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Candidate session number

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Examination session (May or November)

MAY

Year

2008

Diploma Programme subject in which this extended essay is registered: BIOLOGY

(For an extended essay in the area of languages, state the language and whether it is group 1 or group 2.)

Title of the extended essay: "Are non biological washing
powders more effective to the removal of
stains than biological washing powders?"

Candidate's declaration

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I confirm that this work is my own work and is the final version. I have acknowledged each use of the words or ideas of another person, whether written, oral or visual.

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Date: 22.1.08

“Are non biological washing powders more effective to the removal of stains than biological washing powders?”

An Extended Essay in Biology by:

Student Identification Number:

Supervisor:

Words: 3,336

Abstract

The difference between biological and non-biological laundry detergents is that, biological laundry detergents are genetically modified to insert enzymes which help fight stains at lower temperatures than non-biological detergents, for example the enzyme protease is added to help remove protein stains from clothes, however, non-biological detergents are better for the environment, because they are more biodegradable than biological detergents. The objective of this study is to find out if non-biological laundry detergents are more effective than biological ones; **“Are non biological washing powders more effective to the removal of stains than biological washing powders?”** Pieces of cotton cloth were smeared with different stains, then washed with the different detergents and the change in weight was recorded and compared.

The results were hard to interpret, but essentially the results supported the hypothesis that biological detergents are better at removing stains than non-biological laundry detergents. Two methods were used, and the method of washing the cotton cloths in room temperature yielded results which could not be explained. The results of the second method, in which the cotton cloths were washed in a higher temperature of water (60C), supported the hypothesis. The alternative method that I compared the other methods to; was making a small circle in agar jelly where the different detergents were dropped then iodine was dropped onto the agar jelly and the clear circles around them were measured using a ruler. This experiment also supported my hypothesis. I also found out that higher temperature washes need to be used in order to effectively remove stains, as the enzymes are denatured at higher temperatures.

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Introduction

In recent years, pollution of the environment has become a rapidly growing issue. The developing pressure on the younger generations have made virtually all of the youth aware of the “Greenhouse Effect” now commonly referred to as, the more dramatic “Climate Crisis”. During a class, we began to discuss environmental issues, mostly the growing knowledge of the Climate Crisis, which raised a heightened conflict. Since then, I became interested in learning more about the effect that everyday tasks have on the environment. So, as I considered different ideas for an extended essay, it seemed natural to choose a topic I am interested in, so I began research for a suitable idea that would have a simple and efficient way to obtain results and would allow me to find more about environmental issues, however broad enough to make into a good essay question.

I started research, not knowing exactly what I was looking for and found information about detergents and the environment. While researching, I found out that studies have shown that the lacking biodegradability of biological washing detergents may be a contributing factor to breast cancer, which has increased almost 50% in the last 20 years, in addition to the pollution problem. Between the years 1940 and 1970 detergent had become a major problem; in the 1960’s ‘suds’ from the detergent formed in rivers, lakes, streams and even at the foot of Niagara Falls, it was even noted that discolored detergent foam rose eight feet high. Phosphates in waste water increased due to the additives in the detergents, which caused algal blooms (algae) to grow rapidly. The algal blooms consumed the majority of the oxygen in the waters, which caused aquatic plants and animal to die.¹ I also stumbled upon an article/which said companies which manufacture detergent, are not required by law to list all of the properties in the detergents. The thought of not knowing what exactly is in our own household items was extremely thought provoking.

Footnotes

1. http://en.wikipedia.org/wiki/Laundry_detergent

At first I wanted to use the idea of the effect of detergent toxicity on the environment, but then realized the task of collecting results would be an enduring and tedious process. Nevertheless, I continued searching and subsequently found articles on the effects of biological detergents on the environment, not only are there detergents bad for the environment but they also can cause severe skin irritation, especially in the case of newborns. I decided that it would be interesting to see what difference the detergents have in the effective removal of stains. The difference between biological and non-biological detergents is that biological detergents are genetically enhanced, so that enzymes can be added to help remove protein based and other types of stains. Non-biological enzymes do not have these enzymes, and are better for the environment.

I choose to prepare and carry out an experiment in which I would use cotton as a base to spread different stains on. This method is an adequate way of testing and can be completed reasonably quickly; also the supplies are readily available. Therefore; this piece will be based on the research question; **“Are non biological washing powders more effective to the removal of stains than biological washing powders?”** This experiment will be completed and analyzed to try to formulate a solid conclusion based on the outcome, and consequently evaluated.

Hypothesis

Biological laundry detergents are synthetically processed, so that enzymes can be added to remove stains, Non-biological Detergents do not have these additives. Protease enzymes break down protein into smaller, more soluble particles¹ (peptides and amino acids), protease is an enzyme that is added to biological laundry detergents. The reason that laundry detergents supposedly work better is because this enzyme is added. The majority of clothing stains are made up of protein, adding protease breaks down the protein during the wash without having to use a stringent high temperature wash.

Thus, I expect my results to show that the biological laundry detergent is more effective than the non-biological laundry detergent. Conversely, I think that during the high temperature wash the detergents will generate similar results when removing the stains.

Method Development and Planning

Formulating a method for testing my hypothesis was tricky because there were various problems that arose as I considered the ways that I could control the variables. It was hard to formulate a way of measuring which washing detergents (biological or non-biological) remove stains more effectively. There is no certain way of measuring how much of a stain is left without visually looking at the stain; even then there is a large room for error because it would only be one person's perception, which is also not a fair test.

At first I thought of using an idea that my group during group 4 project used, in which we tested how much dye had been removed from different cloth samples. After careful consideration I decided to use this method which is described in full detail below, for my project because the method worked during our group four project, I assumed that the same would happen for my experiment. I also wanted quantitative data so that I could use different ways of comparing my results to get a greater picture of the accuracy of my results. I also wanted to be able to formulate graphs using my results, to use as another comparison.

Some of the other ideas I had to consider were the material I would use. I chose to use cotton because of its superior absorbancy¹. I also had to choose between powder and liquid detergent. The reason I chose liquid is because it is pre-dissolved³ whereas powder has to be dissolved and there is also the risk of the powder not getting fully dissolved which would make it an unfair test. Another problem I was faced with was the pressure of water. In a laundry machine the water pressure can be adjusted i.e. Higher pressure for heavier stains. There was no way of changing the pressure of water when I did my experiment but I do not expect that to have affected my results significantly. I also had to make the decision of what type of stain I would use. I chose to test ketchup and grape jelly, because they are both common stains and are readily available. Ketchup is also known to stain clothes and jelly is sticky so I figured that the jelly would stick onto the cotton and make it difficult to remove.

