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Commentary to support marking

Subject: Biology

Paper component: EE

Language: English

Exam session: NOVEMBER 2018

Essay: 26E

Criterion	Mark	Out of	Justification
A	4	6	The topic is clear and has biological relevance. The RQ is precise and can be effectively investigated, although it is not clear why both aspartame and ethanol need to be studied. The methods is clearly stated albeit in a recipe format and presented as a "preliminary" method (without any follow up). As a result there is limited evidence of informed choices having been made. Overall the experiment needs more controls and the variables need amore careful presentation.
B	4	6	Background knowledge is mainly relevant and presented clearly. Knowledge and understanding are evident in a useful survey of the literature with integrated ideas and a clear link to the RQ.
C	9	12	The research is thorough and is based on a reasonable range of sources and the experiment generates some useful data. Data analysis is not optimum ("% change in pH" is not straightforward in the sense that pH is a logarithmic scale). Otherwise processing is clear and relevant but limited to bar graphs with error bars based on standard deviation. The approach to data processing is not explicitly justified. There is some effective critical evaluation.
D	4	4	There is a clear, appropriate and uncomplicated structure to the essay. The chapter headings are informative and other structural elements are clear and appropriate.

E	5	6	The first and interim reflections are largely descriptive with some evaluation of steps taken and some analysis of decisions made. The final reflection contains some strong evaluative ideas, focussing mainly on personal growth. Some critical evaluation in the early reflection would improve this.
Total:	26	34	

Candidate Marks Report

Series : M18 2018

This candidate's script has been assessed using On-Screen Marking. The marks are therefore not shown on the script itself, but are summarised in the table below.

Centre No :	[redacted]	Assessment Code :	BIOLOGY EE EXTENDED ESSAY in ENGLISH
Candidate No :	[redacted]	Component Code :	EE(ENG)TZ0
Candidate Name :	[redacted]		

In the table below 'Total Mark' records the mark scored by this candidate.
'Max Mark' records the Maximum Mark available for the question.

Examiner:	[redacted]
Paper:	**M18bioloEEEE0XXXX**
Paper Total:	**26 / 34**

Question	Total / Max Mark Mark
Criterion A	4 / 6
Criterion B	4 / 6
Criterion C	9 / 12
Criterion D	4 / 4
Criterion E	5 / 6

[redacted]

Coursework confirmation
Yes

Hours supervisor spent with candidate
5

A STUDY ON THE EFFECT OF ASPARTAME AND METHANOL IN THE REACTIONS CATALYSED BY THE DIGESTIVE ENZYME LIPASE

To what extent is the rate of breakdown of lipids into fatty acids and glycerol affected by a change in the concentration of aspartame and methanol?

IB subject of Extended Essay: Biology

Word count: 3168

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Chapter 1: Introduction

1.1 Research question

To what extent is the rate of breakdown of lipids into fatty acids and glycerol affected by a change in the concentration of aspartame and methanol?

1.2 Background information

Despite being highly used in the food industry aspartame has been the subject of many scare stories. This sweetener has been extremely controversial since its approval in the 1980s [1]. The NHS states that in 1996 a report suggested a link between aspartame and an increase in the number of diagnosed brain tumours. However, the study had very little scientific basis and later studies showed that aspartame was in fact safe to consume [1]. The European Ramazzini Foundation of Oncology and Environmental Sciences published several long-term studies in 2006 and 2007 linking the consumption of aspartame with an increase in cancers, mainly lymphomas and leukaemia in rats [1]. Following these studies the US National Cancer Institute and the European Food Safety Authority (EFSA) conducted various studies concluding that aspartame was in fact safe to consume [1]. These contradictory studies fuelled my interest in aspartame and its effects on the body, which led me to investigate it further.

