Biology Internal Assessment

Purpose

My interest in the ripening of fruit developed from an observation that fruits bought in my local supermarket do not always ripen effectively. This stimulated me to find out more about the process of ripening in fruits. I chose nectarines as my material because they were in season and they seemed to be the worst affected by the problem of ripening.

Paul Billiet 29/7/13 11:38 PM
Comment [1]: PE The purpose is clear and the candidate justifies the choice of the research question.

Research Question

How do two different methods of fruit ripening affect the metabolism of starch to glucose in nectarines (*Prunus persica*) over 7 days?

Paul Billiet 27/8/13 10:29 AM
Comment [2]: Ex Research question stated but it could be made more focussed by reference to the ripening methods used.

Introduction

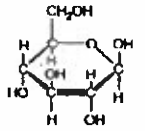


Figure 1 Glucose molecule

1 1

Glucose is one of the most important carbohydrates in biochemistry and is pivotal in the key biological processes of photosynthesis and cellular respiration. In the ripening process, starch molecules (polysaccharides) are broken down by digestive enzymes to glucose (monosaccharide). This process is made possible by the induction of ethene gas.[2][3]
Ethene gas is biological hormone that is used in plants to stimulate key processes, for example the germination of seeds, fruit abscission and the ripening process. It is more readily produced by some fruit, in particular bananas and apples, and will hasten the ripening of fruit when in a contained environment, for example inside a plastic bag or box. Another method suggested is to bury the fruit in rice. It is supposed to retain the ethylene gas produced by the fruit longer.[4]

Paul Billiet 21/7/13 5:15 PM
Comment [3]: Ex Relevant background context. Sources referenced.

This experiment aims to simulate three different ripening conditions, all of which are presumed to induce the ripening process. In the first trial, a banana will be placed with a nectarine in a closed bag. In the second, a nectarine will be placed under rice in a plastic box. Thirdly, a control whereby a nectarine is placed alone in a plastic bag, will be set up as the null hypothesis, supporting the assumption that the production of ethene gas and the concentration of glucose are independent of one another. It is important that all three trials be conducted in closed environments, which favour the retention of ethene gas.

Paul Billiet 21/7/13 5:15 PM
Comment [4]: Ex Good methodology. Control experiment.

The presence of glucose has been used in this experiment to indicate the extent to which ethene gas has affected the metabolism of starch and the concentration of simple sugars in nectarines.

The detection of glucose concentration is possible through the use of a coloured indicator composition of potassium permanganate ($KMnO_4$) solution and an acid, in this case sulphuric acid (H_2SO_4). A strong oxidising agent, $KMnO_4$ solution is used to convert alkenes to glycols and

[1] http://mwsu-bio101.ning.com/profiles/blogs/the-molecules-within-you-1
[2] http://www.newton.dep.anl.gov/askasci/bot00/bot00553.htm
[3] J.H.LaRue & R.S.Johnson (1989) Peaches Plumbs and Nectarines U Cal Google Books http://books.google.fr/books?id=0EEtgcbJaAIC&pg=PA163&lpg=PA163&dq=starch+in+nectarines&source=bl&ots=8lab1znGzd&sig=bjD1Nk0gCGTwj3zlbRenFlbREms&hl=en&sa=X&ei=wzo6T_C3LYfL0QWKk42QCw&redir_esc=y#v=onepage&q=starch%20in%20nectarines&f=false
[4] Matthew Rogers 14/06/11 http://lifehacker.com/5811686/ripen-fruit-faster-by-burying-it-in-rice

1

thereby quantitatively test for the presence of unsaturated bonds within a sample. The $KMnO_4$ solution is pink in colour and its discolouring demonstrates the metabolism of starch to glucose. The time taken for the pink colour to disappear is demonstrative of the concentration of glucose in the filtrate sample, e.g. the smaller the amount of time taken for the colour to disappear, the higher the concentration of glucose in the sample.

Prediction
It is expected that the nectarines exposed to the rice packaging trial will ripen the fastest. The contained environment in which they are placed will favour the retention of ethene gas around the nectarine. As a result, there will be a faster decrease in the concentration of polysaccharides (starch) and a faster increase in the concentration of monosaccharides (glucose) in this trial. The nectarines kept with the banana will also ripen faster than the control as the ethane produced by the banana will supplement that produced by the nectarines themselves.