Once I had finished my preliminary work I was able to see the problems with my experiment and then I was able to correct them. Some problems that arose were that the

amount of cloth used was far too much so I decided to use a smaller amount (15cm x 15cm down to 12cm x 12cm). Also in my first experiment I did not measure out a specific amount of ketchup to be used. After doing the first experiment I decided I should measure out an estimate of 4 ± 0.001 g. The reason I decided to do this is because the larger mass of ketchup on cotton squares could cause excess ketchup on the cotton squares that dried however, the cotton did not completely absorb all of the ketchup.

After I finished my first experiment I decided to look up the way that laundry detergent works, I then found out that the detergent needs to be used at high temperatures in order to effectively remove the stains. Since I had been using de-ionized water at room temperature with the detergent I had to ~~change~~ my method slightly; instead of de-ionized water at room temperature I decided to ~~boil~~ the water to 60°C before adding the detergent. The problem with using hot water is that heat is lost quickly, so I decided that I needed to use some form of insulation to ensure that it was a fair test. Styrofoam coffee cups seemed to be the best idea because they are readily available and Styrofoam is an excellent insulator.

After completing the experiments I decided to use an alternative method (taken from the book Practical Advanced Biology²) to fully ensure that my experiment was working.

Method

Materials and Apparatus

12 Medium Styrofoam coffee cups with lids	Scale (3dp)
Measuring cylinder (50ml)	De-ionized Water
Ketchup (Heinz)	Kettle
Grape Jelly (Welch's)	Thermometer (°C)
Oven (°C)	Ruler (30cm)
Stopwatch	Pencil
Washing detergent; Fairy (non-bio), Tide	Glass rod
Scissors	Small droppers

Twelve 12x12cm squares were marked on cotton sheets, using a pencil, and then cut out using scissors. After the squares were cut, they were weighed using a 3dp scale and recorded in an appropriate table. Around 5g of ketchup was measured onto each piece of cotton, and then spread evenly with a glass rod. Each piece was put into the oven, (arranged in diagram ___ to dry at 100°C, and then removed 60 minutes later. Each piece is then placed into a 150ml glass beaker with 7ml of washing detergent and 143ml of de-ionized water at room temperature for 30 minutes, each beaker of detergent, water and cotton square is stirred for 2 minutes each. This method was then repeated using ketchup however the water temperature was 60°C and insulated coffee cups with lids instead of the glass beakers. Then the method was repeated once more but with jam instead of ketchup.

The alternative method I decided to use was taken from the book Practical Advanced Biology².

Materials and Apparatus

Cork borer	Ruler
Starch–Iodine Agar Jelly	Dropper
Washing detergent; Fairy (non-bio), Tide	Iodine

A cork borer is used to cut 3 evenly dispersed wells in 6 starch–iodine Agar jelly Petri dishes. Next a dropper is used to place 3 drops of detergent in each of the wells. The dishes were left overnight in room temperature.

Footnote

1. <http://en.wikipedia.org/wiki/Cotton>
2. Practical Advanced Biology by Tim King, Micheal Reiss with Micheal Roberts (Nelson Thornes)
3. <http://www.laundromatfinder.com/powder-vs-liquid.shtml>

Results

Experiment One: Ketchup on Cotton Squares

Table One. First set of results, water at room temperature of $23 \pm 0.1^\circ\text{C}$.

Square No.	Weight (± 0.001 g) of Cotton Square		
	Before	After	Change (+ / -)
<i>Biological Washing Detergent: Tide</i>			
1	4.961	1.917	-3.044*
2	3.351	1.892	-1.459
3	3.419	1.929	-1.49
4	3.601	1.929	-1.672
5	3.468	1.905	-1.563
6	3.562	1.948	-1.614
Average	3.727	1.920	-1.5596

<i>Non-Biological Washing Detergent: Fairy</i>			
7	3.543	1.995	-1.548
8	3.461	2.094	-1.367
9	3.485	2.320	-1.165
10	3.715	2.209	-1.506
11	3.413	1.960	-1.453
12	3.334	2.015	-1.319
Average	3.492	2.099	-1.393

*This result was anomalous so I chose to leave it out of my calculations.

Table Two. Second set of results, water at temperature of $60 \pm 0.1^\circ\text{C}$

Square No.	Weight (± 0.001 g) of Cotton Square		
	Before	After	Change (+ / -)
<i>Biological Washing Detergent: Tide</i>			
1	2.081	2.204	0.123
2	2.133	2.243	0.11
3	2.079	2.067	-0.012
4	2.052	2.048	-0.004
5	2.065	2.117	0.052
6	2.049	2.266	0.217
Average	2.077	2.158	0.081

<i>Non-Biological Washing Detergent: Fairy</i>			
7	2.183	2.245	0.062
8	2.069	2.2	0.131
9	2.144	2.217	0.073
10	2.196	2.25	0.054
11	2.133	2.196	0.063
12	2.223	2.303	0.08
Average	2.158	2.235	0.077

*Note: The before results, are measured after the ketchup has dried in an oven of 100°C. The after results, are measured after the ketchup after submerged in detergent and dried in the oven of 100°C, thus displaying the weight of ketchup that has stayed on the 12x12±0.05mm piece of cotton.