Aspartame is one of the most common artificial sweeteners used nowadays. It is made from joining together the amino acids aspartic acid and phenylalanine [2]. Aspartame is up to 200 times sweeter than sugar and it is low in calories [1]. These characteristics make Aspartame the perfect substitute for sugar in the production of foods and beverages. Aspartame is cheaper for the companies as they need less product to give the same level of sweetness that regular sugar would, and as a result of that calories are also reduced. Aspartame can be found in prepared foods and beverages, and occasionally as flavouring in some medicines

[1]. Aspartame is broken down into phenylalanine, aspartic acid, and methanol. Methanol can be toxic in high amounts, but the amounts that result from the breakdown of aspartame are lower than with many natural foods [2]. A litre of fruit juice can be broken down to produce an average of 680 mg of methanol, compared to one litre of diet coke which can be broken down into 55 mg of methanol [2]. We can therefore see that methanol production is greater when ingesting fruits than it is in products containing aspartame, thus, aspartame consumption should not be a problem considering that the amount of methanol released in the body is considerably lower than that with common fruits.

A scientific journal written by the School of Biosciences in the Mahatma Gandhi University described how long term consumption of aspartame leads to hepatocellular injury and alterations in liver antioxidant status [3]. Hepatocellular injury refers to the primary injury of the hepatocytes [4], which are functional cells found in the liver that carry out many metabolic, endocrine and secretory functions [5]. Damage to the liver can derive to elevated liver enzymes, as injured liver cells leak higher than normal amounts of certain chemicals into the bloodstream [6]. Therefore, following the information obtained from this journal, it can be concluded that aspartame can cause direct damage to the liver.

A research study conducted by a team of scientists from the Massachusetts General Hospital found that aspartame can interfere with an intestinal enzyme called intestinal alkaline phosphatase (IAP) which is shown to prevent obesity, diabetes and metabolic syndrome [7]. IAP breaks down cholesterol and fatty acids [8]. It was found that feeding IAP to mice kept on a high-fat diet could prevent the development of metabolic syndrome and reduce symptoms in animals that already had the condition. Phenylalanine which is one of the chemicals that aspartame is broken down to, is known to inhibit the action of IAP [7]. Therefore, aspartame was found to affect the breaking down of cholesterol and fatty acids.

On the other hand, aspartame has also been found to encourage weight gain, and an increased chance of developing obesity, type 2 diabetes, metabolic syndrome and other health issues [9]. Aspartame and other high intensity sweeteners are linked with an increase of body weight and fat [9].

In view of this information I decided to investigate further the effect of aspartame in the breaking down of lipids. However, it was impossible to further investigate the effects of aspartame in IAP due to the difficulty of sourcing the required chemicals. Therefore, it was decided to investigate the effects of aspartame in the enzyme lipase, because of its close relationship with lipids. Lipase is an enzyme produced by the pancreas and secreted by the small intestine, which contributes to the breakdown of fats. Lipase hydrolyses triglycerides into glycerol and fatty acids [10]. Enzymes are biological catalysts that speed up reactions within the body [11]. Lipids are substances of a biological origin that are soluble in non-polar solvents [12]. The main biological functions of lipids are; storing energy and acting as structural components of cell membranes. Lipids are both hydrophobic and amphiphilic molecules. The amphiphilic characteristic of some lipids allows them to form structures such as vesicles and membranes in an aqueous environment [13]. Because of their characteristics, lipids are ideal to form membrane structures, and storing energy. They are broken down by lipase into glycerol and fatty acids. Fatty acids are long hydrocarbon chains which contain a carboxyl group. They are carboxylic acids; therefore have an acidic nature [13].

Chapter 2: Methodology

2.1 Objective of study

The main focus of this experiment will be to test the effects of aspartame and methanol on the rate of breakdown of lipids into its components. The rate of breakdown of lipids will be measured by the decrease in the pH. As stated before fatty acids are acidic in nature, therefore, when lipids are broken down into fatty acids and glycerol the pH of the solution will decrease (i.e. will become more acidic).

2.2 Hypotheses

Experimental hypothesis

We expect that the rate of breakdown of lipids into fatty acids and glycerol in milk by lipase will increase with the use of aspartame and methanol. The pH of the solution tested will therefore decrease.

Null hypothesis

We do not expect any change in the rate of breakdown of lipids into fatty acids and glycerol by lipase or methanol with the use of aspartame and methanol. Therefore, pH will remain constant.

