ALCOHOLIC FERMENTATION ANALYSIS WITH YOUNG RESEARCHERS IN PRIMARY SCHOOL ANKARAN

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Abstract: *Research in primary school has recently become a hot topic and is gaining a foremost position among the educational goals and objectives in primary education.*

Thus a responsible contemporary teacher of a natural science subject enables the student to get to know research work, which means that he or she guides them – through quality mentoring – through the methodology of writing a research paper, which is basically the same at all levels of the educational system, differing only in the complexity of the set research problem. At the same time, a teacher mentor should find pleasure in doing research work with their students, and regard that as an opportunity to make their work more interesting and to enhance their own knowledge. At our primary school we decided to actively integrate students into research work. The article presents a research assignment in which students in the final year of primary school (age 14-15) researched the question of what happens to apple juice of different sorts of apples before and after alcoholic fermentation. We tried to find out whether the sort of apples and the amount of sugar in apple juice affect the process of alcoholic fermentation. During experimental work, we took notes and gathered data on the amount of sugar in juice and the temperature changes that occur during alcoholic fermentation, which we measured by using a Vernier interface.

Keywords*: RESEARCH ASSIGNMENT IN PRIMARY SCHOOL, ALCOHOLIC FERMENTATION, EXPERIMENTAL WORK*

1. Introduction

Scientific research is defined as diverse pathways in which scientists study nature and natural phenomena and suggest different explanations on the basis of gathered evidence. Scientific research that pertains to the "natural sciences" lessons includes activities through which students develop their knowledge and begin to grasp scientific concepts and the way scientists approach nature. Doing scientific research is an effective way of getting to understand natural sciences concepts. Using strategies of scientific research, students learn to pose research questions and to use evidence to form answers to the questions set, to carry out practical research, to gather data from different sources, to derive explanations from data, and to present and defend their conclusions.

In the process we need to help students to learn how to recognise and set appropriate questions which one can answer with the help of "scientific" research; to plan and direct research towards gathering evidence needed to answer different questions; to use the right equipment and tools for analysis and explanation of data; to make inferences and to think critically, to base their explanations on solid evidence and to deliver and defend their results in front of their peers and others.

This is why a natural sciences teacher needs to ensure lessons that set as a priority the observation and collection of evidence, conducted either indoors, in laboratory, or in the field. Thus teachers can inspire students to develop a special relationship towards scientific thinking and natural sciences. At the same time we need to make certain that students can perform laboratory analyses in a safe environment.

Laboratory tests should help students develop a growing understanding of the complexity and uncertainty of empirical work as well as their ability to calibrate laboratory equipment and to remedy any problems with it. Students need to cope with measuring mistakes and need to be able to connect, explain and present the gained results.

When students progress to a higher year, they are expected to improve their ability to effectively cooperate with other people when carrying out complex tasks and to share work on a common task, to take over different roles in different stages of research, to contribute their own ideas and to respond to others' ideas.

Moreover, it is significant that we find appropriate space in the classroom where we can easily conduct laboratory work. In elementary school, this is a classroom with enough working space and mobile desks with a flat surface and chairs as well as access to water and electricity. At the same time, school needs to provide a well-equipped natural sciences study, or, even better, a laboratory with the required equipment and water and electricity access.

2. Research assignment on alcoholic fermentation as an example of using scientific research in primary school

The writing of a research assignment enables students to do independent research into the links between different phenomena, to form hypotheses and to test them by doing experiments, which the student plans and carries out on his or her own. Students who attended the school's Chemistry Club decided that they would investigate what happens to apple juice made from different apple sorts before and after alcoholic fermentation. They decided to focus on apples because at the time of their research it was not the grapes season. They tackled the question whether alcoholic fermentation is different for different sorts of apples. While doing research, they collected different types of data: temperature, sugar content, and the quantity of different juices before, during and after alcoholic fermentation.

1. INTRODUCTION

1.1 Objectives

Alcoholic fermentation is a process that changes glucose into ethanol in the presence of yeasts, which contain various enzymes that enable this process.

Instead of using grapes we chose apples because they also contain a lot of sugar.

The students posed the following questions:

1. How much does the temperature rise during alcoholic fermentation?

2. How does the amount of sugar affect the process of alcoholic fermentation?

3. How does the amount of sugar in juice change during the process (what is the difference in the amount before and after fermentation)?

1.2 Hypotheses

Students formed the following hypotheses:

HYPOTHESIS **1**:

Different sorts of apples have different amounts of sugar.