Experiment Two: Grape Jelly on Cotton Squares

Table Three. third set of results for second experiment, water at temperature of 60±0.1°C

Square No.	Weight (+0.001g) of Cotton Square				
	Before (Without Jam)	Dried Jam	After Wash	Change (+ / -)	
				Before → Dried Jam	Before → After Wash
<i>Biological Washing Detergent: Tide</i>					
1	2.123	5.919	2.014	3.905	-0.109
2	2.117	5.687	1.998	3.689	-0.119
3	2.121	5.469	2.001	3.468	-0.120
4	2.119	4.362	1.998	3.364	-0.121
5	2.130	5.651	2.013	3.638	-0.117
6	2.139	5.864	2.033	3.831	-0.106
Average	2.125	5.492	2.100	3.649	-0.115
<i>Non-Biological Washing Detergent: Fairy</i>					
7	2.091	5.682	2.024	3.658	-0.067
8	2.075	5.467	2.014	3.453	-0.061
9	2.079	5.138	2.014	3.124	-0.065
10	2.081	4.784	2.002	2.782	-0.079
11	2.100	4.604	2.028	2.576	-0.072
12	2.101	4.757	2.042	2.715	-0.059
Average	2.088	5.072	2.021	3.051	-0.067

Experiment 3

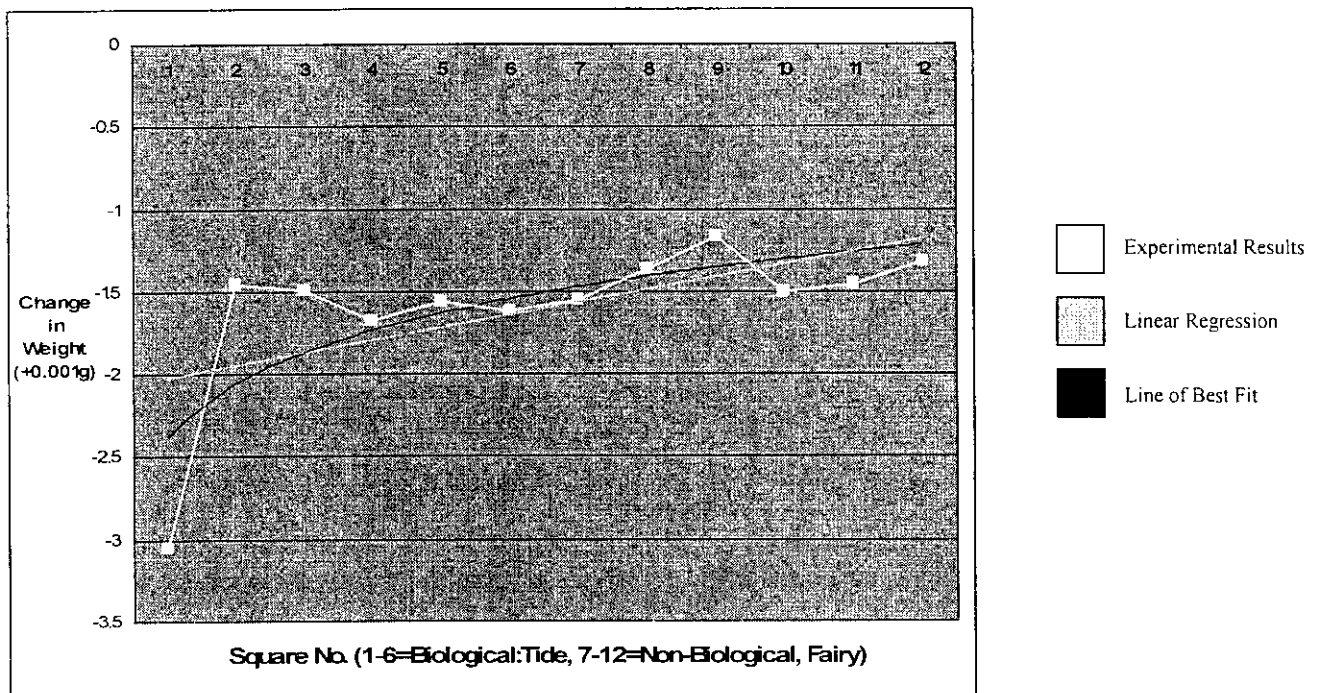
Table Four. Agar Jelly, used in the comparing break down of starch abilities between non biological and biological washing powders at room temperature of 17±0.1°C

Circle No.	Circle Diameter
<i>Non-Biological Detergent: Fairy</i>	
1	7
2	8
3	6.5
Average	7.167
<i>Biological Detergent: Tide</i>	
4	13
5	10
6	15
Average	12.667

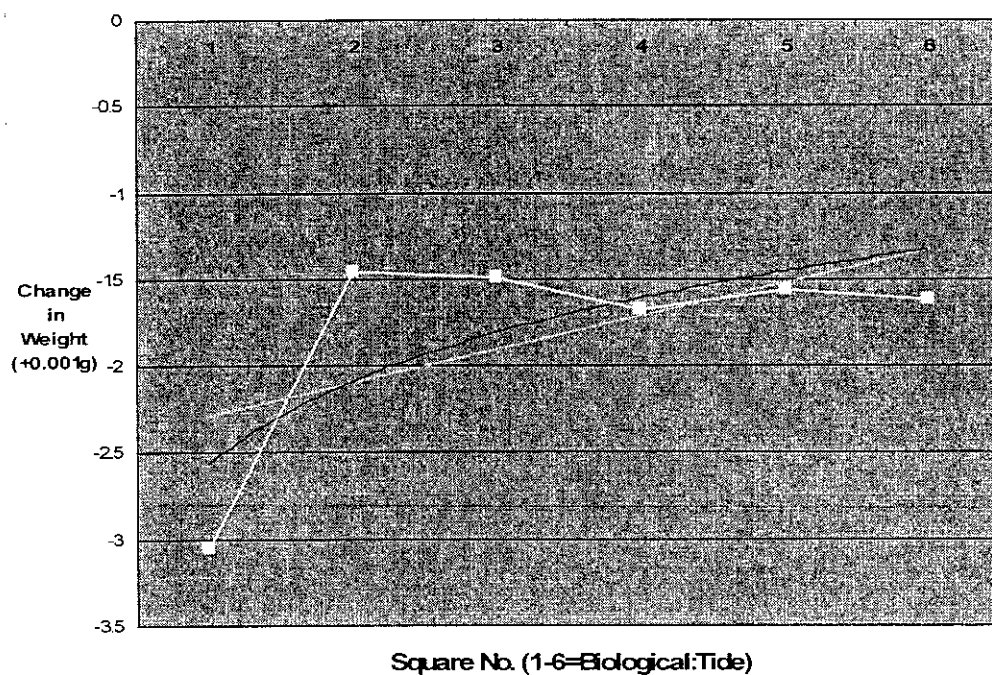
Graphs

Experiment One: Ketchup on Cotton Squares Washed in Biological and Non-Biological Washing Detergent