2.3 Equipment

- Full fat milk
- 0.05 lipase solution
- Water bath ($35C^0$)
- Mercury thermometer ($\pm 0.5C^0$)
- Test tubes
- Canderel Artificial Sweetener tablets (contains 10% of Aspartame)
- Measuring cylinder
- Distilled water
- 0.01% Methanol solution
- 0.001% Methanol solution
- pH probe
- Mortar and pestle
- Beaker (100ml)
- Measuring cylinder ($10cm^3$) (± 0.2cm)

2.4 Preliminary method

1. Set up two thermostatically controlled water baths at $35C^0$ (close to optimum body temperature), and monitor its temperature with a mercury thermometer.
2. Measure 5 cm^3 of full fat milk and place it in a test tube, place the test tube in the water bath as a control group.
3. Record the starting pH of the milk, and 10 minutes after record the final pH.
4. Crush the sweetener tablets into a fine powder using a mortar and pestle.
5. Measure $1cm^3$ of the sweetener powder using a $10cm^3$ measuring cylinder and add to a clean 100ml beaker.
6. Add $9cm^3$ of distilled water using a clean $10cm^3$ measuring cylinder to the 100ml beaker to create a 0.01% solution of Aspartame.
7. Measure $0.5cm^3$ of sweetener powder using a $10cm^3$ measuring cylinder and add to a clean 100ml beaker
8. Add $9.5cm^3$ of distilled water to the 100ml beaker using a $10cm^3$ measuring cylinder to create a 0.005% solution of Aspartame.
9. Place both beakers containing the aspartame solutions in the water bath to allow the solutions to acclimatise to the $35C^0$ temperature for 2 minutes.
10. Place the lipase enzyme and the full fat milk in the water bath to allow the solutions to acclimatise to the temperature for 2 minutes.
11. Make sure all solutions are at the same temperature before starting the experiment.
12. Using a $10cm^3$ measuring cylinder add $1cm^3$ of milk, $1cm^3$ of 0.05% lipase solution into 10 test tubes and measure the pH of the solutions using a pH probe.
13. Add the 0.01% aspartame solution into each test tube and place back in the water bath.

14. Allow 10 minutes for the reaction to take place using the stopwatch. After 10 minutes, measure and record the pH of the test tubes
15. Repeat the same process with the 0.005% aspartame solution.
16. Add an extra 10 tubes into the water bath. Using a 10cm^3 measuring cylinder add 1cm^3 of 0.05% lipase solution and 1cm^3 of milk and place into the 10 test tubes. These will be the control groups.
17. Measure the starting pH of each milk and lipase test tubes, and after 10 minutes measure the final pH using a pH probe.
18. To measure the impact of methanol on the activity of the enzyme lipase repeat the same method with the 0.01% and 0.005% solution of Aspartame with two solutions of 0.01% and 0.001% of methanol.

2.5 Overview of variables in this investigation

Various variables were controlled in order to obtain reliable results.

- **Concentration of aspartame:** This was one of the independent variables in the experiment. It was controlled using branded tablets of an artificial sweetener named Canderel tablets. These tablets contained 10% of aspartame. This variable was controlled to see the accurate effect of aspartame in the rate of reaction o lipase.
- **Concentration of methanol:** This was the second independent variable of this experiment. 0.01% and 0.001% methanol solution were used. This variable was controlled to see the accurate effect of methanol in the rate of reaction of lipase.
- **Percentage decrease of pH:** This was one of the dependent variables controlled in this experiment. The percentage decrease of pH was monitored using a stopwatch, a pH probe and a data logger. The percentage decreased of the solutions was controlled in order to obtain an accurate result for the rate of breakdown of lipase as it can be observed for each concentration of aspartame and methanol.
- **Control variables:** Control variables were kept constant thorough all repeats to ensure that the only variables affecting the dependent variable were the concentration of methanol and aspartame. The control variables monitored were:
  - Lipase concentration
  - Time allowed for the reaction to happen
  - Temperature of the water bath
  - Full fat milk
  - Temperature of the milk
  - Temperature of lipase solution
  - Volume of milk used
  - Volume of lipase solution

controlled

Chapter 3: Data collection and processing

3.1 Processed results

See table of raw results in appendix (chapter 7)

Processed data table showing the average % decrease in pH and standard deviation for all the conditions tested

not avery informative way of expressing the data. pH is a logarithmic scale.