Method

Materials
- 36 nectarines
- 12 bananas
- Snap lock bags, plastic containers
- Basmati Rice (approximately 3kg)
- 560ml Sulphuric Acid 1M (H_2S0_4)
- 230ml Potassium Permanganate solution 0.01M ($KMnO_4$)
- Knife, cutting board, food processor, sieve
- Stop watch
- Syringes - 3ml, 5ml and 10ml
- 4x 750ml beaker (each repeat)
- 12x 50ml beaker (each repeat)

This experiment aims to determine how ethene gas affects the concentration of glucose in nectarines. In order to come to a conclusion, two common methods of fruit ripening, i.e. banana packaging and rice packaging, were tested together with a control. The methods below correspond to these different conditions.

Due to the subjective nature of the 'end point' of the solution, i.e. when the pink colour disappears and the stop-watch is stopped, it was decided that measures should be taken to eliminate as much as possible this error. On each day of the different conditions (banana, rice and control), 4 nectarines were pulverised and effectively, tested. The filtrate of each nectarine was tested three times. This was done so as to eliminate any error that might be associated to the - stirring of the solution and avoid disparity in the results.

On Day 1 of the experiment the following were set up:
(a) one banana and one nectarine were placed into a snap-lock bag. The air inside the bag was removed and the bag was sealed
(b) one nectarine was placed into a plastic box. The container was filled with rice until the nectarine was fully covered and the box was sealed
(c) one nectarine was placed into a snap-lock bag. The air inside the bag was removed and the bag was sealed.

This was repeated in four trials for each treatment.
One untreated nectarine was retained on Day 1 to establish the initial glucose levels.

Paul Billiet 21/7/13 5:16 PM
Comment [5]: Ex safety needs to be considered (see page 4)

Paul Billiet 21/7/13 5:17 PM
Comment [6]: Ex Does not consider the presence of other organic molecules that may get oxidised.

Paul Billiet 21/7/13 5:18 PM
Comment [7]: Comm typo? Elsewhere ethene is used correctly.

Paul Billiet 21/7/13 5:19 PM
Comment [8]: Ex Considers limitations

Paul Billiet 21/7/13 5:19 PM
Comment [9]: Ex Repeats during the runs are OK but only one initial trial.

Paul Billiet 21/7/13 5:21 PM
Comment [10]: Ex Sufficient trials during the runs considering the manipulation required in this investigation

Paul Billiet 21/7/13 5:21 PM
Comment [11]: Ex Weak. This ought to have been trialled more than once.

The fruit were left for 3, 5 or 7 days in room temperature conditions. At the end of the period the nectarines were removed and qualitative observations and measurements of the glucose levels were made in the following way.

1. The flesh of the nectarine was removed and placed into a food processor. 500ml of distilled water were then placed in the same processor and pulsed for 30 seconds. The liquid was filtered, through a sieve, into a 750ml beaker.

2. 10ml of the nectarine filtrate was placed into a 50ml beaker. In addition to this, 2ml of $KMnO_4$ solution and 5ml of H_2SO_4 solution were added into the beaker simultaneously. The stopwatch was started immediately. The solution was swirled in a constant motion and at a constant speed.

3. When the pink colour of the solution had disappeared, the stopwatch was stopped and the time taken was recorded.
   This was repeated three times from the filtrate from each nectarine.

Paul Billiet 21/7/13 5:21 PM
Comment [12]: Ex Considers factors that may influence data collection

Paul Billiet 21/7/13 5:22 PM
Comment [13]: Ex Considers factors that may influence data collection

Variables

Variable	Identify variable	How to control variable
Independent	Conditions that the nectarines are exposed to, i.e. banana packaging, rick packaging and controlled environment	
Dependent	Time taken for the pink colour of potassium permanganate solution to disappear (demonstrative of glucose concentration)	
Controlled	Source and age of nectarines	All the nectarines were picked on the same day and sourced from the same supplier. When chosen, it was observed that they were of similar colour, size and firmness.
	Source and age of bananas	All the bananas were picked on the same day and sourced from the same supplier. When chosen, it was observed that they were of similar colour, size and firmness.
	Indicator composition	Remained constant. The ability of $KMnO_4$ solution to react with impurities meant that the same solution had to be maintained throughout trials.
	Same concentration of $KMnO_4$ and H_2SO_4	Ensures consistency. Pour a standard solution at beginning of experiment and use throughout
	Initial concentration of glucose	One nectarine was tested and used as an initial value. This value was used across all my trials.
	Nectarine sample	The entire nectarine flesh was pulverized to a filtrate on all repeats.
	Judgement of end point	The 'end-point' of the experiment had to be decided on. Therefore same person had to conduct the experiment to ensure valid results.
	Constant temperature	Temperature affects enzyme activity, i.e. will affect the rate of npening. Conduct experiment in closed environment.
	Closed environment	Mold and other microorganisms require oxygen to grow, therefore, restricting the amount of oxygen in samples will restrict the development of mold.