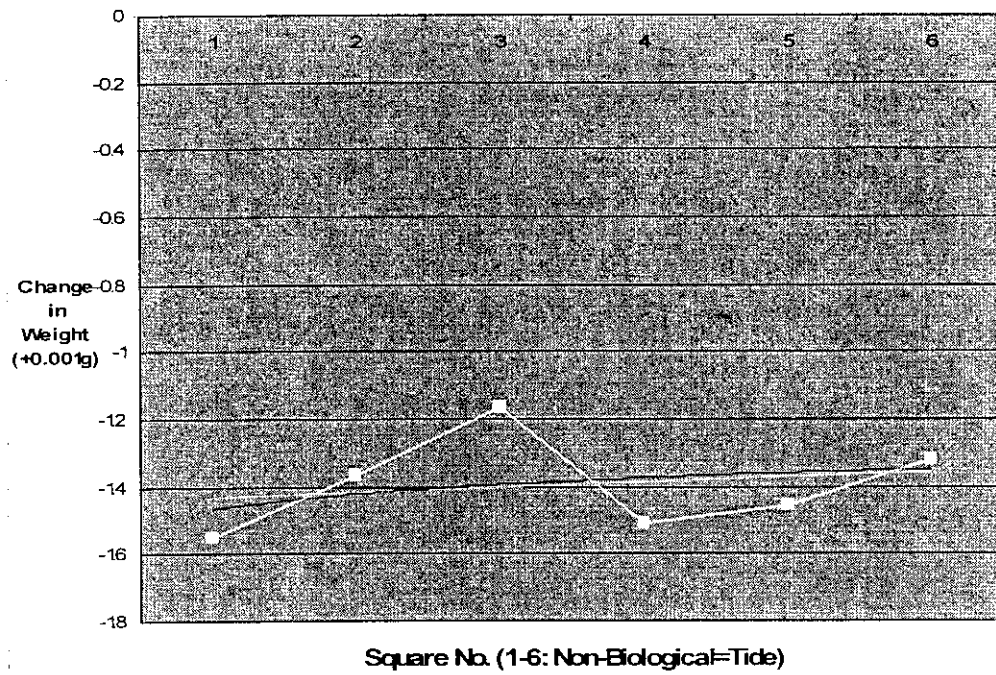
Graph One



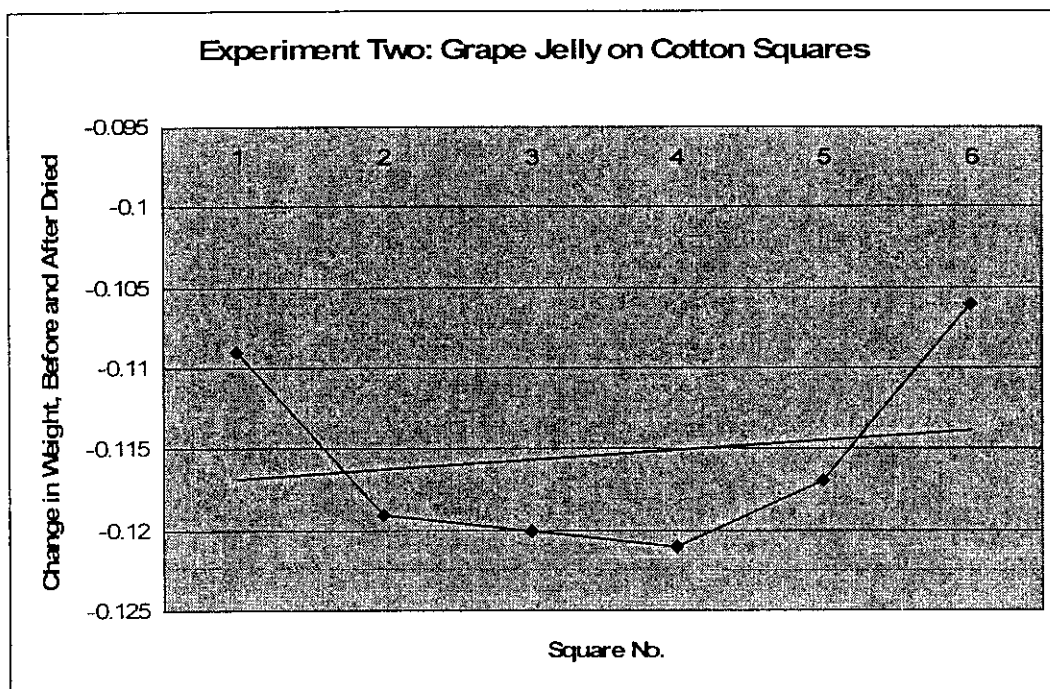
Graph Two



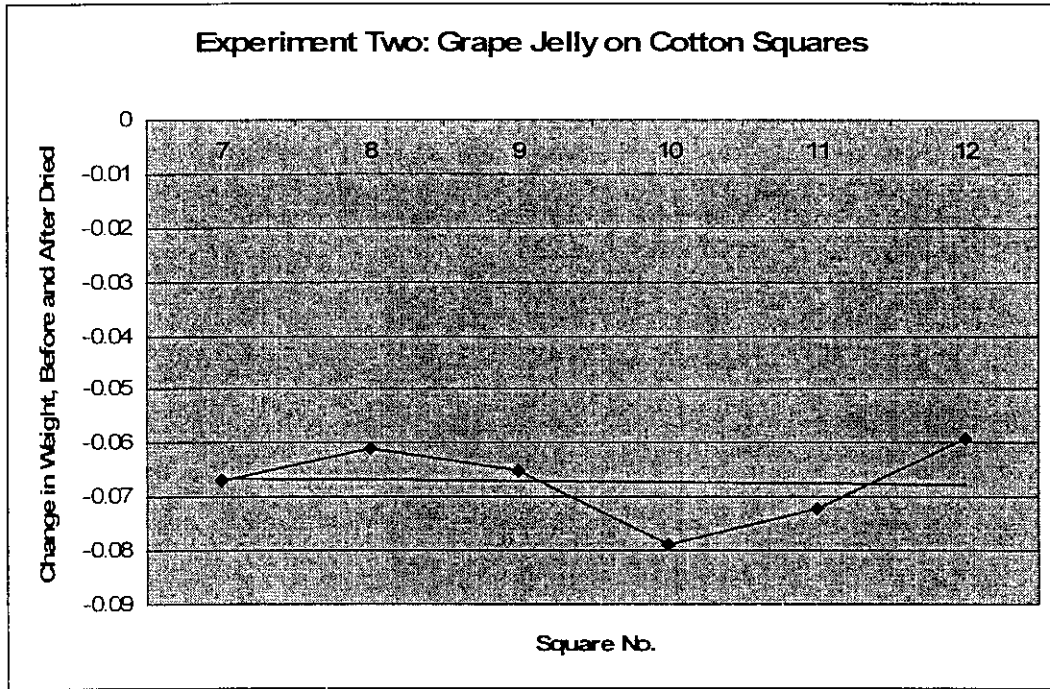
Graph Three



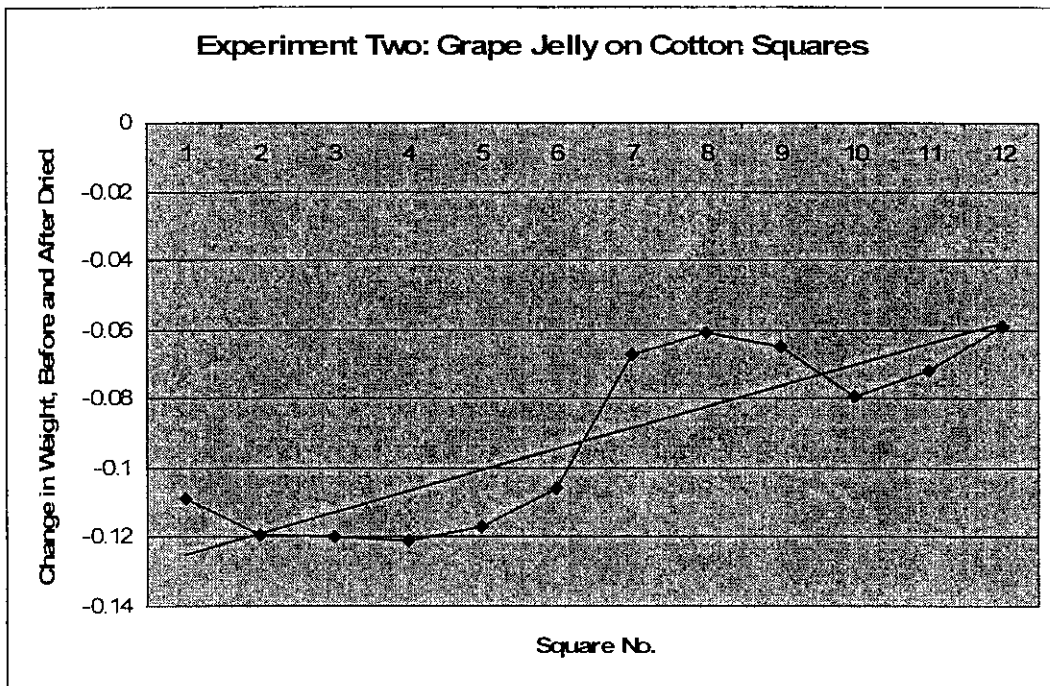
