Determination of Vitamin C of Citrus Juices

by Dr. Walter Scharf and Dr. Charles Malerich
Natural Sciences, Baruch College
New York, NY 10010

Introduction--Vitamin C is a water-soluble vitamin that is that is needed daily (The minimum daily requirement for an adult is about 60 mg.) to maintain the skin and teeth, to resist stress and infection, and of course, to prevent scurvy. The vitamin is present in foods such as citrus fruit, green vegetables, and potatoes, but it is easily deactivated by cooking or standing in the presence of air. The chemical instability of vitamin C acid is due to the fact that it is a strong reducing agent and can be deactivated by a wide range of oxidizing agents. For example, the oxidation of vitamin C by atmospheric oxygen in opened citrus juices slowly reduces the vitamin C concentration in these juices when the juices are stored in open containers. This experiment studies orange and grapefruit juices of different brands as sources of vitamin C.

Chemically, vitamin C is both a reducing agent and a weak acid, and the vitamin C concentration in the citrus juices will be determined using an oxidation and reduction titration. The titration reaction is:

$$H_2C_6H_6O_6(\text{vitamin C}) + HC_{12}H_6C1_2O_2N(\text{indolphenol}) \rightarrow C_6H_6O_6 + HC_{12}H_8C1_2O_2N.$$

In this reaction, the reactants and products are colorless or pale yellow with the exception of indolphenol which is either blue (pH > 4) or purple (pH < 4). Hence the reaction between vitamin C and indolphenol bleaches indolphenol, and the color of the reaction mixture can be used to detect the end point of the titration.

A problem with indolphenol is this intensely colored compound is readily reduced, and the purity of the compound cannot be readily reproduced. In the experiment, the concentration of an indolphenol will be determined by titration of a vitamin C solution of known concentration. This procedure is called standardization.

Procedure
Materials

75-100 ml of indolphenol solution
15-20 ml of standard vitamin C
15-20 ml of Orange juice and Grapefruit juice
6 eye droppers
7 beakers

Using a beaker of appropriate volume, gather the solutions listed under the materials list. Place a clean eyedropper in each solution.

Standardization of Indolphenol blue solution with standard Vitamin C

Using an eye dropper, add precisely 3.0 ml of standard Vitamin C solution to a 10 ml graduated cylinder. Record volume of standard vitamin C solution and concentration of standard

vitamin C solution. With an eye dropper, add one or two drops of indophenol solution to the graduated cylinder. Shake the graduated cylinder to mix the standard vitamin C and indolphenol mixture. Continue adding indophenol solution until the reaction mixture changes color to a blue or purple color. Record the volume of the reaction mixture at the end point. Discard the reaction mixture into a waste beaker then rinse the graduated cylinder with about 1 ml of standard vitamin C. Repeat the titration. If the total volume of reaction mixture for two titrations agrees to ± 0.2 ml, go on to the citrus juices. If the total volume of reaction mixture for two titration does not agree to ± 0.2 ml, do a third titration.

Titration of Citrus Juice

Using an eye dropper, add precisely 3.0 ml of citrus juice to a 10 ml graduated cylinder. Record volume of citrus juice and type and brand of citrus juice. With an eye dropper, add one or two drops of indophenol solution to the graduated cylinder. Shake the graduated cylinder to mix the citrus juice and indolphenol mixture. Continue adding indophenol blue until the reaction mixture changes color to a blue or purple color. Record the volume of the reaction mixture at the end point. Discard the reaction mixture into a waste beaker then rinse the graduated cylinder with about 1 ml of citrus juice. Repeat the titration. If the total volume of reaction mixture for two titrations agrees to ± 0.2 ml, go on to a different juice. If the total volume of reaction mixture for two titration does not agree to ± 0.2 ml, do a third titration.

This procedure should be repeated for each citrus juice. At least, three different juices should be titrated.

Clean-up

Dispose of any waste containing indophenol solution by pouring it into a special waste bottle at the instructor's desk. Excess orange juice, grapefruit juice or standard vitamin C solution can be thrown down the drain.

