PRACTICAL REPORT: THE CONCENTRATION OF VITAMIN C IN VARIOUS SUBSTANCES THROUGH REDOX TITRATION.

INTRODUCTION

Anti-oxidants are an essential part of our body as they block free radical atoms from starting a chain reaction that causes damage to the body. These anti-oxidants inhibit oxidation reactions in which the free radical atoms are produced. Free radical atoms are further produced by the breakdown of food and from exposure to harsh chemicals; a build up of these particles can cause diseases such as cancer and heart disease. For this reason Vitamin C as an antioxidant is so very important to ensure well being.

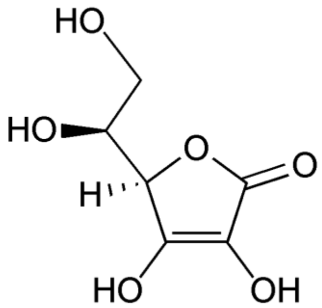

Figure 1. Structure of the anti-oxidant Vitamin C

Vitamin C, also known as Ascorbic Acid ($C_6H_8O_6$), is an anti-oxidant that is an essential part of the human diet as it is crucial to maintain good health and normal growth and development. As humans don't synthesis their own it must be taken from the outside environment from natural or artificial sources. Vitamin C is a water soluble acid which means it can readily be found in most fruits and vegetables, for example citrus fruits and green leafy vegetables, and if need be can also be provided through supplements.

By using redox titration, the levels of Vitamin C in different substances will be tested and then compared in order to find what substance has the highest concentration of Ascorbic Acid. Titration is a method of quantitative chemical analysis that determines the unknown concentration of a known reactant, in this case Vitamin C. This redox reaction will occur due to the iodate ions (IO_3-) of the titrant, potassium iodate, being reduced to form iodine and iodide ions (I-) being oxidised to form iodine. The iodine will then oxidise in the analyte with the ascorbic acid. Once all the ascorbic acid has been oxidised, the iodine will react with the starch, turning it blue-black in colour. It is at this point that the measurement of the titrate will be measured and compared in order to fine the concentration of Vitamin C in the solution.

AIM

To test levels of vitamin C in Cranberry juice, Packaged Orange Juice, Vitamin Supplement and Freshly squeezed orange juice in order to find which one contains the highest level of Vitamin C and therefore is best for human consumption. They will be tested through a redox titration using potassium iodate in the presence of potassium iodine.

MATERIALS

- Burette and stand
- 20 ml pipette
- 10 and 100 ml measuring cylinders
- 250 ml conical flasks
- Potassium iodate solution
- 250 ml beaker
- Combined HCl and Potassium iodate solution
- Starch indicator
- Distilled water
- White Tile
- Vitamin C Supplement

METHOD

1. Set up burette on stand, rinse with a small portion of potassium iodide to remove any foreign materials.

2. Measure 2 grams of powder into a beaker dissolve in 200 ml of distilled water,

3. Measure 20 ml of the solution and add a further 130ml of distilled water into a beaker, this becomes the analyte.

4. Measure 20 ml of the analyte and add a further 150ml of distilled water into a conical flask.

5. Add 10 ml of combined HCl and potassium iodide solution and a further 1ml of starch indicator solution.

6. Fill the burette with potassium iodide and record the initial value.

7. Titrate the sample adding quick bursts of potassium iodide until the colour change takes longer to disperse. After this point, add the potassium iodide drop by drop until the colour change becomes permanent, at this point stop immediately.

8. Note the final value of titrate, this may need to be refilled for the next titration.

9. Repeat steps 2-7 until concordant results (within 0.1ml of one another) are achieved.

RESULTS

Table 1. Summary of Results and Calculations gained.

Vitamin C Supplement				
Initial Measurement (ml)	**Final Measurement (ml)**	**Amount Used (ml)**	**Average Titrant (ml)**	**Concentration (g/100ml)**
9.20	18.05	8.85		
26.20	35.01	8.81		
35.01	42.85	8.84	8.83	$3.49*10^{-1}$
Packaged Orange Juice				
Initial Measurement (ml)	**Final Measurement (ml)**	**Amount Used (ml)**	**Average Titrant (ml)**	**Concentration (g/100ml)**
5.30	7.21	1.91		
7.40	9.22	1.82		
11.85	13.79h	1.94	1.89	$9.99*10^{-3}$
Cranberry Juice				
Initial Measurement (ml)	**Final Measurement (ml)**	**Amount Used (ml)**	**Average Titrant (ml)**	**Concentration (g/100ml)**
10.57	12.06	1.49		
12.06	13.56	1.50		
15.21	16.74	1.53	1.51	$7.96*10^{-3}$
Freshly Squeezed Orange Juice				
Initial Measurement (ml)	**Final Measurement (ml)**	**Amount Used (ml)**	**Average Titrant (ml)**	**Concentration (g/100ml)**
43.50	38.80	4.71		
27.33	22.51	4.82		
22.51	17.66	4.85	4.79	$2.53*10^{-2}$