Graph Four



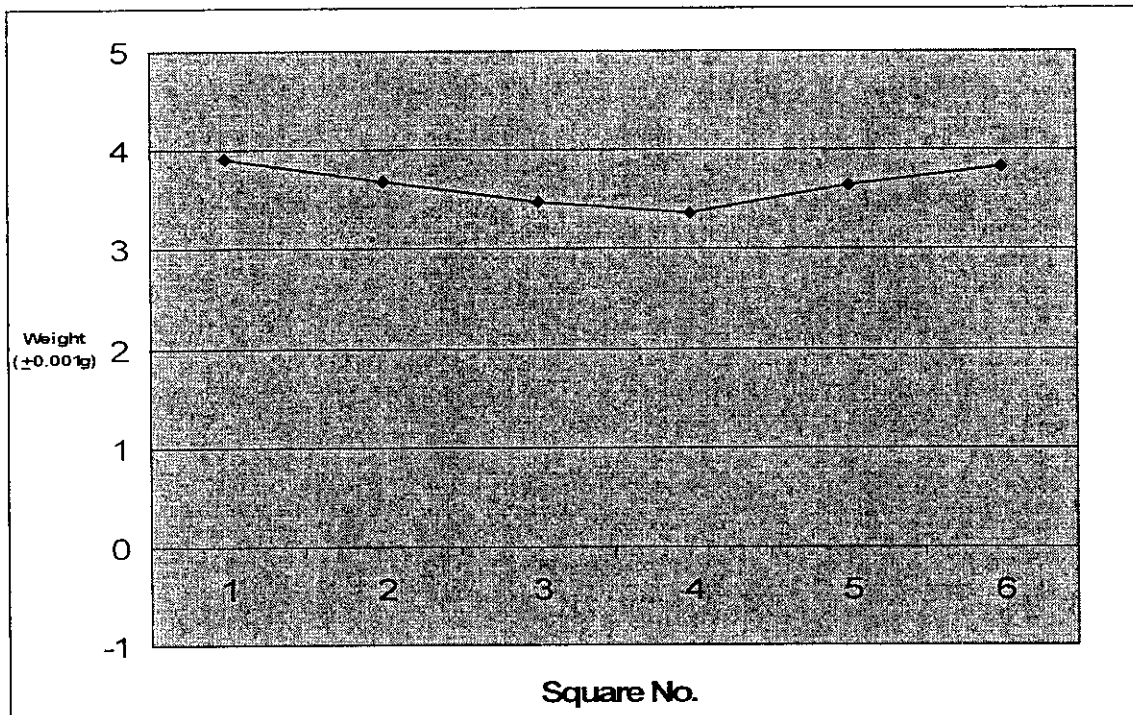
Graph Five



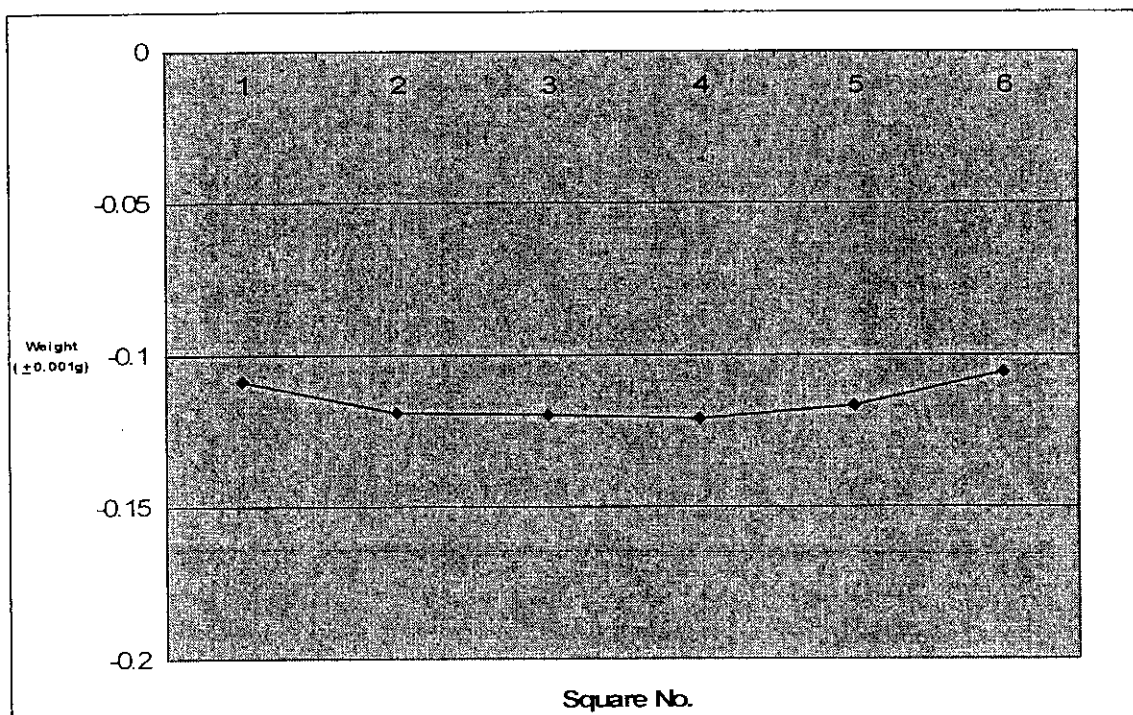
Graph Six



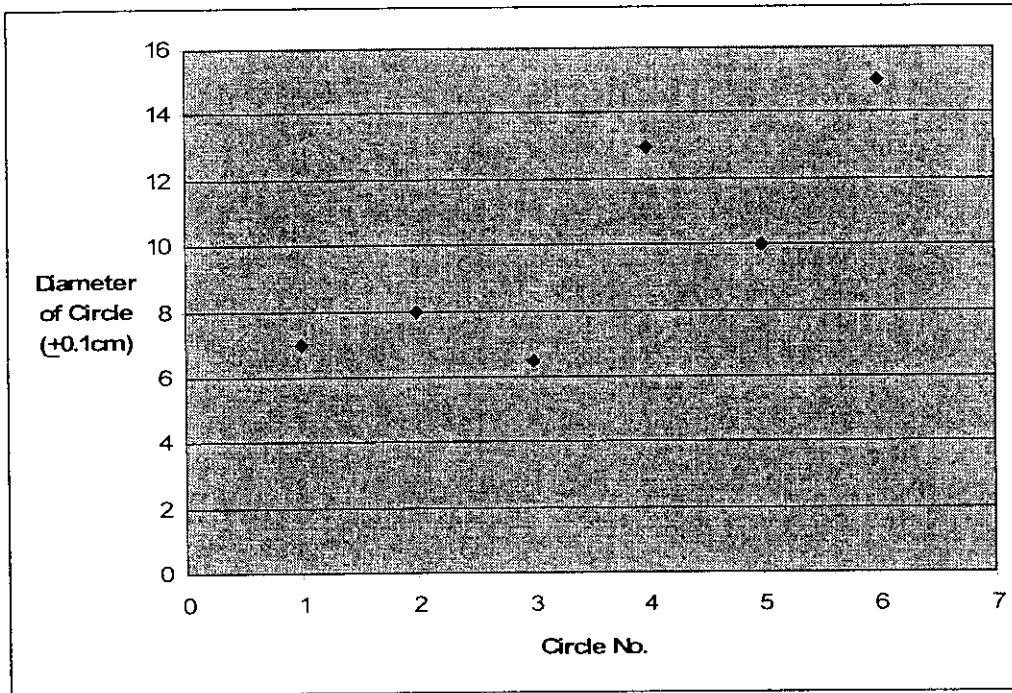
Graph Seven showing the weight of