Chapter 4: Fruits

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?

Speed up the reaction

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

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

Slightly acidic (pH 5-7), warm temperature

Food Explorations Lab II

1. What is an antioxidant? A substance that inhibits or slows oxidation

2. What is another name for vitamin C? Ascorbic acid

3. Why are antioxidants important to our bodies?

They fight against damage-causing oxidants

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	White	Browned
Orange	Orange	Did not change
Banana	White	Browned

Conclusion:

1. Compare and contrast the fruits' chemical reactions.

The apple and banana both turned brown, but the orange stayed the same color.

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

The orange did not brown because it contains Vitamin C (ascorbic acid), an antioxidant. Vitamin C is also acidic, resulting in a lowered pH and inhibition of the browning process. Apples and bananas do not contain significant amounts of Vitamin C; therefore, oxidative browning occurred.

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. Vitamin C

2. Lemon Juice

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	Vitamin C or Cream of Tartar	The antioxidant properties will prevent oxidation from occurring. The acidity of the substance will reduce the pH of the fruit, preventing oxidation from occurring.
Sample B	Lemon Juice or Vinegar	The acidity of the juice will reduce the pH of the fruit, preventing oxidation from occurring; the presence of antioxidants will also prevent browning. The acidity of the vinegar will reduce the pH of the fruit preventing oxidation from occurring.

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	Dependent upon sample choices. If one of the correct substances was chosen, there will be little to no color change observed; if not, browning will occur as it did in Part A.	See Sample A, 10 minutes
Sample B	See Sample A, 10 minutes	See Sample A, 10 minutes

Conclusion:

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

Greatest: Dependent upon chosen samples

_____

Least: _____

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

Decreased enzymatic browning (effective): Vitamin C, Cream of Tartar, Lemon Juice, Vinegar

Increased enzymatic browning: Baking Soda

No Effect on enzymatic browning: Sugar-water, Salt Water, Water

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

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

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

Lemon juice, cream of tartar, and vinegar are all acids, which decreases pH and prevents enzymatic browning from occurring. Baking soda is a base, which will possibly increase the browning rate. Sugar-water, salt water, and water are all neutral substances that will have no effect on the reaction.

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.

Lemon juice or cream of tartar

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	Clear	Iodine disappeared; solution is clear	(YES) NO
Cream of Tartar Solution	Clear	Iodine turned the solution golden yellow	YES (NO)
Lemon Juice	White, Cloudy	Iodine disappeared; solution is still white and cloudy	(YES) NO
Vinegar	Clear	Iodine turned the solution dark (or golden) yellow	YES (NO)

Conclusion:

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

Vitamin C Tablet Solution and Lemon Juice reacted the same as each other and differently than Cream of Tartar Solution and Vinegar.

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

Vitamin C and Lemon Juice have antioxidant properties. Comparison to predictions will vary based on student predictions

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

The orange did not turn brown because it contains Vitamin C, which is an antioxidant that will prevent enzymatic browning from occurring.

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

Student responses will vary. Acids are substances that have a high concentration of hydrogen ions (H+). While, antioxidants are substances that can prevent the transfer of H+ ions to oxidize other substances (e.g. free radical) in the body that can be potentially harmful. pH and antioxidant are not interchangeable. pH measures hydrogen ion concentration. "Antioxidant" refers to the reducing power of a compound (i.e. potential of donating electrons). Some antioxidants are acidic, but not all acids are antioxidants. For example, lemon juice is acidic and contains the antioxidant vitamin C. Cream of tartar is also acidic, but it does not contain any 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.

pH and antioxidant are not interchangeable. pH measures hydrogen ion concentration. "Antioxidant" refers to the reducing power of a compound (i.e. potential of donating electrons).

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

Antioxidants aid in the prevention and repair of cells damaged from oxidation. It is important to eat foods containing antioxidants to help keep our bodies healthy and to treat and prevent the stress caused by oxidation. Antioxidants can be found in fruits, vegetables, grains, nuts, and spices. Including these foods in our diets may help prevent diseases, such as cancer and heart disease.

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	
Serving Size	_____
Calories	_____
Total Fat	_____
Sodium	_____
Total Carbohydrates	_____
Dietary Fiber	_____
Sugars	_____
Protein	_____

Vitamin A	____%	Vitamin C	____%
Vitamin E	____%	Calcium	____%
Iron	____%	Thiamin	____%
Niacin	____%	Folate	____%
Vitamin B_{12}	____%	Zinc	____%
Magnesium	____%		

Nutrition Facts	
Serving Size	_____
Calories	_____
Total Fat	_____
Sodium	_____
Total Carbohydrates	_____
Dietary Fiber	_____
Sugars	_____
Protein	_____

Vitamin A	____%	Vitamin C	____%
Vitamin E	____%	Calcium	____%
Iron	____%	Thiamin	____%
Niacin	____%	Folate	____%
Vitamin B_{12}	____%	Zinc	____%
Magnesium	____%		

Nutrition Facts	
Serving Size	_____
Calories	_____
Total Fat	_____
Sodium	_____
Total Carbohydrates	_____
Dietary Fiber	_____
Sugars	_____
Protein	_____

Vitamin A	____%	Vitamin C	____%
Vitamin E	____%	Calcium	____%
Iron	____%	Thiamin	____%
Niacin	____%	Folate	____%
Vitamin B_{12}	____%	Zinc	____%
Magnesium	____%		

TEACHER'S NOTE: Regardless of the source used to obtain the food labels, students should seek labels that use identical serving sizes. If students choose a fruit with different serving sizes listed on the label, they will need to mathematically standardize each serving size before comparing them. Dried fruit will have the smallest serving size, while frozen fruit will have the largest. This is because the calories and nutrients are condensed in dried fruit.

To standardize serving sizes across nutrition labels, students will need to convert each serving size into the same value (cup, tablespoon, etc.). Students will then need to convert all fractions to a decimal. Finding the largest decimal, the students will then divide it by one of the others. Multiply each number in the nutrition facts label using this answer. For example: ¾ = 0.75, 0.75 ÷ 0.5 = 1.5. Repeat these steps with the other labels. Please reference the Sample Nutrition Facts Standardization Worksheet found at www.foodmaster.org.

Students should find that dried and canned fruit have more sugar for the same mass or volume than frozen fruit. The vitamin content will also vary. Frozen fruit normally contains higher amounts of Vitamin C.

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

   Vitamin C, Vitamin E, Zinc, & Iron

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

   Frozen pineapple - (Vitamin C: 13%; Iron: 2%)

   Dried pineapple - (Iron: 2%)

   Canned pineapple - (Vitamin C: 20%)

5. Describe other differences between the fruit types.

   Dried pineapple has the most calories, sugar, and sodium. Canned pineapple is the second highest in sugar and calories.

6. Infer why these differences occur.

   Dried pineapple has added sugar that is acting as a preservative. The fruit is also condensed, making it more nutritionally dense per serving. Dried pineapple has more sodium to help preserve it. Half a cup of dried fruit is equivalent to 1 cup of fruit. Canned pineapple may also have added sugar in liquid it's canned in.

PART B: Everyday Fruits

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

RECIPE #1: BREAKFAST

Student answers will vary.

RECIPE #2: LUNCH

Student answers will vary.

RECIPE #2: DINNER

Student answers will vary.

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!