Data

Standardization of Indolphenol blue solution with standard Vitamin C

Concentration of standard vitamin C solution _____M

	Run 1	Run 2	Run 3
Total volume of reaction mixture			
Volume of standard Vitamin C solution			
Volume of Indolphenol solution at end point			

Titration of Citrus Juices

Type of juice and brand _____

	Run 1	Run 2	Run 3
Total volume of reaction mixture			
Volume of juice			
Volume of Indolphenol solution at end point			

Type of juice and brand _____

	Run 1	Run 2	Run 3
Total volume of reaction mixture			
Volume of juice			
Volume of Indolphenol solution at end point			

Type of juice and brand _____

	Run 1	Run 2	Run 3
Total volume of reaction mixture			
Volume of juice			
Volume of Indolphenol solution at end point			

Type of juice and brand _____

	Run 1	Run 2	Run 3
Total volume of reaction mixture			
Volume of juice			
Volume of Indolphenol solution at end point			

Data processing

Standardization of Indolphenol blue solution with standard Vitamin C

1) Convert ml of standard vitamin C solution to liters of solution.

2) Molarity(M) is defined as moles of solute/liters of solution. Use this definition, recorded molarity of standard vitamin C solution, and answer to step 1 to calculate moles of vitamin C in reaction mixture at the end point of the titration.

3) Use the titration reaction (see introduction) to convert moles of vitamin C in reaction mixture to moles of indolphenol at end point.

4) Calculate the average volume of indolphenol solution at end point and then convert the average volume from ml to liters of indolphenol solution.

5) Use the definition of molarity (see step 2) and the answers to steps 3 and 4, to calculate the molarity of the indophenol solution. This concentration (molarity) is used for the calculating the concentration of vitamin C in the citrus juices.

Titration of Citrus Juices

1) Calculate average volume of indolphenol solution needed to reach the end point.

2) Convert average volume from step 1 from ml to liters.

3) Using the definition of Molarity (see step 2 in standardization of indolphenol blue solution), calculate moles of indolphenol blue at end point using answer to step 2 and concentration of indolphenol blue solution.

4) Use the titration reaction (see introduction) to convert moles of vitamin C in reaction mixture to moles of indolphenol bule at end point. The answer to this step is the number of moles of vitamin C in the juice sample.

5) Using the chemical formula of vitamin C, calculate the molar mass (sum of atomic masses for all atoms composing one vitamin C molecule)

6) Avogodro's law states that one mole of compound equals the molar mass of compound in grams. Using Avogrodro's law and the molar mass of acetic, calculate the mass of acetic acid in the juice sample.

7) Convert the mass of vitamin C from step 6 to mg of vitamin C.

8) Use the answer to step 7 and volume of juice sample to calculate mg of vitamin C/ml of juice. Record your answer in Table below.

9) Use the answer to step 8 to find the volume of juice that provides the minimum daily requirement of 60 mg of vitamin C. Record your answer in Table below.

10) Repeat steps 1-9 for each juice studied. Note, it is not necessary to repeat steps 1-9 in detail for each juice and you may want to use a spread sheet to carry out the calculations.

Brand of juice	Type of juice	Concentration of vitamin C in juice (mg/ml)	Volume of juice needed to meet minimum daily requirement of 60 mg (ml).

Conclusions

Which juice, if any, is best and what is your criteria for selecting the best juice?

Many people drink about a half a cup (125 ml) of orange or grapefruit juice each day. Is this sufficient juice to meet the minimum daily requirement for any of the juices studied?

Questions

1. Another name for vitamin C is ascorbic acid. Given this information, could an acid-base titration be used to determine the vitamin C concentration of a citrus juice?

2. Many fruits and vegetables, e.g. apples, pears, potatoes, mushrooms, etc turn brown when cut open, and exposed to air. Vitamin C is often used to keep dried fruits from browning. From what you have learned by doing the experiment, how can you explain the ability of vitamin C to function as the bleaching agent?

3. Why would an opened container of orange juice tend to lose its Vitamin C more rapidly than an unopened container?

4. Humans need to ingest vitamin C every day to stay healthy Is this due to the fact that vitamin C is chemically unstable? Explain.