the amount of jam removed from cotton square cloth.



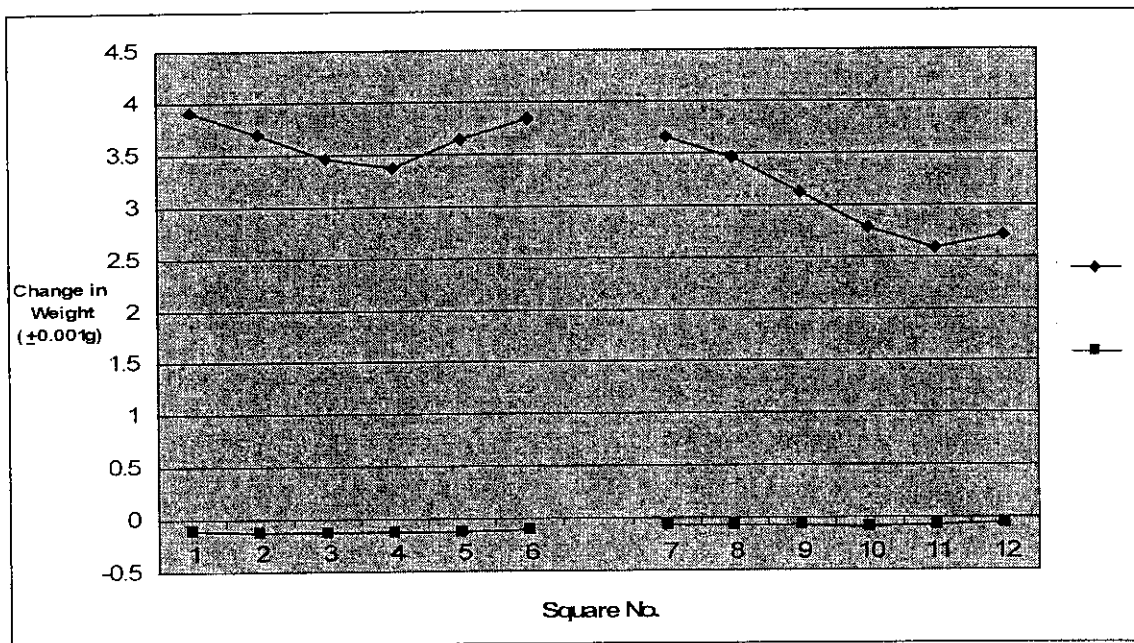
Graph Eight showing the difference between the dry cotton before the wash and dry cotton after the wash.