Paul Billiet 21/7/13 5:22 PM
Comment [14]: Ex Good appreciation of the controlled variables. Considers factors that may influence data collection.

Risk Assessment

All apparatus was labelled with relevant information (name, date class nature of materials and experiment)

All unnecessary materials were cleared away from the work space.

Glassware is fragile it was used towards the centre of the bench with stable supports.

Sharp cutting tools and the blender were used with care.

Electrical apparatus

The connections of the balance, magnetic stirrer and blender, were kept away from running water and trailing cables were avoid

Spills were cleaned up

Chemicals

Sulphuric acid is corrosive and toxic.

$KMnO_4$ is a powerful oxidiser and can cause fires.

Eye protection, gloves and lab jacket were worn when handling these chemicals.

Paul Billet 21/7/13 5:22 PM

Comment [15]: Ex Risk assessment carried out.

4

Results

Table showing the observations of the three methods on the ripening process

	Banana	Rice	Control
Day 1	One nectarine was used for all of the trials to ensure that the initial concentration of all the repeats was constant. All nectarines on Day 1 where firm, white/yellow in colour and had no visible mould on their surfaces.		
Day 3	Nectarines 1 and 4 showed signs of developing mould. The bananas of these nectarines were discolouring and condensation was visible inside the snap lock bags.	Nectarines were 90-100% covered by the rice. There was minimal condensation inside the box. No mould present.	No mould. No condensation. White/yellow in colour. Firm.
Day 5	All nectarines were softer. Signs of mould. White residue on nectarine 4. Flesh was noticeable darker. Condensation inside of bag.	All nectarines were mouldy, with nectarines 2 and 4 showing the largest mould colonies. White residue. Condensation inside the box. Nectarines were mostly covered by rice, one nectarine was only 75% covered.	No mould. Minimal condensation. Pinkish in colour.
Day 7	All nectarines are at least partially covered by mould and are emitting white residue.	All nectarines at least 9.0% covered in mould. The flesh is a deep brown colour. White residue.	Pink and white in colour. No mould. 'Bruising' patches (soft spots on surface).

Paul Billiet 21/7/13 5:23 PM
Comment [16]: An Good qualitative observations

Comm Concise & unambiguous table

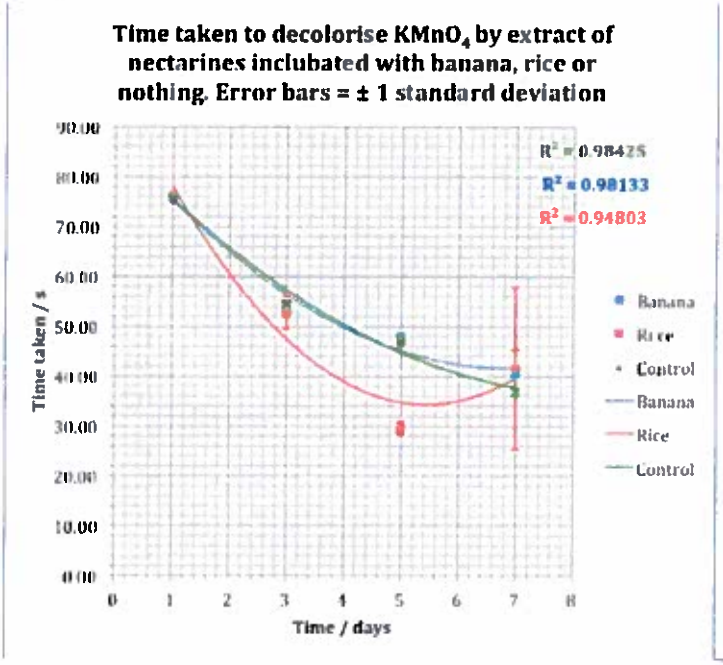
Paul Billiet 27/8/13 10:30 AM
Comment [17]: An This looks a bit more precise than is possible.

Paul Billiet 27/8/13 10:30 AM
Comment [18]: An What is this referring to? This could be clearer.