HYPOTHESIS **2**:

The amount of sugar in juice is different before and after alcoholic fermentation.

HYPOTHESIS **3**:

The temperature rises during the process of alcoholic fermentation.

HYPOTHESIS **4**:

Alcoholic fermentation leads to the creation of carbon dioxide.

HYPOTHESIS **5**:

The higher the sugar content in juice, the higher the maximum temperature during fermentation.

2. THEORETICAL PART

2.1 What is alcoholic fermentation?

Ethanol fermentation is one of anaerobic metabolic processes that begins with glucose and finishes when glucose turns into CO_2 and ethanol.

$C_6H_{12}O_6$	→	$2C_2H_6O$	+	$2CO_2$
glucose	→	ethanol	+	carbon dioxide

Alcoholic fermentation is a process which changes glucose into ethanol in the presence of yeast, which contains various enzymes that enable this transformation. Beside ethanol fermentation, there are two more types of fermentation: lactic acid fermentation (lactose changes into lactic acid and carbon dioxide with the help of bacteria) and acetic acid fermentation (fructose changes into carbon dioxide and acetic acid with the help of bacteria).

2.2 Yeasts

Yeasts are microscopically small, normally single-cell proper funghi. The cells of some kinds of yeasts group together and form compact branched chains (pseudomycelia). If any kind of yeast forms a proper mycelium, it appears in this form for only a short time, usually in extraordinary circumstances. Singular, separate cells or cells associated in small groups are thus a characteristic, dominant or even the only form for yeasts.

Yeasts are widely spread in nature. The main reservoir of yeasts is the soil, where they also spend the winter. The essential part played by yeasts in nature is that they, together with other heterotopic microorganisms, take part in the decomposition and mineralization of organic material. For humans, yeasts are especially important in terms of economy. According to A. Roseu, yeasts are ideal industrial microorganisms because they are vital, they are not attacked by phages, they are undemanding as regards their food, they grow and reproduce very quickly, and we can separate them from the substrate.

3. EXPERIMENTAL PART

For the purposes of our research assignment we used the following methods:

- the overview of relevant literature;
- laboratory work.

We gathered the majority of literature at the Srečko Vilhar Central Library in Koper, while also finding some things of interest on the Internet.

After collecting all literature we came up with the concept of our research. Our essential research method was laboratory work. We precisely determined the experimental procedure and prepared the laboratory equipment.

We decided that we would do our laboratory work at school, in Chemistry room.

3.1 Laboratory equipment

For one experiment we needed:

- a beaker holding 1000 ml;
- a test tube;
- a measuring cylinder;
- a glass rod;
- a sieve;
- a knife;
- gauze;
- a grater;
- rubber, glass tubes;
- Erlenmayer flasks;
- a plastic bottle cap with two holes;
- a kitchen board;
- a thermos bottle;
- plastic bottles.

3.2 Measuring instruments

- a laboratory balance
- a portable refractometer ATAGO
- a Vernier interface
- Vernier temperature sensors
- alcohol thermometer
- a computer and the programme Logger Lite for measurement capture

3.3 Apple sorts

We chose five apple sorts for the experiment with ethanol fermentation:

- GOLDEN DELICIOUS
- GRANY SMITH
- FUJI
- KIKU
- PINK LADY

3. 4 Work procedure

3.4.1. Preparing limewater

First we prepared limewater. We added 300 ml of water into an Erlenmayer flask and 2 spoons of calcium oxide. We let this solution rest overnight. Next day we poured the clear liquid that formed above the sediment into another Erlenmayer flask. It was this solution that we used in further experiments.

3.4.2 Experiment with alcoholic fermentation

Each sort of apples was first weighed; we made sure that we had approximately 1 kg of each sort of apples at our disposal. We washed the apples with water and dried them with paper towels. We finely grated them and then ground them with an immersion blender. The apples' mass lessened in the process, since we removed the useless parts.

We squeezed the apple purée into juice lump by lump; we needed a lot of physical strength to do that.

- 50 ml of the thus obtained apple juice was mixed with 21 g of yeast. The mixture was then heated up to the temperature of 30°C.
- We added 300 ml of the leftover juice to this mixture. We stirred everything and poured it into the thermos.
- We connected the thermos, the Vernier temperature sensor, the Vernier interface and a laptop. We took great care that the thermos bottle caps were properly sealed so that the air from the outside would not enter thermos bottles.

- The carbon dioxide that formed during fermentation was channelled off into limewater, which became hazy. This is how we proved the presence of this gas.
- The interface took temperature every minute. It read out temperature for 24 hours.