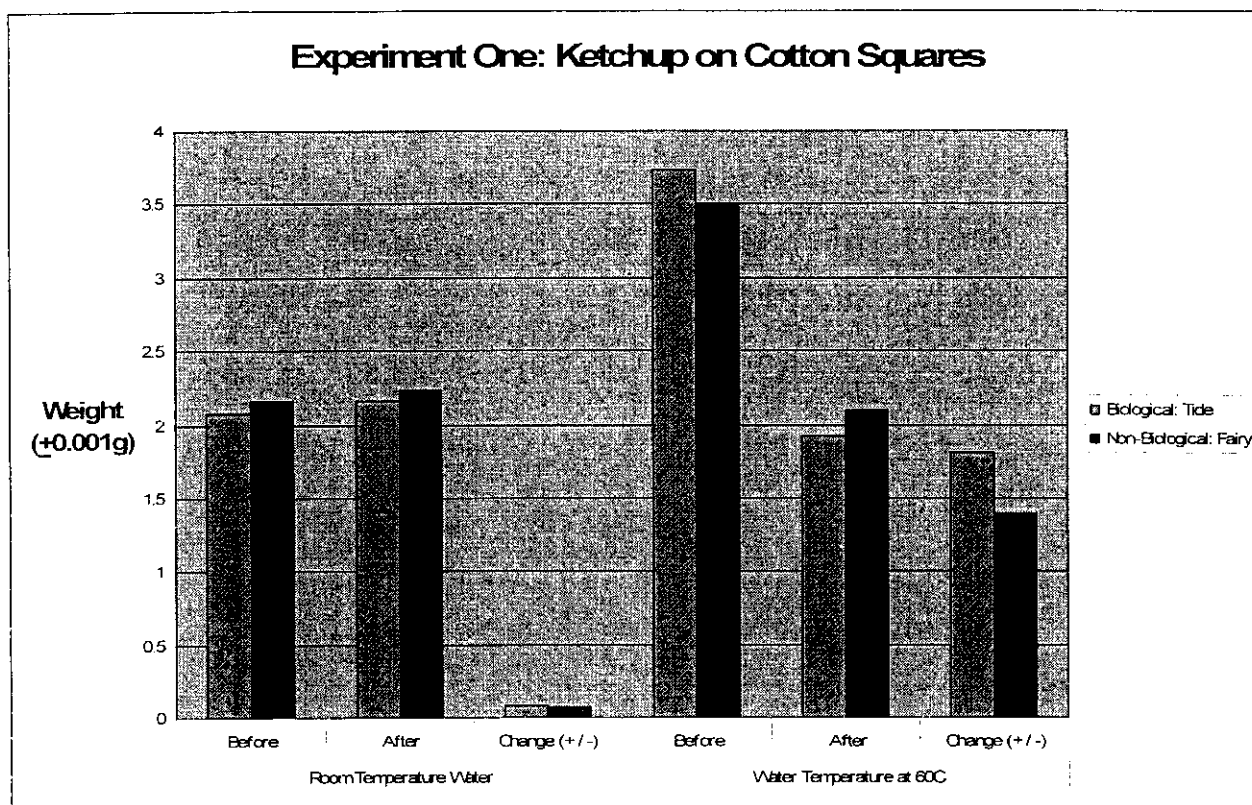
Graph Nine showing the diameter of the circle of clear space around the circle made from the borer including the circle



Graph Ten showing the Changes in weight of 12 pieces of cotton cloth squares.



Graph Eleven



Analysis

The data I have collected is *quantitative continuous*. This means that I can use a statistical method of analysis. Such as Chi- Squared, or Pearson's Correlation Co-efficient and Standard Deviation

I have chosen the **Standard Deviation** test to give insight on how the data is dispersed. Standard deviation can be determined using the following formula:

$$s = \sqrt{\frac{\sum(x-\bar{x})^2}{n}}$$

x is any score

\bar{x} is the mean of the distribution

n is the total number of scores

Table One Biological Washing Detergent

x	x-x	(x-x) ²
-1.459	-0.1006	0.01012036
-1.49	-0.0696	0.00484416
-1.672	0.1124	0.01263376
-1.563	0.0034	1.156E-05
-1.614	0.0544	0.00295936
-7.798		0.0305692
Standard Deviation = 0.006114		x=-1.5596

Non-Biological Washing Detergent

x	x-x	(x-x) ²
-1.548	0.155	0.024025
-1.367	-0.026	0.000676
-1.165	-0.228	0.051984
-1.506	0.113	0.012769
-1.453	0.06	0.0036
-1.319	-0.074	0.005476
-8.358		0.09853
Standard Deviation = 0.016422		x=-1.393

Table 2: Biological Washing Detergent

x	x-x	(x-x) ²
0.123	-1.516	2.298256
0.11	-1.503	2.259009
-0.012	-1.381	1.907161
-0.004	-1.389	1.929321
0.052	-1.445	2.088025
0.217	-1.61	2.5921
0.486		13.073872
Standard Deviation = 2.178979		x=0.081

Non- Biological Washing Detergent

x	x-x	(x-x) ²
0.062	-1.455	2.117025
0.131	-1.524	2.322576
0.073	-1.466	2.149156
0.054	-1.447	2.093809
0.063	-1.456	2.119936
0.08	-1.473	2.169729
0.463		12.972231
Standard Deviation = 2.162039		x=0.077

The Standard Deviation of my results shows that the results are not very close to the mean. The standard deviation is large therefore the data points are far away from the mean suggesting that my results are not very accurate.

Evaluation

The results do not support the hypothesis that biological washing detergents are more effective in the removal of stains than non-biological washing detergents. After comparing results from various experiments I have found that the hypothesis is not supported in most cases. I choose to compare four different experiments and two different methods to ensure my results were correct. The first method was washing various pieces of cloth in non-biological and biological detergents, I weighed the cotton cloth whilst it was dry before it was washed and after it was washed and dried, this gave me the weight of ketchup that was left on the piece of cloth. I predicted the biological washing powder to have a lower change in weight than the non-biological; however my results showed that the cloth significantly decreased in weight which was odd and unexplainable. I assume that the cloth may have lost weight due to strands of cotton that may have been lost during the wash or some of the cloth may have been left in the solution for too long and decomposed.