	Average % decrease in pH	SD
Milk	0.0000	0.00000
Milk + lipase	5.0400	0.500910
0.01 Aspartame solution	36.618	2.337058
0.005 Aspartame solution	33.448	2.109459
0.01 methanol	33.066	2.789911
0.001 methanol	29.412	3.391476

Processed data table showing the rate of reaction (s^{-1}) for all the conditions tested

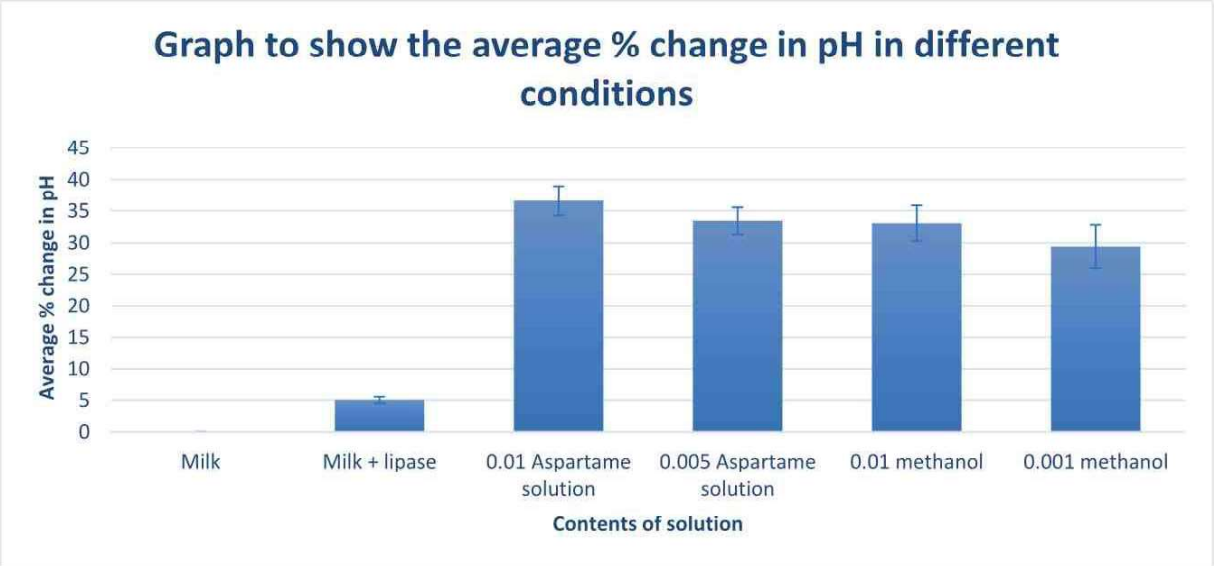
	Rate of reaction (s^{-1})
Milk	0.00000
Milk + lipase	0.00840
0.01 Aspartame solution	0.06103
0.005 Aspartame solution	0.05575
0.01 methanol	0.05511
0.001 methanol	0.04902

To calculate the rate of reaction the following formula was used:

$$rate = \frac{\%\ change\ in\ pH}{time\ in\ seconds}$$

Chapter 4: Analysis

4.1 Analysis of percentage change in pH



This graph shows the percentage change in pH for all the conditions tested in this experiment. We can observe a clear increase in the change of the pH when aspartame and methanol were present in the reaction. A dramatic change was observed on the pH of the reactions that contained aspartame and methanol. Both of these substances considerably decreased the pH level of the solutions.

We can observe, thus, how the control groups had a minimal percentage change compared to the groups containing aspartame and methanol. The pH of the milk remained unchanged, this was expected as there was nothing it could react with. The second control group had a minimum percentage change, with an average of 5.04%. This result demonstrates the normal percentage change in pH that occurs when milk and lipase react together.