The whole apparatus for alcoholic fermentation is shown in the picture below.

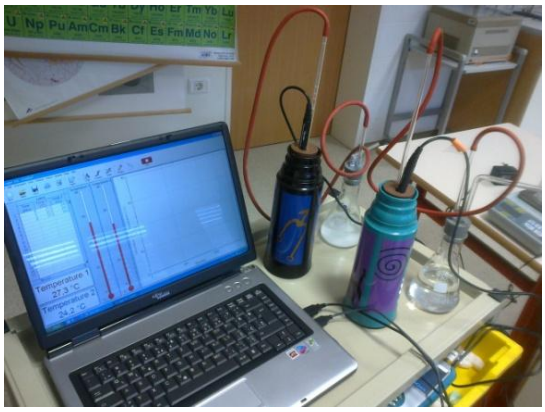


Image 1: The apparatus for alcoholic fermentation

3.4.3 Determining the sugar content

We determined the amount of sugar in apple juice before and after fermentation by using a portable manual refractometer.

Refractometer is a standard device for establishing the sugar levels in professional wine-making. Substances dissolved in a liquid affect the diffraction of light which travels through solutions. The higher the concentration of sugar in a sample, the more diffracted the light and the more visible the cross-hair between the dark and the light field.

Before the measurements we checked the precision of the refractometer's cross-hair by using distilled water with 20 °C. On the prism we dropped 2-3 drops of water and noticed that there were no bubbles. We shut the lid and looked through the eye-piece towards the light. The line between the dark and the light field was passing through the zero, which meant that the calibration of the device was successful.

The procedure was then repeated using our samples. We read the sugar content, expressed as sucrose's percentage by mass, on the left scale.

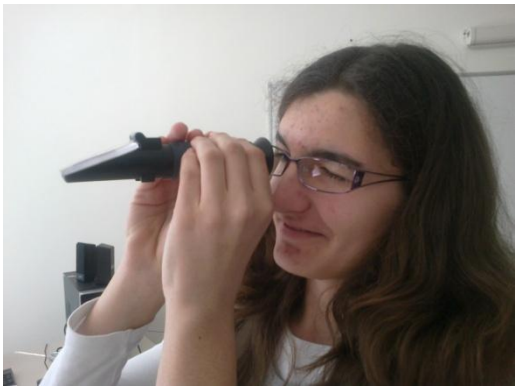


Image 2: Measuring sugar with a refractometer

4. RESULTS

4.1 The quantity of juice squeezed from 1 kg of apples

One of the measured experimental values was the amount of juice we got from 1 kg of apples.

In Diagram 1 the results are presented in the form of columns with a dependence between the quantity of juice and the apple sort.

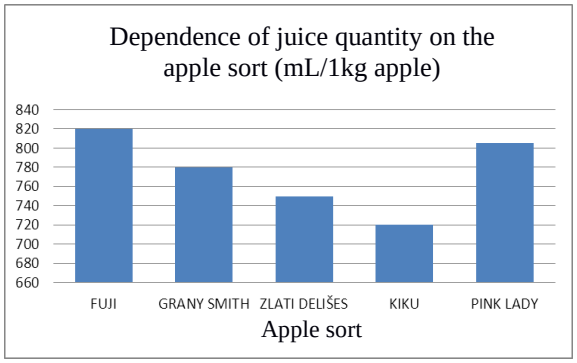


Diagram 1: *Dependence of juice quantity on the apple sort*

The results show that the greatest amount of juice was squeezed from the Fuji apples (829 ml) while the least juice came from the Kiku apple sort (720 ml).

4.2 The maximum temperature during alcoholic fermentation

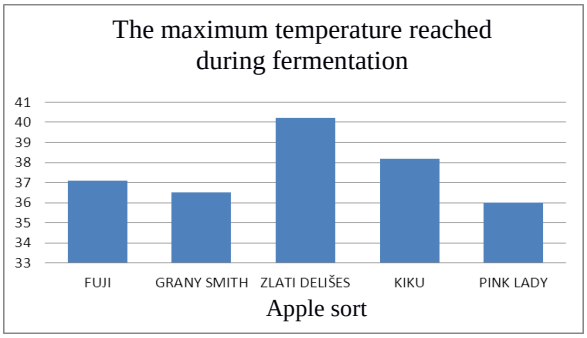


Diagram 2 *: The maximum temperature reached during fermentation*

We can see from Diagram 2 that the juice from the Golden Delicious reached the highest temperature during fermentation, which was 40,2 °C, while the lowest temperature was reached during the fermentation of juice made from the Pink Lady apples, which was 36 °C.