Table showing the amount of time taken for the pink colour of the potassium permanganate solution to disappear

	Time for $KMnO_4$ colouration to disappear / s ± 0.05s											
	Banana				Rice				Control			
Day	1	3	5	7	1	3	5	7	1	3	5	7
Trial 1	76.23	52.37	47.00	33.03	76.23	56.09	30.57	56.78	76.23	54.33	47.13	36.96
		52.98	48.87	34.31		54.59	31.00	57.23		54.67	46.98	36.78
		52.66	47.96	35.97		54.35	30.78	57.13		55.13	47.96	35.98
Trial 2		54.34	48.28	44.53		50.50	30.19	25.19		54.78	46.56	37.23
		55.65	47.88	45.66		49.86	28.20	26.63		54.65	46.78	37.65
		54.23	48.53	45.17		50.06	29.37	24.78		55.07	46.99	37.98
Trial 3		54.75	47.76	44.27		48.98	29.22	26.78		55.02	47.12	36.87
		54.17	48.22	43.18		49.43	30.45	25.87		55.34	47.56	36.45
		54.23	47.89	44.73		49.56	30.76	26.98		54.69	47.32	36.22
Trial 4		53.98	45.66	38.97		56.33	28.25	57.43		54.79	46.98	36.87
		54.37	46.76	39.24		57.19	27.91	56.91		54.99	47.51	36.98
		54.21	46.23	39.58		56.74	27.65	56.50		55.34	47.35	36.56
Mean	**76.23**	**54.00**	**47.59**	**40.72**	**76.23**	**52.81**	**29.53**	**41.52**	**76.23**	**54.90**	**47.19**	**36.88**
St Dev	**0.00**	**0.91**	**0.97**	**4.60**	**0.00**	**3.32**	**1.26**	**16.18**	**0.00**	**0.30**	**0.38**	**0.66**

N.B There is only one value for Day 1 as only one nectarine was used to test for the initial concentration of glucose. This value was used as the initial value (Day 1 value) for all of the subsequent trials.



Paul Billiet 21/7/13 5:23 PM
Comment [19]: An Relevant quantitative data collected

Comm Concise, unambiguous & conventions respected

Paul Billiet 26/7/13 9:55 AM
Comment [20]: An Appropriate, successful processing. Uncertainties considered

Comm Processing can be followed. Correct notation and conventions used.

Paul Billiet 21/7/13 5:25 PM
Comment [21]: An As stated in method this is weak

Paul Billiet 21/7/13 5:25 PM
Comment [22]: Comm Concise presentation of processed data. Processing can be followed (colour coded R^2 values). Unambiguous (title, key used, colour code used). Correct notation and conventions used.

An Appropriate processing. R^2 values. Uncertainties presented as trend line, error bars and R^2 values

6

t-test

The data for the banana treatment and the control do not show much difference for the time taken except after 7 days. The control looks as though it has a higher glucose content than the banana treatment at Day 7. I decided to see if this difference was significant.

Paul Billiet 21/7/13 5:26 PM
Comment [23]: An Appropriate method of analysis

Null Hypothesis = there is no difference between the results for the banana treatment and the control on Day 7

Alternative Hypothesis = There is a difference between the results for the banana treatment and the control on Day 7

t-test equation

$$t = \frac{|\bar{x}_1 - \bar{x}_2|}{\sqrt{\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}}}$$

$t_{calc} = 2.93$

For p = 0.05 using a two tailed test

$t_{crit} = 2.07$

Paul Billiet 21/7/13 5:26 PM
Comment [24]: Comm Processing can be followed

There for there is a significant difference the alternative hypothesis is retained the null hypothesis is rejected. However, this difference is not great, it is only significant to p = 0.01

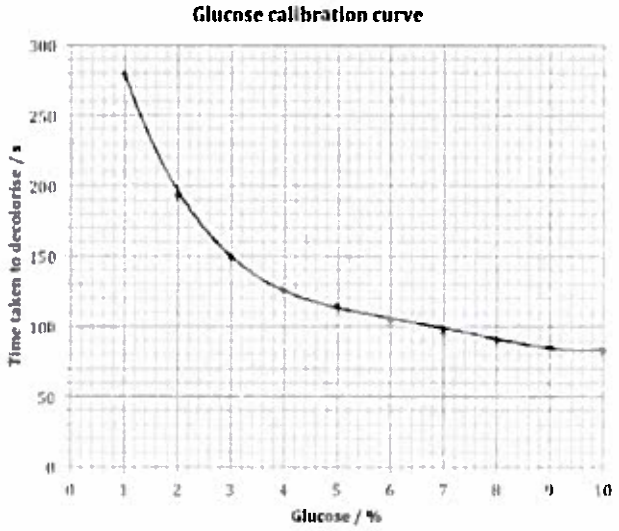
Paul Billiet 21/7/13 5:26 PM
Comment [25]: An Processing successful

Standard Reference Curve for Glucose Concentration

Paul Billiet 21/7/13 5:26 PM
Comment [26]: Comm Correct notation and conventions used

Glucose calibration

Glucose / %	Time taken / s ± 0.05s
1	280.00
2	194.00
3	150.00
4	126.00
5	115.00
6	105.00
7	96.00
8	91.00
9	87.00
10	83.00



Unfortunately the data obtained was outside of the range of the standard curve so curve could not be used to obtain an estimate of the glucose content of the filtrate.