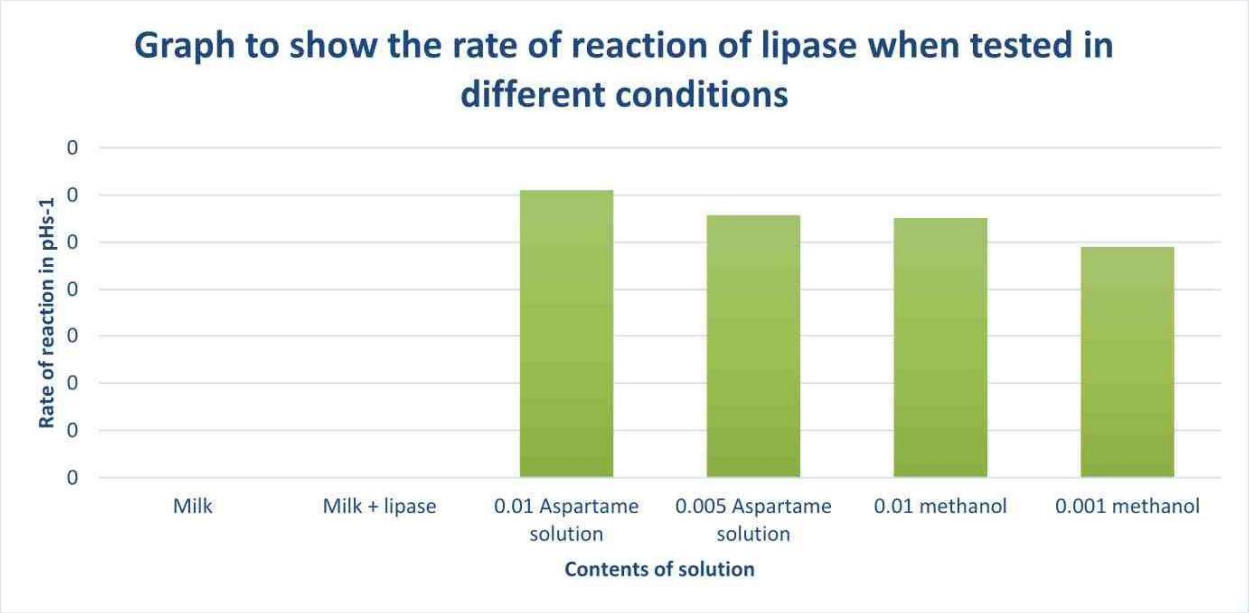
It was observed that the percentage change drastically changed when aspartame and methanol were present. The solution containing 0.01% of aspartame had an average

percentage change of 36.618%. This was the highest recorded percentage change for all the variables. The next aspartame solution (0.005%) showed a percentage change of 33.448%. This, although being a high percentage change, was smaller than the 0.01 solution of aspartame. In methanol, the biggest percentage change was observed in the 0.01 solution. This solution's percentage change was recorded to be 33.066%. This had a very similar percentage change than the 0.005 aspartame solution, although it was a bit smaller. Lastly, the 0.001 methanol solution had a percentage change of 29.412%, again, smaller than the 0.01 methanol solution.

We can definitely see a trend in those results. The more concentrated the solution is (i.e. 0.01 methanol and 0.01 aspartame) the bigger the percentage change. This for instance shows that the more concentrated the solution is the more fatty acids are present, therefore the pH decreases, thus, the rate of reaction is higher.

The standard deviation was calculated in order to see how the results where spread out around the mean. The standard deviation of each condition were included in the graph in the form of error bars. We can observe in the graph how the error bars for all the conditions are small. Thus, there is a small spread of results around the mean. Therefore, the results are reliable. However, the standard deviation for each condition, excluding the control groups overlap with each other. This could indicate that there is no significant difference between the conditions. This shows how the results of all this conditions are close to the mean obtained for each condition, thus, proving the results to be more reliable, as they have a similar standard deviation.