CALCULATIONS (VITAMIN C SUPPLEMENT)

$$2(IO_3) + 10I + 12H \rightarrow 6I_2 + 6(H_2O)$$

Where v(IO_3)= 0.00882 L

And c(IO_3)=0.002 M

$$n(IO_3) = c * v$$

$$= 0.002 * 0.00882$$
$$= 1.76 * 10^{-5} mol$$

$$n(I_2) = \frac{unknown}{known} * \ n(IO_3)$$

$$= \frac{6}{2} * 1.76 * 10^{-5}$$

$$= 5.29 * 10^{-5} mol$$

$$C_6H_8O_6 + I_2 \rightarrow 2I + C_6H_6O_6 + 2H$$

Where $n(I_2)$=$5.29 * 10^{-5}$mol

$$n(C_6H_8O_6) = \frac{unknown}{known} * \ n(I_2)$$

$$= 5.29 * 10^{-5} mol$$

Taking into account the dilution of the Vitamin Supplement:

$$\frac{n_1}{v_1} = \frac{n_2}{v_2}$$

$$\frac{n_1}{150} = \frac{5.29 * 10^{-5}}{20}$$

$$n_1 = 3.97 * 10^{-4}$$

After second dilution:

$$\frac{n_1}{v_1} = \frac{n_2}{v_2}$$

$$\frac{n_1}{200} = \frac{3.97 * 10^{-4}}{20}$$

$$= 3.97 * 10^{-3}$$

$$n(C_6H_8O_6) = \frac{m}{M_r}$$

$$m = 3.97 * 10^{-3} * 176.124$$

$$= 6.99 * 10^{-1} g \ in \ 200ml$$
$$= 3.49 * 10^{-1} g \ in \ 100ml$$

DISCUSSION

Table one quantifies the amount of Vitamin C in various substances, from these results it can be concluded that the Vitamin C supplement tested contained by far the most amount of Ascorbic acid followed by fresh orange juice and then finally packaged orange juice and cranberry juice are third and fourth respectively. These results were what were expected however the quantities when compared to the manufactures specifications show some striking differences.

There is, of course, a margin of error, for example these results conclude that the Vitamin C Supplement contained 360mg of Ascorbic acid in 100ml however the packaging stated it contained 250mg. These results are more than 100mg different and hence it can be concluded that our results are incorrect. However due to the presence of calcium ascorbate and sodium ascorbate, as well as various other components, the redox titration may have not reacted with only vitamin C in the form of ascorbic acid, this would rationally explain the results gained.

The other substances tested also showed a large difference between results gained and the information gained from the packaging. The results gained through this redox titration showed that the concentration of packaged orange juice was 9.99mg/100ml, however the package specified the concentration to be 40mg/100ml, likewise the concentration of cranberry juice was concluded to be 7.96mg/100ml but was specified as being 24mg/100ml. Freshly squeezed Orange Juice was much the same. These results are clearly off by a factor of 3 and the only rational explanation for these results is based around the potassium iodide solution.

Potassium iodide is very sensitive to light and due to the lid being removed for prolonged periods of time while measurements were being gained, the potassium iodide had begun to go off. This would explain the unexpected quantifications that were gained as it meant not all of the ascorbic acid would react in the expected manner. This systematic error would lead to all results being below the true value, as was found. Overall this experiment can be evaluated as successful considering these errors.

Scientific theory states that Cranberry juice contains less Ascorbic acid than Orange juice and furthermore freshly squeezed contains more than packaged orange. Freshly squeezed orange juice contains more ascorbic acid than packaged orange juice due to the ascorbic acid oxidizing during shelf time, our results back this theory by showing a substantial increase in vitamin C in freshly squeezed orange juice. Our results show that Packaged Cranberry has less ascorbic acid ($7.96*10^{-3}$g/100ml) than Packaged Orange juice ($9.99*10^{-3}$g/100ml) which also has less than the freshly squeezed orange juice ($2.53*10^{-2}$g/100ml).

By testing different brands of the same substances more accurate results could be achieved in order to be able to conclude what substance has the highest level of Vitamin C. By repeating the titration with potassium iodide that had not been exposed to external factors not only would it reduce the margin of error but would also allow more concise measurements to be taken. The final change to the experiment would be to test different substances in order to gauge what truly has the highest concentration of Vitamin C and hence what is best for human consumption.

CONCLUSION

By using a redox titration in which an oxidation/reduction reaction occurred using potassium iodate in the presence of potassium iodine various substances were tested to gauge the level of vitamin C within them. Through these results it was found that the artificial supplement contained the highest levels of Vitamin C followed by freshly squeezed orange juice. Packaged orange juice and cranberry juice were also tested and were found to have lower concentrations of Vitamin C in comparison. Through these results it could be stated that in order to gain the highest levels of Vitamin C a supplement should be taken and failing that freshly squeezed orange juice should be consumed to ensure well being.

REFERENCES

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