Error and Limitations

It was acknowledged that the method for this experiment contained certain flaws and that the results obtained from the trials were subject to error. Error-reducing methods were implemented where possible.

Uncertainties were accounted for and are recorded below:

Identify uncertainty	Degree of uncertainty
Stopwatch	Reaction time ± 0.05 s
3ml syringe	± 0.1ml
5ml syringe	± 0.1ml
10ml syringe	± 0.2ml
Beakers	± 1.0ml

Because the glassware used in the experiment was not altered from trial to trial, the level of uncertainty in each trial would have remained constant. Care was taken to measure exact values, for example the amount of water added to the food processor and the volume of sulphuric acid, potassium permanganate solution and nectarine filtrate added to each trial. The stopwatch would have caused the greatest amount of uncertainty in the method as it relied on the reaction time of the person conducting the experiment. While the observer was constant throughout all of the trials, a number of different factors could have affected how quickly the stopwatch was started/stopped and subsequently, the time that was recorded. In improving the method, the 'end-point' could be objectively tested for using colorimetric methods. A standard solution could be passed through the colorimeter and the time taken for the solution to reach a certain percentage of light absorption recorded. Each trial would be tested for in a similar way.

Paul Billiet 21/7/13 5:27 PM
Comment [27]: Comm Context unambiguous

Paul Billiet 21/7/13 5:27 PM
Comment [28]: An Uncertainties considered

Paul Billiet 21/7/13 5:27 PM
Comment [29]: Comm Correct notation and conventions used

Paul Billiet 21/7/13 5:28 PM
Comment [30]: Ev Considers uncertainties and their impact. However it is not so much the experimenter's reaction time as the ability to judge when the fading pink colour has disappeared that will influence the results.

Paul Billiet 21/7/13 5:28 PM
Comment [31]: Ev Sensible realistic improvement

8

Potassium Permanganate, which was used as the indicator solution for this experiment, is a strong oxidising agent. With the ability to convert alkenes to glycols and thereby detect the presence of unsaturated bonds in a solution, the potassium permanganate could have reacted with impurities in the nectarine filtrate. In such a case, this would have affected the results considerably as the time taken for the pink colour of the potassium permanganate solution to disappear might not have been just testing for glucose. Thus the person conducting the experiment was in reality testing for another variable, the metabolism of impurities in the filtrate, which had not been accounted for in the method. In order to reduce this error, another indicator solution, which does not react with impurities to the same extent as potassium permanganate, could be used, for example iodine solution. Deep blue in colour, iodine solution detects the presence of starch in biological samples. Recognising that starch hydrolyses into glucose molecules, iodine could be used to show the concentration of starch in the nectarine filtrate, diminishes with the ripeness of the fruit. Alternatively a specific glucose test such as that used by diabetics could be used.

In the method, it was decided that each individual fruit should be tested three times, i.e. the time it took for the pink colour of potassium permanganate solution to disappear when placed with the filtrate was tested three times using a constant solution. Due to the subjective nature of the 'end-point' test, where we look for a change in colour to indicate the metabolism of carbohydrates to glucose, testing each solution three times limited any error that might be associated to the stirring of the solution and minimised the possibility of outliers in my results.

Each repeat was independent of one another, i.e. the nectarines from Day 3 and Day 5 trials had no relation to one another. A variety of different factors, which were not accounted for in this experiment and which could have been present in the repeats, for example the presence of pesticides and artificial ripening agents, or a former exposure to ethene gas, could have influenced the results. In effect, this meant that the method relied on commonalities between all of the nectarines in determining a relationship between the production of ethene gas and glucose concentration. The standard deviations remain reasonable except for the rice packaging treatment on Day 7. In general the standard deviation increased with the duration of the ripening. This might be expected as the fruits will vary at slightly different rates.

The abscission zone, or the region the closest to the stem of the fruit, has been shown to contain higher concentrations of glucose[5]. In order to minimise this factor, when pulverising the nectarines into a filtrate, the person conducting the experiment made use of all of the flesh of all the nectarines. This meant that the variation of glucose concentration within the fruit would remain constant throughout the experiment.