4. 2 Analysis of the rate of reaction of lipase



This second graph shows the rate of reaction of lipase when tested in different conditions. We can observe that the rate of reaction was higher in the conditions were aspartame or ethanol were present. The control groups showed none or a negligible rate of reaction, as shown in the graph. Milk had a rate of reaction of 0, which was expected as it was not reacting with any chemical. The milk and lipase condition had a very small rate of reaction of 8.40×10^{-3} s^{-1}. This result was also expected as the percentage change observed in this condition was considerably below the ones observed in the aspartame and methanol conditions.

In the 0.01% aspartame solution the rate of reaction was of 0.06103 s^{-1}. This was the highest rate of reaction of all conditions, it was also higher than the 0.005% aspartame condition which had a rate of reaction of 0.05575 pHs^{-1}. In the methanol conditions the 0.01% methanol concentration had the highest rate of reaction which was of 0.05511 s^{-1}.

In the rate of reaction we can observe the same trend in each condition than with the percentage average. The most concentrated solution (i.e. 0.01% aspartame and 0.01%

methanol) the rate of reaction is higher than their respective concentrations (i.e. 0.005% aspartame and 0.001% methanol). When the concentration of the solution is higher, the rate of reaction increases. Therefore, more fatty acids are produced the more concentrated a solution is. Thus, there is a higher pH decrease the more concentrated a solution is.

Overall, we observed the 0.01% aspartame solution to be the one which highly decreased the overall pH of the solution. Thus, it was the one to have the greatest impact on the rate of breakdown of lipids.

Chapter 5: Conclusion

The results obtained indicated that aspartame and methanol have an effect on the rate of breakdown of lipids into glycerol and fatty acids.

The results supported the initial hypothesis proposed at the start of the experiment. The rate of breakdown of lipids into fatty acids and glycerol in milk by lipase increased with the use of aspartame, because the pH of the solutions containing aspartame and methanol decreased after 10 minutes. Although the initial hypothesis was supported by the findings of this experiment, we cannot be certain how aspartame would react in the body as it's also exposed to other chemicals.

The percentage change calculations showed that the more concentrated the solutions were, the more the pH decreased. From the percentage change we were also able to observe that aspartame had a biggest change on the pH of the solution, compared to the methanol.

Although a strong conclusion can be drawn from the data obtained it is not entirely reliable. As mentioned before, one of the disadvantages of this experiment was the fact that it was not sure how aspartame and methanol would react inside the body, when mixed with other chemicals. We also do not know how they would interact with other food in the digestive system. Another disadvantage of this experiment was that the amounts of aspartame and methanol used were not compared to those found in foods and beverages. Thus, we do not know how these chemicals would interact with the lipase enzyme in other concentrations. Although we could predict the outcome, for instance, the more concentrated the solution of aspartame or methanol is, the bigger the rate of reaction will be, thus, the more acidic the solution will be. An improvement for the methodology of this experiment could be to use a known amount of aspartame found in a specific food or beverage, (e.g. Diet coke) and test how it interacts with the lipase enzyme. In this way, a more realistic view of the effect of

aspartame in the lipase enzyme could be obtained. In addition, when the Canderel tablet was dissolved, some remained undissolved at the bottom and side of the test tube. This weakness could be improved by applying heat to the solution while stirring it, to ensure that as much of the powder is completely dissolved.

Furthermore, the solution was allowed to react for 10 minutes, it is likely that inside the body these chemicals would react with each other for a longer period. Thus, the reaction could be allowed to react for longer to obtain more accurate results.

However, despite these weaknesses, this experiment also had many advantages. For instance, the temperature of the water bath was monitored and purposely kept close to body temperature in order to simulate body conditions. In addition, a pH probe was used to measure the changes in pH, thus, acquiring very reliable results. The experiment also included two different control groups which gave a great insight into how milk and lipase behave together, which allowed to compare it to how they both behave when aspartame and methanol are present. Furthermore, this experiment had a great amount of repeats for each condition, allowing obtaining more reliable results.