4.3 Temperature changes during alcoholic fermentation

During alcoholic fermentation, we observed the following temperature changes between the initial and maximum temperatures, as shown in Diagram 3.

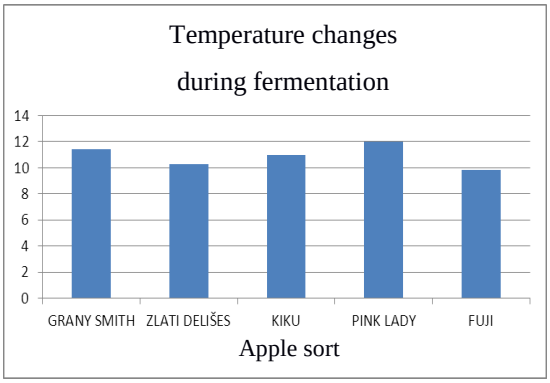


Diagram 3: *Temperature changes during fermentation*

Diagram 3 shows that the temperature differences during fermentation are very similar, independent of the apple sort. The largest difference was observed during the fermentation of the Pink

Lady juice (12 °C) and the smallest during the fermentation of the juice made from the Fuji apples (9,8 °C).

4.4 The sugar content in particular apple sorts

The following quantities of sugar were measured in particular sorts of apple juice before and after fermentation – the measured values of sucrose in particular sorts of apples are captured in Diagram 4.

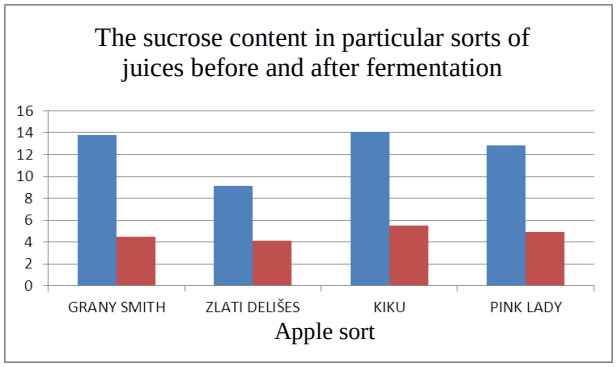


Diagram 4: *The sucrose content in particular sorts of juices before and after fermentation*

Diagram 4 shows that the concentration of sucrose dropped after alcoholic fermentation. At the beginning, the Golden Delicious apples had the least sugar, while the Kiku apples had the most. The greatest difference in the sucrose content before and after fermentation was discovered in the Grany Smith apple sort.

4.5 Diagrams of temperature changes during alcoholic fermentation

Below there are charts that represent the changing temperature of apple juice during fermentation. The charts were made with the programme Logger Lite, with the help of Vernier interface and a temperature sensor.

