Title: FRUIT JUICE PROPERTY RESEARCH: Ascertainment of Vitamin C concentration in fruit juice

Topics: FRUIT JUICE PROPERTY RESEARCH: Ascertainment of Vitamin C concentration in fruit juice	**Time**: 90 minutes (2 lessons)	**Age**: 10 class 15 – 16 years old pupils

Differentiation:

- With the more gifted pupils the question is discussed, in what capacity of one or another juice is the day norm of vitamin C.
- Students who complete the work quickly are asked to work on the extension tasks provided.

Guidelines, ICT support etc.:

- Students are presented with a consistent workflow and with a list of equipment needed for this activity.
- As the results of this work among students are not known in advance, the possibility of discussion in groups arises. Analysis of results and discussion effective when the work is done in groups of 2-3 students.
- In case class does not contain the necessary equipment and reagents, the teacher demonstrates researched juice titration.

Equipment needed for this activity:

- scales;
- burette with a holder;
- 250 ml measurement flask;
- conical flasks for titration;
- chemical glasses;
- pipettes;
- washing dish with distilled water;
- Textbooks;
- Activity sheet.

Reagents:

- 0,01 M I_3^- solution (0,63 g I_2 and 1,00 g KJ is dissolved in approximately 200 ml of distilled water, poured into 250 ml measurement flask and diluted up to the mark .)
- 1 % starch solution.
- Fruit juice, squeezed by hands or from trade.

Required knowledge:

- Concept of vitamin, molar concentration;
- Fractions, proportions, percent calculation.

Health and Safety:

Safe handling of experimental equipment and reagents.

Learning outcomes for this activity:

<u>All</u>

- Will understand vitamin meaning in everyday nutrition.
- Will be able to arrange the instruments for work according to instruction.
- Will be able to apply iodometric titration method.

<u>Most</u>

- Will be able to calculate molar concentration of the solution.
- Will be able to calculate vitamin C concentration in juice.

<u>Some</u>

- Will be able to calculate the mean square error of the measurements.
- Will be able to calculate titration error.
- Will be able to evaluate the result accuracy.

Lesson description

Starter Activity

Pupils enter the classroom put away coats and bags.

Pupils are asked to recall from mathematics: fractions (proportions), percent calculation, to recollect error calculation.

Pupils are asked about vitamin meaning in everyday nutrition, about significance of vitamins and minerals, what vitamin C sources they know.

Main Activity

Pupils begin work on **Ascertainment of Vitamin C concentration in fruit juice** worksheet.

An explanation of practical is given.

Students in groups of 2-3 carry out juice titration.

In case class does not contain the necessary equipment and* reagents, *the teacher demonstrates researched juice titration:

- Burette is washed twice with iodine solution and filled again up to 25 ml capacity;
- 20 ml of prepared juice is poured into a conical flask;
- 20 ml of distilled water is poured with a pipette;
- 5 drops of 3 M HCl;
- 10 drops of starch solution;
- The iodine solution is dripped from the burette until blue colour occurs, not vanishing for at least 20 seconds;
- During the titration, the solution is stirred with the magnetic stirrer or by hand;
- The titrated iodine solution capacity is measured;
- Titration is repeated three times;
- All juice samples are titrated in this way.

Extension

More able pupils at this point may be asked to consider any issues with the design of the experiment or they could be asked to suggest improvements.

Work sheet activity

Pupils are asked to complete the activity work sheets individually, pupils are asked to record results, to fill in data table, according to equivalence law, to calculate vitamin C concentration, to compare vitamin C concentration in different fruit juice.

More able pupils may be asked to calculate the mean square error, titration error, to write down the results and to explain them.

Extension activity

Pupils who complete the work quickly are asked to work on the extension tasks provided (**Ascertainment of Vitamin C concentration in fruit juice**).

Plenary

Pupils are asked about the procedure carried out; they are asked to consider the reason for any odd results.

Pupils are asked to make a conclusion about vitamin C concentration in different fruit juice. They are asked to compare vitamin C concentration in freshly squeezed juice and in the juice from the trade centre.