In view of the results obtained, if I were to repeat this experiment I would concentrate on investigating a specific product containing aspartame. In this way, a more accurate view of the effect of aspartame in the lipase enzyme could be observed. After my research into aspartame and its effects on the body I would also be interested in investigating the effects of aspartame in the pancreas, and its possible correlation to elevated liver enzymes.

Chapter 6: Bibliography

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Chapter 7: Appendix

7.1 Raw and processed data of the control conditions

Table showing the raw and processed results obtained from the milk control group

	Initial pH	Final pH
Milk	6.78	6.78

Table showing the raw and processed results obtained from the milk and lipase control group

	Initial pH	Final pH	pH difference	% change
1	6.63	6.29	0.34	5.13
2	6.73	6.31	0.42	6.24
3	6.63	6.29	0.34	5.13
4	6.65	6.30	0.35	5.26
5	6.60	6.27	0.33	5.00
6	6.61	6.28	0.33	4.99
7	6.63	6.30	0.33	4.98
8	6.59	6.29	0.30	4.55
9	6.58	6.29	0.29	4.41
10	6.58	6.27	0.31	4.71

7.2 Raw and processed data of the aspartame and methanol conditions

Table showing the raw and processed results obtained from the 0.01 aspartame solution experiment

	Starting pH	End pH	pH difference	% change
1	6.98	4.38	2.60	37.25
2	6.89	4.39	2.50	36.28
3	6.43	3.96	2.47	38.41
4	6.85	4.43	2.42	35.33
5	6.83	4.44	2.39	34.99
6	6.91	4.45	2.46	35.60
7	7.75	4.47	3.28	42.32
8	6.89	4.47	2.42	35.12
9	6.89	4.46	2.52	36.57
10	6.85	4.50	2.35	34.31

Table showing the raw and processed results obtained from the 0.005 aspartame solution experiment

	Starting pH	End pH	pH difference	% change
1	6.85	4.51	2.34	34.16
2	7.01	4.49	2.52	35.95
3	6.98	4.51	2.47	35.39
4	7.02	4.53	2.49	35.47
5	6.96	4.54	2.42	34.77
6	7.00	4.60	2.40	34.29
7	6.99	4.79	2.20	31.47
8	7.03	4.88	2.15	30.58
9	6.96	4.83	2.13	30.60
10	6.95	4.74	2.21	31.80

Table showing the raw and processed results obtained from the 0.01 methanol solution experiment

	Starting pH	End pH	pH difference	% change
1	6.48	4.72	1.76	27.16
2	6.76	4.74	2.02	29.89
3	6.94	4.63	2.31	33.29
4	7.01	4.68	2.33	33.24
5	7.01	4.60	2.41	34.38
6	6.62	4.54	2.08	31.42
7	7.06	4.57	2.49	35.27
8	7.03	4.55	2.48	35.28
9	7.00	4.50	2.50	35.71
10	7.11	4.62	2.49	35.02

Table showing the raw and processed results obtained from the 0.001 methanol solution experiment

	Starting pH	End pH	pH difference	% change
1	6.99	4.60	2.39	34.19
2	7.12	4.74	2.38	33.43
3	6.68	4.67	2.01	30.09
4	6.63	4.68	1.95	29.41
5	6.49	4.38	2.11	32.51
6	6.49	4.61	1.88	28.97
7	6.49	4.67	1.82	28.04
8	6.38	4.63	1.75	27.43
9	6.23	4.81	1.42	22.79
10	6.31	4.59	1.72	27.26

EE/RPPF

For use from May/November 2018

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Candidate personal code [redacted]

Extended essay - Reflections on planning and progress form

Candidate: *This form is to be completed by the candidate during the course and completion of their EE. This document records reflections on your planning and progress, and the nature of your discussions with your supervisor. You must undertake three formal reflection sessions with your supervisor: The first formal reflection session should focus on your initial ideas and how you plan to undertake your research; the interim reflection session is once a significant amount of your research has been completed, and the final session will be in the form of a viva voce once you have completed and handed in your EE. This document acts as a record in supporting the authenticity of your work. The three reflections combined must amount to no more than 500 words.*

The completion of this form is a mandatory requirement of the EE for first assessment May 2018. It must be submitted together with the completed EE for assessment under Criterion E.