Diagram 4.5.1*: The FUJI apple sort, 13.2.2012*

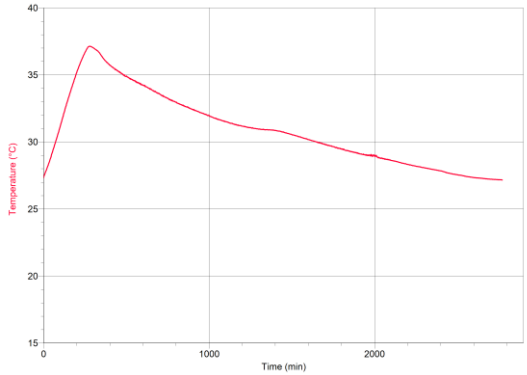


Diagram 4.5.2: *The GRANY SMITH apple sort, 16.2.2012*

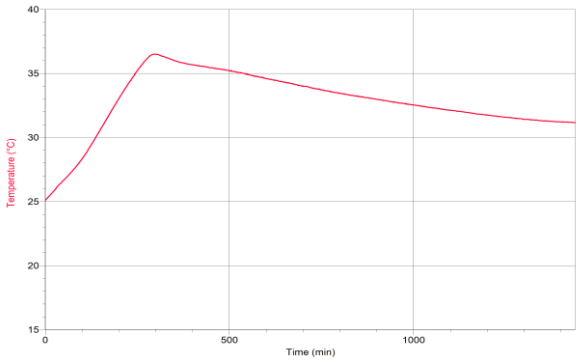


Diagram 4.5.3*: The KIKU apple sort, 5.3.2012*

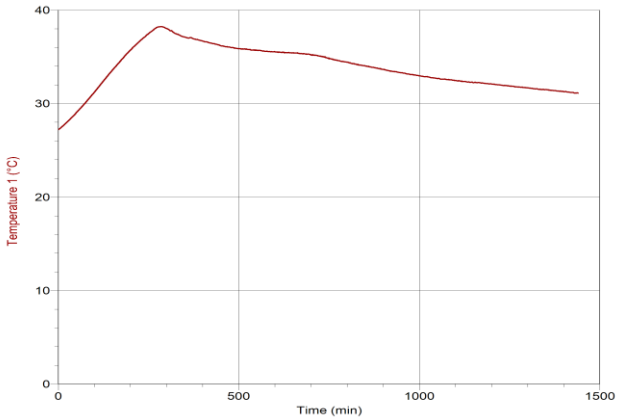


Diagram 4.5.4: *The PINK LADY apple sort, 5.3.2012*

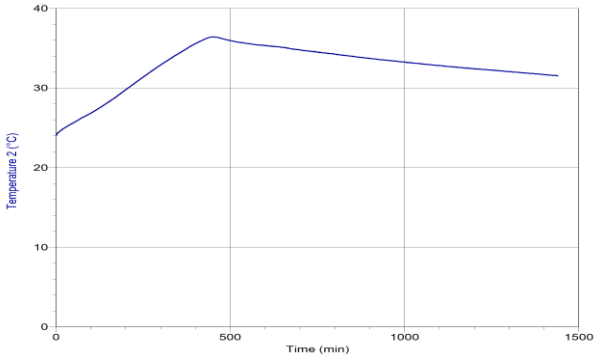
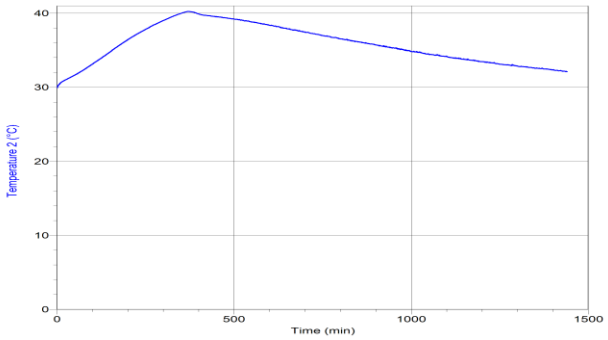


Diagram 4.5.5: *The GOLDEN DELICIOUS apple sort, 16.3.2012*



5. DISCUSSION AND CONCLUSION

The experiments done have lead to the following conclusions:

5.1 By using a refractometer we determined different sugar contents in different sorts of apples (for example: the Kiku apples contain 14.1 % of sucrose before fermentation, while the Golden Delicious apples contain 9.1 %), which confirmed our first hypothesis, namely that *different sorts of apples have different amounts of sugar*. The sugar content also affects the taste of a particular sort of apples - its sweetness.

5.2 The juice's sugar content dropped during fermentation (example: the Grany Smith apples contain 12.8 % of sucrose before alcoholic fermentation and only 4.9 % after it), which confirmed our second hypothesis, namely that *the amount of sugar present in juice is different before and after alcoholic fermentation*. This is due to the fact that sugar turns into other substances during fermentation.

5.3 Temperature rose during alcoholic fermentation, with one sort of apples even reaching 40 ºC (example: the Golden Delicious apples heated up to 40.2 ºC, while the Pink Lady apples reached 36

ºC maximum), which is why we could also confirm the third hypothesis, namely that the *temperature rises during the process of alcoholic fermentation.* Alcoholic fermentation is an exothermic process.

5.4 The process of alcoholic fermentation produces carbon dioxide, which we proved by using limewater which became hazy. We thus confirmed also the fourth hypothesis, the claim that *alcoholic fermentation leads to the creation of carbon dioxide.*

5.5 The juice's sugar content does not affect the maximum temperature during the process of fermentation itself, by which we refuted the fifth hypothesis, namely that *the higher the sugar content in juice, the higher the maximum temperature during fermentation.*

3. Conclusions

While writing a research paper, pupils gain an abundance of new knowledge and skills. The use of laboratory equipment and experimental work meant for them extending and deepening their knowledge of chemistry and biology. Research assignments provide individuals with a chance to develop their potentials, interests and their particular talents. They represent an ideal opportunity for personalization, which essentially means that we adapt our teaching to an individual student. Research allows students to direct their interest and learning. Of course the mentor's support and consultation are indispensable.

4. References

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