With the more gifted pupils the question is discussed, in what capacity of one or another juice is the day norm of vitamin C.

FRUIT JUICE PROPERTY RESEARCH
Vitamin C concentration ascertainment

Fruit and vegetable juice is produced from ripe fruit, berries and vegetables squeezing them for extraction. The most valuable part of the juice is the pulp, because all cellulose fibres get into it, for example, tomato, carrot, sea buckthorn, apricot, plum. Produced juice is used fresh, you do not have to boil it, preserve or pasteurize, otherwise all ferments and a part of vitamins will be destroyed. Juice with sugar is of less value. In a lot of juice, there are vitamin C, potassium, calcium ions, and in very small amounts of iron, copper, manganese, cobalt, zinc, nickel ions, necessary for the body.

Fruit drinks have up to 30 % of fruit juice; e.g., in grape drink there is 6 %, lemon –about 10 % of juice. These drinks are very widespread, because they are cheaper.

The cellulose fibre, being the major structural component in vegetables and fruit, influences fat circulation, decreases the level of cholesterol in blood, helps to remove poisonous materials from our body. Potassium – regulates the transmission of nerve impulse, muscle activity, water balance in the cells. A day potassium dose is 2000 mg. Potassium is the major compound of bone and teeth mass. There body stores about 98% of potassium in human cells, for example Potassium citrate helps strengthen bones. Potassium, which is not in the bone tissues, plays a great role transmitting nerve impulse for ribs and heart muscle fibres. This part of potassium is important for coagulation systems, fermentation reaction regulation. A day potassium dose is 800 mg.

Vitamin C, ascorbic acid ($C_6H_8O_6$), is one of the most unstable water-soluble vitamins. Reacting with oxygen, it quickly oxidizes, it is unstable for the influence of temperature, therefore thermally processed, the juice decomposes. The cells of almost all mammals can synthesize vitamin C, unfortunately, human cells do not possess this feature therefore, its demand is satisfied, eating food of plant origin. Vitamin C is in all organism liquids and cells, however, it is not stored in the organism, and the excess is excluded with urine. Vitamin C is also important as co ferment and as an antioxidant, takes part in collagen synthesis, the adrenal cortex, steroid hormone and other hormone synthesis. Vitamin C deficiency results in scurvy, increasing blood vessel fragility, occurring bone tissue changes, teeth becoming loose and falling out; developing heart function failure, anaemia. A day dose of vitamin C is 75-100 mg.

Vitamin C concentration can be determined by ***iodometric titration method****, carrying out its oxidation with iodine solution. Molecular iodine very weakly dissolves in water (only at a 1,3* $\times 10^{-3}$ *M 20°C temperature.*

0,05 M I_3^- *solution is usually prepared dissolving 0,12 mol KI and 0,05 mol* I_2 *in one litre of water.*

Performing the titration with iodine solution, starch is used as an indicator. If there are no other colour combinations in iodine solution, one can still see the iodine colour at a concentration of at least ~ 5 μM. Performing the titration with the starch, determination limit widens almost ten times.

Carrying out the titration with I_3^- *, starch is added at the beginning of the titration. Having reached the equivalence point the first excess* I_3^- *drop turns the solution dark blue. Iodine and starch complex formation return reaction depends on temperature. Raising solution temperature from 25°C to 50°C, colour intensiveness decreases ten times. In order to reach the biggest sensitiveness, it is recommended to chill the titrated solution in ice water.*

Standard I_3^- *solution is made dissolving solid* I_2 *in a significantly bigger concentration KI solution (to be an* I^- *excess). For making standard solution, sublime* I_2 *is that suits. As, in the process of weighing, the iodine evaporates a little, it has to be standardised by* $Na_2S_2O_3$ *solution.*

The solution is comprised of a solvent and a dissolved substance (solute). One of the main characteristics of a solution is its concentration. Solution concentration shows the dissolved substance mass and quantity, existing in a certain mass or capacity of a solution or a solvent.

Molar concentration shows, how many moles of the solute are dissolved in one litre of solution:

$$C_M = \frac{n}{V},\ \text{mol}/\ell;$$

Where n is the number of moles of the solute; V – solute capacity in litres.