Supervisor: *You must have three reflection sessions with each candidate, one early on in the process, an interim meeting and then the final viva voce. Other check-in sessions are permitted but do not need to be recorded on this sheet. After each reflection session candidates must record their reflections and as the supervisor you must sign and date this form.*

First reflection session

Candidate comments:

My passion for biological processes has been constant thorough the IB course. During my research for biological topics I came across the controversy surrounding artificial sweeteners. I discussed the topic further with my supervisor and I decided to concentrate on the effect of aspartame on digestive enzymes. However, the digestive enzymes readily available in the school lab were limited, so after another discussion I decided to concentrate on the effect of aspartame on the enzyme lipase.
I was advised to create a plan of what specifically I wanted to test, and I came up with my research question which was "To what extent is the rate of breakdown of lipids into fatty acids and glycerol affected by a change in the concentration of aspartame and methanol?".

EVAL

Date: 07/06/2017

Supervisor initials: [redacted]

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Interim reflection

Candidate comments:

I did an extensive research on the effects of aspartame in the body, mainly concentrating on its effects on digestive enzymes. During my research I found that aspartame is broken down in the body into aspartic acid, methanol and phenylalanine. My research also led me to discover that lipids are broken down into glycerol and fatty acids. Thus, after another meeting with my supervisor I decided to focus on the pH change of the solutions, meaning that the greater the pH decrease, the greater the rate of reaction of lipase. I then planned and carried out my investigation.

EVAL

Date: 15/01/2018

Supervisor initials: [redacted]

Final reflection - Viva voce

Candidate comments:

I have really enjoyed doing this investigation. Some good results were obtained from it and they were quite consistent thorough all conditions. However, in reflection I realized that the results obtained are not entirely reliable due to the sample size, as well as not taking into account bodily functions, and other chemicals that could interact with aspartame and methanol during digestion. To improve this study I think it would be interesting to expand my research and maybe do a separate experiment to observe how aspartame interacts with other chemicals during digestion. This information could then be added to the preexisting method, thus, making it more reliable. Sample size should also be increased to avoid any errors. Overall this study allowed me to broaden my knowledge of digestion enzymes as well as allowed me to discover how external factors can affect physiological factors. My research into aspartame also increased my knowledge in artificial sweeteners, and how they can affect physiological processes in the body. The controversy surrounding aspartame has also helped become more critical during my research process, as well as increased my confidence in including scientific journals, and scientific sources in my research. As well as academic growth, the EE has helped me develop my communication skills, time management, and most importantly it has helped me improve my planning skills for big projects which extend over a great period of time. All this skills acquired through the EE will be vital in my development as a biomedical scientist.

EVAL

Date: 08/03/2018

Supervisor initials: [redacted]

Supervisor comments:

***Supervisor**: By submitting this candidate work for assessment, you are taking responsibility for its authenticity. No piece of candidate work should be uploaded/submitted to the e-Coursework system if its authenticity is in doubt or if contradictory comments are added to this form. If your text in the box below raises any doubt on the authenticity of the work, this component will not be assessed.*

The candidate was always keen to write an EE in Biology as this is the area that she wants to study at university. She showed an interest in the current controversy regarding artificial sweeteners and carried out some preliminary research before deciding on her research question. Her research highlighted particular liver enzymes, but due to the limitations of equipment and resources available in the school laboratory she concentrated her experimental research on lipase enzymes. Her experiment produced interesting valid results, but she is fully aware that the results may differ inside the human body.

She has worked with effort on this EE and has organized her time sensibly. She reflected sensibly on her preliminary research and chose sources wisely. She developed a clear and coherent research question and once she had gathered experimental results she evaluated them critically in light of her preliminary research.

She was able to describe confidently her research and conclusions and how she had managed her time by setting goals and planning a time-line of when she wanted the individual sections of the EE to be finished. Throughout the EE she communicated confidently and politely her ideas and needs with the Biology technician and other staff. She was a pleasure to work with and showed intelligence, independence and initiative throughout the process.

SEEN