The second set of results were derived from the same method however the water used was not at room temperature, it was at a higher temperature of 60C. The results showed that more ketchup stayed on the pieces of cotton cloth that were washed in the biological detergent because the change in weight was higher. This result alone disproves my hypothesis however I did more tests to make sure.

The third set of results was the outcome of a different substance used to smear on the cloth, grape jelly. With this set of results I wanted to have another way of comparing how much substance was removed from the cloth so I decided to weigh each piece of cotton at every step. I weighed the cotton when it was dry before the jelly was smeared onto it, I also weighed it when the jelly was dried and lastly I weighed the cloth when it was dry after the wash. I compared the results in **graph ten**. Graph ten is showing the two different methods of comparing the results. From the graph it can be said that the method of comparing which proves my hypothesis is the method of weighing the dried jam and cloth then weighing the cloth after it has been washed and dried in the oven. The difference between the two will give the amount of jam that has been washed off, therefore the higher the value, the better the detergent. The results pointed to the

biological washing powder as removing the most stain. It is hard to say which method of comparing is correct because there are factors which will influence my results, for example, I could have washed the cotton sheets on water before weighing the starting weight because some loose cotton could be on the sheets and may have been a factor influencing the weight change also there could have been lint on the cotton sheets. Also there were strands of cotton that became loose from the sheet and did not get weighed. All of these factors influenced my results.

I decided that I was not satisfied with the ambiguous results I had gotten, so I came to the decision of using another way of determining which detergent is better at removing stains, which is described in my method. The results from this method also supported my hypothesis. The biological detergent made a larger clear circle around the detergent than the non-biological detergent. This is due to the enzymes in the biological detergent, which denatured the starch enzymes; more starch was removed by the biological detergent than the non-biological detergent. I chose to put together a graph to show the results so I could get a visual idea of the results, it can be seen that the diameter is larger in the circles 4, 5 and 6, which are the wells which I added the biological detergent to. The results from this experiment are useful however, starch is not the only type of stain, and the results merely prove that biological detergent is better at removing stains containing starch. It would have been a better test if I tested the ability of the detergents breaking down fats, oils and protein as well as starch.

Another source of error could be that the concentrations of laundry detergent were too high. I used the recommended volume of detergent between 6 samples of cotton cloth in about 50 ml of water. This factor could be considered an unfair test, because in one load of laundry the concentration is not that high. However I soaked the cotton squares for a shorter period of time. Also the recommended volume of detergent for one load is different for the biological and non-biological detergents. I decided to keep the volume and concentrations of detergent the same to make it a fair test, however, liquid detergent is merely pre-dissolved detergent and I did not know the concentration of the dissolved powder, which could have been very different, and this could have affected my results.

To eliminate error I could have repeated the experiment more times, so that I could have stronger results, which would leave less room for error and anomalous results

could be seen more clearly and then excluded. Repeating the experiment would make the results more accurate; however, this will not eliminate other errors and will not help control variables that cannot be controlled.

Conclusion

I conclude that my hypothesis, biological washing detergents are more effective in the removal of stains than non-biological washing detergents. The results were hard to interpret, but essentially the results supported the hypothesis that biological detergents are better at removing stains than non-biological laundry detergents. Out of the two methods used washing the cotton cloths in room temperature yielded results which could not be explained and the second method in which the cotton cloths were washed in a higher temperature of water (60C) supported the hypothesis which I chose to represent visually in graphs.

The alternative method that I compared the other methods to; was making a small circle in agar jelly where the different detergents were dropped then iodine was dropped onto the agar jelly and the clear circles around them were measured using a ruler. This experiment also supported my hypothesis. I also found out that higher temperature washes need to be used in order to effectively remove stains, as the enzymes are denatured at higher temperatures.

Works Cited

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Subject: Biology

Title of essay: Are non-biological washing powders more effective to the removal of stains than biological washing powders?

Criterion	Mark awarded (criterion)	<i>Comments should reference each individual assessment criterion. Please copy this form and include a copy per script – please type or write in the space below and continue on a separate sheet if necessary (maximum 50 words per criterion sample). Comments will be made available to examiners undertaking training.</i>	Total
A	1	The research question is clearly stated but is not well focused. There is no attempt to restrict the study in any way.	1
B	1	There is a limited attempt to place the study in context on p4 and 5. However there is much confusion about the meaning of basic terms such a biodegradability, genetic modification and effect on the environment.	1
C	2	There are only three relevant references. However the student has collected a sufficient body of data through experimentation, using suitable controls, to at least partly address the research question. More detail could be provided on the method in order to show that the investigation was well planed.	2
D	2	There is some knowledge and understanding but limited background reading is reflected in the lack of a clear understanding of basic terms. There are some good ideas expressed in the section on interpreting the data. This shows that the student has some understanding but limited knowledge base.	2
E	2	There is some attempt to set out reasoned argument . However while there are some well developed ideas especially in the discussion, the student is not always clear about what exactly is being investigated.	2

F	2	The analysis is superficial and incomplete. The data are not presented in the most appropriate way making a thorough analysis difficult.	2
G	1	The language of the essay is usually accurate and easily followed. However the ideas are expressed in simple terms and the student does not show a good command of technical terms related to this topic.	1
H	1	There are some relevant conclusions. The final paragraph contains a clear contradiction and shows that the candidate is not clear about the type of enzyme being investigated.	1
I	2	There is a clear layout to the essay. The structure is well organized and technical aspects are dealt with competently. However there is a very limited bibliography and few in text references where many more would have been appropriate. Poor use is made of tables and graphs and these are not presented in the most appropriate format.	2
J	1	The research question is clearly stated. The section dealing with the scope provides few details. There is an apparent contradiction in the last line of the conclusion.	1
K	1	There is little evidence of initiative or motivation on the part of the student either in the essay itself or in the teacher comments.	1
<p><i>Comments: Please add a short holistic summary (approximately 100 words) summing up the strengths and weaknesses of the essay. This essay shows little initiative or insight. The success of this study is clearly limited by poor planning and by a lack of background knowledge on the part of the candidate.</i></p>			Total 16