The biodegradation process, whereby microbes chemically digest materials, was one of the largest sources of error in this experiment. Mould, which develops as a result of an excess of moisture in an environment, was observed on all nectarines in the banana and rice trials after Day 5. The extent to which the propagation of mould had on the results can be seen in the calculated standard deviation values for the rice packaging trial. Day 7, in particular, had a massive standard deviation (16.18s), indicating that there was an enormous spread of data. Furthermore, because chance was a major factor in these results, they are not reliable and could probably not be reproduced again. The reproduction of microorganisms is affected by temperature. Therefore, the maintenance of a constant and relatively low (around 15°C) temperature would restrict the development of microorganism reproduction without significantly affecting the temperature required by the ripening process (remembering that the enzymes

Paul Billiet 21/7/13 5:29 PM
Comment [32]: Ev an important source of error identified and its significance is assessed.

Paul Billiet 21/7/13 5:29 PM
Comment [33]: Ev Logical suggested improvement. It will be specific to falling starch levels rather than rising glucose levels.

Paul Billiet 21/7/13 5:30 PM
Comment [34]: Ev Could be an appropriate alternative (even if these tests are only usually semi-quantitative.

Paul Billiet 21/7/13 5:30 PM
Comment [35]: Ev Discusses reliability

Paul Billiet 21/7/13 5:31 PM
Comment [36]: Ev Considers reliability and its impact.

Paul Billiet 21/7/13 5:31 PM
Comment [37]: Ev Considers accepted scientific theory but the discussion could have referred back to the context set in the introduction.

Paul Billiet 21/7/13 5:32 PM
Comment [38]: Ev Relative impact of uncertainty considered.

Paul Billiet 21/7/13 5:33 PM
Comment [39]: Ev Evaluates the reliability of the data.

Paul Billiet 21/7/13 5:33 PM
Comment [40]: Ev Feasible modification

[5]Studies on locating the signal for fruit abscission in the apple tree. J. Beruter and Ph. Droz, Swiss Federal Research Station for Fruit-Growing, Viticulture and Horticulture, CH-8820 WadenswilSwitzerland, Accepted 8 October 1990- Available online 14 October 2003

involved in the conversion of polysaccharides to monosaccharides work within a specific and narrow temperature range). The contamination of the fruit by microbes might be reduced by making sure the fruit is thoroughly cleaned on its surface before use. A sterilisation solution might be used.

Certain measures were taken to achieve environmental controls, for example temperature and exposure to light. The experiment was conducted in room temperature conditions, with the temperature of the laboratory being recorded twice each day. It was observed that the temperature fluctuated between 28°C and 29.5°C during the day. No recordings were taken between 3pm and 8am, There would have been great variation at night, however, this could not be controlled by the observer due to practical reasons, ideally, the experiment would be left in a consistently controlled environment, for example an incubator, where a constant temperature could be maintained.

Paul Billiet 21/7/13 5:34 PM
Comment [41]: Comm These data could have been presented earlier.

Paul Billiet 21/7/13 5:34 PM
Comment [42]: Ev Suggests realistic improvement.

The standard reference curve for glucose concentration that was produced proved to be irrelevant for the data. The data obtained was outside of the range of the standard curve. It was not possible to extrapolate the standard curve to cover the range of outcomes and therefore to infer the glucose concentration arising from the experimental trials. A calibration curve using higher concentrations of glucose would have to be reproduced.

Paul Billiet 21/7/13 5:35 PM
Comment [43]: Ev Identifies weaknesses

Paul Billiet 21/7/13 5:35 PM
Comment [44]: Ev Suggests realistic improvement

Due to time constraints each trial was only repeated four times. In order to be able to draw concrete conclusions, 20 repeats would be required. This was taken into account when processing the results and it was acknowledged that any conclusions drawn from this experiment may or may not be wholly accurate.

Evaluation and Conclusion

It was hypothesised that the nectarines exposed to the rice-packaging trial would contain the highest concentration of glucose. It was thought that the rice would be conducive to the retention of ethane gas produced by the nectarines themselves around the fruit, hastening the ripening process and increasing the rate at which starch metabolised to glucose. In addition, the rice and nectarine were stored in a container from which air had not been removed. By contrast, the air had been removed from the plastic bags containing the fruit from the other two trials. It is possible that the higher concentration of oxygen in the box would have helped promote the metabolic process and the propagation of mould.

Paul Billiet 21/7/13 5:35 PM
Comment [45]: Comm typo? Elsewhere ethane is used correctly.

Bananas are used in both traditional and industrial situations to induce the ripening of fruit, due to their ethene-producing characteristics. This assertion, however, cannot be seen in the results. Whilst the bananas might have produced a small amount of ethene, on Day 7 of the experiment the control trial had a higher concentration of glucose though the results are not very different from the banana treatment though this difference is significant according to the t-test carried out on these data. The fact that the nectarines placed into plastic bags individually ripened at a faster rate than the nectarines that were placed with the bananas points to two possible conclusions. Firstly, methodological error meant that the conditions in which the bananas were placed were not conducive to the production of ethene. Or, secondly, that the nectarines used in the control trial were affected by factors that were not accounted for in this experiment, for example they contained higher concentrations of glucose at the beginning of the experiment.

