	Zinc ____%	Vitamin B_{12} ____%	Zinc ____%	Vitamin B_{12} ____%	Zinc ____%
Magnesium ____%		Magnesium ____%		Magnesium ____%	

2. Before you begin, compare the serving size for each label. If the serving sizes are different use the space below the labels to standardize each label so that you can compare their nutritional content. Ask your teacher for help if you have to standardize your labels.

Frozen Fruit:	**Dried Fruit:**	**Canned Fruit:**
_____	_____	_____

Nutrition Facts		**Nutrition Facts**		**Nutrition Facts**	
Serving Size	_____	**Serving Size**	_____	**Serving Size**	_____
Calories	_____	**Calories**	_____	**Calories**	_____
Total Fat	_____	**Total Fat**	_____	**Total Fat**	_____
Sodium	_____	**Sodium**	_____	**Sodium**	_____
Total Carbohydrates	_____	**Total Carbohydrates**	_____	**Total Carbohydrates**	_____
Dietary Fiber	_____	Dietary Fiber	_____	Dietary Fiber	_____
Sugars	_____	Sugars	_____	Sugars	_____
Protein	_____	**Protein**	_____	**Protein**	_____
Vitamin A ____%	Vitamin C ____%	Vitamin A ____%	Vitamin C ____%	Vitamin A ____%	Vitamin C ____%
Vitamin E ____%	Calcium ____%	Vitamin E ____%	Calcium ____%	Vitamin E ____%	Calcium ____%
Iron ____%	Thiamin ____%	Iron ____%	Thiamin ____%	Iron ____%	Thiamin ____%
Niacin ____%	Folate ____%	Niacin ____%	Folate ____%	Niacin ____%	Folate ____%
Vitamin B_{12} ____%	Zinc ____%	Vitamin B_{12} ____%	Zinc ____%	Vitamin B_{12} ____%	Zinc ____%
Magnesium ____%		Magnesium ____%		Magnesium ____%	

3. Identify which of the listed vitamins and minerals are antioxidants. Circle each in the standardized labels.

4. Which fruit has the highest % Daily Value for each antioxidant? List the fruit, the antioxidant, and the amount below.

5. Describe other differences between the fruit types.

6. Infer why these differences occur.

PART B: Everyday Fruits

Create three recipes, one for each meal – breakfast, lunch & dinner, using fruit as a main ingredient.

RECIPE #1: BREAKFAST

RECIPE #2: LUNCH

RECIPE #2: DINNER

TRY THIS AT HOME:

Fruit Salad

Makes 5 – 1 cup servings

You will need:

1 medium orange
½ large red delicious apple
1 cup seedless green grapes, rinsed
½ cup seedless red grapes, rinsed
1 medium banana
1 Tablespoon lemon juice (optional)

INSTRUCTIONS:

1. Slice orange thinly. Make sure to remove the peel and seeds.

2. Cut the apple into thick slices, remove the seeds and core, and then cut into triangles.

3. Add apple slices, and green and red grapes to bowl with oranges and apples.

4. Peel banana. Slice banana into bowl with other fruit.

5. Add lemon juice to fruit mixture.

6. With rubber spatula, gently mix fruits.

7. Cover with plastic wrap and chill for several hours.

8. Spoon fruit salad onto small dishes or plates and enjoy!