Or

$$C_M = \frac{m_1}{M \cdot V},\ \text{mol/ℓ};$$

Where m_1 is solute mass; M is solute mole mass; V is solute capacity.
Instead of measurement unit mol/ℓ often one letter M is written. Solutions, in one litre of which there is 0,1; 0,01 moles of substance, are correspondingly called *decimoles and centimoles.*

To describe solution concentration ppm units are used - parts per million. 1 ppm = 1 mg/ℓ.

Often, from concentrated solutions one has to make solutions of smaller concentration. In such cases, it is very comfortable to use dilution rule:

$$C_1 \cdot V_1 = C_2 \cdot V_2,$$

Where C_1 and V_1 – molar concentration and capacity of concentrated solution;
C_2 and V_2 – molar concentration and capacity of dilute solution.
If solution concentrations are expressed in parts per mass, for calculation such formula is used, then:

$$C_1 \cdot V_1 \cdot \rho_1 = C_2 \cdot V_2 \cdot \rho_2,$$

Where C_1, V_1, ρ_1 – concentration, capacity and density of a concentrated solution;
C_2, V_2, ρ_2 – concentration, capacity and density of dilute solution.

Questions	Answers
1. What important substances for human body are found in fruit juices? 2. Why is Potassium -K vital for the human body? 3. Why is Calcium-Ca vital for the human body? 4. Why is vitamin C vital for the human body? 5. 0.45 mol of carbamate (27 g) is dissolved in 1 litre of distilled water. What is molar concentration of the solution?	.

FRUIT JUICE PROPERTY RESEARCH
Vitamin C concentration measurement
Answer sheet

- Fruit juice titration data insert in table 1.

Table 1

Solution capacity of titrated iodine

Juice name	I titration, V_I, mℓ	II titration, V_{II}, mℓ	III titration, V_{III}, mℓ	Mean value, $\bar{V}$, mℓ

- Calculate vitamin C concentration in juice.

Vitamin C concentration is calculated according to equivalence law, expressed in mol/ℓ.

$$V_1 \times C_1 = V_2 \times C_2;$$

Where: V_1 – solution capacity of titrated iodine, V_2 – capacity of juice, taken for titration, C_1 – molar concentration of iodine solution, C_2 – vitamin C molar concentration in juice.

$$C_2 = \frac{V_1 \times C_1}{V_2}.$$

Vitamin C concentration, calculated according to equivalence law, expressed in mol/ℓ. The units used in food industry are - mg/100 mℓ.

- Recalculate vitamin C concentration in units used in food industry mg/100 mℓ juice.
- Enter calculation results in table 2.

Table 2

Vitamin C concentration in fruit juice

Fruit juice name	Vitamin C concentration, mol/ℓ	Vitamin C concentration, mg/100 mℓ

Conclusion

- Compare vitamin C concentration in different fruit juice.

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- Compare vitamin C concentration in freshly squeezed juice and in juice from shops.

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- Ascertain, how much of each fruit juice is needed to give the daily recommended intake.

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- How do experimental results correlate with the results presented in the literature (labels)?)

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FRUIT JUICE PROPERTY RESEARCH

In chemistry lesson, the pupils investigated Calcium ion Ca^{2+} concentration in various fruit juice. Calcium ion concentration in solution was calculated in ppm (*parts per million*) units. The results of the experiment are given in table 1. It is accepted to express concentration in nutrient substances in mg/100mℓ. Fill in the table, having calculated Ca^{2+} concentration in mg/100 mℓ of juice. It is known, that 1 ppm = 1 mg/ℓ.

Table 1

Fruit name	**Ca^{2+} concentration in juice, ppm**	**Ca^{2+} concentration in juice, mg/100 mℓ**
Freshly squeezed orange	44	
CIDO orange	34,8	
Freshly squeezed apple	23,6	
ELMENHORSTER apple	25,6	

- Compare calcium ion concentration in freshly squeezed juice and in juice from shops.

- Estimate, how much one or another juice one has to drink, that it contained the day norm of Ca^{2+}.