Paul Billiet 21/7/13 5:36 PM
Comment [46]: Ev Refers back to context

Paul Billiet 21/7/13 5:36 PM
Comment [47]: Ev Identifies weakness. Any improvement?

It can be seen in Figure 1 that in all three of the trials the nectarines increased their glucose concentration at a similar rate from Day 1 to Day 3. We can thus assume that in this time period, the nectarines metabolised starch at a similar rate and produced similar amounts of ethene gas. It can be seen in the Qualitative Data Table that on Day 3 there were no definitive signs of mould, except on Nectarines 1 and 4 of the banana trial.

On Day 5 of the experiment, the banana and controlled trials continued to increase their glucose concentrations at a similar rate, albeit slower than the rate increase from Day 1 to Day 3. The rice packaging trial, however, had continued to increase its glucose concentration at the same rate, demonstrating a linear relationship between the concentration of glucose (y-axis) and time (x-axis). All of the nectarines subjected to these conditions were mouldy and were secreting a white residue. This was not the case with the nectarines in the banana and controlled trials, which showed little to no mould. One can deduce that it was the presence of mould that caused the sharp increase in glucose concentration. The enzymes from the mould are probably hydrolysing the starch of the nectarines.

Paul Billiet 26/7/13 9:56 AM
Comment [48]: An interpretation sound and relevant

As the nectarines in the banana and controlled trials continued to increase their glucose concentrations from Day 5 to Day 7, the nectarines in the rice packaging trial began to decrease in glucose concentration. Probably consumed by the microbes. At the same time, it was observed that all of the nectarines in this trial had become increasingly mouldy -all were at least 90% covered in mould - and that all nectarines were secreting a white residue. One possible conclusion that can be drawn from this observation is that there exists a 'threshold' whereby the increasing glucose concentration is counteracted by the increasing development of mould colonies. As large starch molecules are metabolised there will be a rise in the concentration of glucose. This process develops parallel to the growth of mould and bacterial colonies, which will feed off the increasing concentration of simple sugars and 'spoil' the fruit. From the results obtained in this experiment, it can be seen that the glucose concentration corresponding to the 29.53 seconds it took for the pink colour of the potassium permanganate solution to disappear is the highest attainable concentration of glucose. After this, the amount of glucose consumed by the microbial colonies outnumbers the amount of glucose being produced by the hydrolysis of starch, and thus a decrease in glucose concentration can be observed. As seen in all three of the trials, the development of mould before this 'threshold' does not have a significant affect on the increasing glucose concentration.

Paul Billiet 21/7/13 5:37 PM
Comment [49]: Ev Reasonable conclusion made

The only differentiating factor that could be observed in this experiment was the removal of air (oxygen) from the plastic bags. On Day 5, the controlled and banana trials possessed relatively similar glucose concentrations and in both of these trials, the air had been removed. Therefore it is unlikely that ethene gas produced by the banana was a significant factor in the conversion of starch to glucose. In the rice trial, where air was not removed from the box, the glucose concentration was significantly higher. The hypothesis that the presence of rice caused the ethene to be concentrated around the fruit does not hold up as ethene gas would equally have been retained around the fruit in the control trial. It is more likely that it was the presence of air, and oxygen in particular, that promoted both the growth of mould and the higher glucose concentration.

Paul Billiet 21/7/13 5:37 PM
Comment [50]: Ev Implications considered

Paul Billiet 21/7/13 5:37 PM
Comment [51]: Ev Valid conclusion

All of trials produced more or less the same outcome (the final values all lay within a 4 second period except Day 7 of the rice treatment). Qualitatively, all of the nectarines were observed as being rotten and covered in mould. The large standard deviations that were calculated from these results emphasised the wide spread of data around these three points and demonstrated the unreliability of the data on Day 7 of the rice treatment. The R^2 values remain high for the control and banana treatment remain high but the rice treatment R^2 is lower, reflecting the problems with these fruits.

As the nectarines were observed as being covered in mould and at this stage, it was likely that other significant chemical reactions were taking place within the fruits. The rice packaging trial had a standard deviation of 17.8 seconds, producing an error bar that encompassed all of the experimental results of the other trials (see Figure 1). The results of the experiment are in part due to processes that were not initially anticipated.

Paul Billiet 21/7/13 5:38 PM
Comment [52]: Comm The candidate is getting a bit repetitive here.

