Microanalysis of Vitamin C in Citrus Juices

PA State Standards:

3.4.12.A	Apply concepts about the structure and properties of matter.
2.5.11.A	Select and use appropriate mathematical concepts and techniques from different areas of mathematics and apply them to solving non-routine and multi-step problems.
1.2.11.A	Read and understand the central content of informational texts and documents in all academic areas.

Introduction:

Vitamin C is a water soluble vitamin that is required daily since it is not synthesized by humans and cannot be stored by the body. Vitamin C is required for cellular respiration, for enzyme function, as a component in collagen formation, and has been reported to increase iron absorption within the body. Dr. Linus Pauling has found that Vitamin C dosages in excess of the recommended daily allowance (RDA) appear to reduce the severity and frequency of the common cold. The RDA of vitamin C in adults is 60 mg per day. This vitamin is nontoxic even at high dosage levels. A dietary deficiency in vitamin C may result in scurvy which is characterized by fatigue, shortness of breath, muscle degeneration, gum bleeding, tooth loss, and even death. Just 10 mg of vitamin C is enough to cure scurvy. Vitamin C, whose chemical name is ascorbic acid, is a weak acid found mostly in citrus fruits and leafy green vegetables (broccoli, parsley, and spinach). Apples, grapes, and peaches are low in vitamin C.

The method of measuring the amount of vitamin C in fruit juices in this lab utilizes the ease at which vitamin C can be oxidized (forced to lose electrons) by iodine.

$$C_6H_8O_6 + I_2 \text{ --> } 2H^+ + 2I^- + C_6H_6O_6$$

After the reaction, excess I_2 is detected by a starch indicator solution that turns blue - black in the presence of iodine. Vitamin C has a long storage life; however, it rapidly decomposes when in solution because it is oxidized by atmospheric oxygen. The decomposition is sped up by heat, light, bases, oxidative enzymes, and traces of iron and copper. In the diet, vitamin C concentrations are greatly reduced by cooking foods in water and then draining off the water.

In this lab starch and vitamin C are mixed in a well-plate. Iodine is added to the solution drop by drop. Iodine will react with both chemicals, but it will react with vitamin C first; there is no visible evidence of this reaction. Once all of the vitamin C has reacted, the next drop of iodine will react with the starch to produce the blue-black color previously mentioned. Thus, the starch is used as an indicator to visually determine the end of the reaction of iodine.

Guiding Question:

Please answer the following questions before beginning the lab.

1. Of the juices to be tested, which will have the highest concentration of Vitamin C?

2. Of the juices to be tested, which will have the lowest concentration of Vitamin C?

Equipment/Materials:

1% starch solution
1.0 mg/mL Vitamin C solution
droppers
fruit juices
iodine solution
well-plate

Safety:

- Always wear safety glasses in the lab.
- Iodine stains hands and clothes, so gloves and aprons are recommended.
- Do not drink the fruit juices after they have entered the lab. Dangerous chemicals may dissolve into the juices after exposure.

Procedure:

1. Using a dropper, place 5 drops of the standard vitamin C solution in 6 wells (one row) of the well-plate. Each well used will be used for a different trial.

2. Add two drops of the starch solution to each well containing the vitamin C solution.

3. Next, drop iodine solution into each well until the solution turns a dark blue color for at least 15 seconds. Count of the number of drops added. After each drop is added, gently shake the well-plate to mix the iodine with the solution. It is easier to see the color change if a white piece of paper is placed under the well-plate. Record the number of drops of iodine used for each trial in the data table.

4. Place 5 drops of a fruit juice in place of the vitamin C standard in each well of the next row (6 wells) and follow steps 2 and 3.

5. Repeat step 4 for as many juices as your instructor requests.

Data:

Sample Name	Trial 1 # I_2 Drops	Trial 2 # I_2 Drops	Trial 3 # I_2 Drops	Trial 4 # I_2 Drops	Trial 5 # I_2 Drops	Trial 6 # I_2 Drops	Ave. # I_2 Drops
Standard Vit. C 1 mg/mL							

Record the following information from the juice containers:

Juice Sample	# servings per container	Volume of Container (mL)	RDA for Vitamin C (%)	Cost per container ($)

Calculations:

1. Calculate the average number of drops of iodine solution required to react with the Vitamin C standard. Repeat for each of the fruit juices. Fill in the appropriate spaces on the data table.

2. Calculate the concentration of vitamin C in each of the fruit juices by comparing the amount of iodine required for vitamin C and the amount needed for the fruit juice. The concentration of the vitamin C standard is 1.0 mg/mL.

3. Using the RDA for vitamin C listed in the introduction section of the experiment, calculate the volume in mL of each juice required to supply the RDA for vitamin C.

4. According to the label, how many mL of each juice would supply the RDA of vitamin C?

5. Using your data, determine the juice that provides the most vitamin C for the least money.

6. Using the volume of juice required to get the RDA of Vitamin C, find the percent error of your data.

Questions:

1. Which fruit juice contained the largest concentration of vitamin C?

2. Which fruit juice contained the lowest concentration of vitamin C?

3. List two nutritional sources of vitamin C other than citrus fruits.

4. What may account for variability among the trials?

5. In order to get the RDA for Vitamin C, which of the juices tested would you choose to drink? Why?