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Paul Billet 21/7/13 5:38 PM
Comment [53]: Comm Clear presentation of reference sources

Title of Investigation: Bio TSM 4 Different methods of fruit ripening and the metabolism of starch to glucose in nectarines Good

Criterion	Personal Engagement (2)	Exploration (6)	Analysis (6)	Evaluation (6)	Communication (4)	Total (24)
Achievement level awarded	2	5	5	4	3	19

Personal engagement: This criterion assesses the extent to which the student engages with the exploration and makes it their own. Personal engagement may be recognized in different attributes and skills. These could include addressing personal interests or showing evidence of independent thinking, creativity or initiative in the designing, implementation or presentation of the investigation.	
Mark	**Description**
0	The student's report does not reach a standard described by the descriptors below.
1	**The evidence of personal engagement with the exploration is limited with little independent thinking, initiative or insight.** • The justification given for choosing the research question and/or the topic under investigation does not demonstrate **personal significance, interest or curiosity.** • There is little evidence of **personal input and initiative** in the designing, implementation or presentation of the investigation.
2	**The evidence of personal engagement with the exploration is clear with significant independent thinking, initiative or insight.** • The justification given for choosing the research question and/or the topic under investigation demonstrates **personal significance, interest or curiosity.** • There is evidence of **personal input and initiative** in the designing, implementation or presentation of the investigation.
Moderators Award 2	**Moderators Comment** The purpose is clear and the candidate justifies the choice of the research question. There is evidence of considerable personal input in the design and the implementation of the investigation.

Exploration: This criterion assesses the extent to which the student establishes the scientific context for the work, states a clear and focused research question and uses concepts and techniques appropriate to Diploma level. Where appropriate, this criterion also assesses awareness of safety, environmental, and ethical considerations.	
Mark	**Descriptor**
0	The student's report does not reach a standard described by the descriptors below.
1-2	• The topic of the investigation is identified and a research question of some relevance is **stated but it is not focussed**. • The background information provided for the investigation is **superficial** or of limited relevance and does not aid the understanding of the context of the investigation. • The methodology of the investigation is only appropriate to address the research question to a very limited extent since it takes into consideration few of the significant factors that may influence the relevance, reliability and sufficiency of the collected data. • The report shows evidence of limited awareness of the significant safety, ethical or environmental issues that are **relevant to the methodology of the investigation**
3-4	• The topic of the investigation is identified and a relevant but not fully focused research question is described. • The background information provided for the investigation is mainly appropriate and relevant and aids the understanding of the context of the investigation. • The methodology of the investigation is mainly appropriate to address the research question but has limitations since it takes into consideration only some of the significant factors that may influence the relevance, reliability and sufficiency of the collected data. 3 • The report shows evidence of some awareness of the significant safety, ethical or environmental issues that are **relevant to the methodology of the investigation.**
5-6	• The topic of the investigation is identified and a relevant and fully focused research question is clearly described. 5 • The background information provided for the investigation is entirely appropriate and relevant and enhances the understanding of the context of the investigation. 5 • The methodology of the investigation is highly appropriate to address the research question because it takes into consideration all, or nearly all, of the significant factors that may influence the relevance, reliability and sufficiency of the collected data. • The report shows evidence of full awareness of the significant safety, ethical or environmental issues that are **relevant to the methodology of the investigation. 6**
Moderators Award 5	**Moderators Comment** The research question is reasonably focussed and relevant background information is provided. The source of this information is cited in footnotes. The methodology is appropriate but it probably would not result in determining the glucose concentrations that the student is after and there is not attempt to establish that starch is there initially.

2

Analysis: This criterion assesses the extent to which the student's report provides evidence that the student has selected, recorded, processed and **interpreted** the data in ways that are relevant to the research question and can support a conclusion.	
Mark	**Descriptor**
0	The student's report does not reach a standard described by the descriptors below
1-2	• The report includes **insufficient relevant** raw data to support a valid conclusion to the research question. • Some **basic** data processing is carried out but is either too **inaccurate or too insufficient to lead to a valid** conclusion. • The report shows evidence of little consideration of the impact of measurement uncertainty on the analysis. • The processed data is incorrectly or insufficiently interpreted so that the conclusion is invalid or very incomplete.
3-4	• The report includes relevant but incomplete quantitative and qualitative raw data that could support a simple or partially valid conclusion to the research question. • Appropriate and sufficient data processing is carried out that could lead to a broadly valid conclusion but there are significant inaccuracies and inconsistencies in the processing. • The report shows evidence of some consideration of the impact of measurement uncertainty on the analysis • The processed data is interpreted so that a broadly valid but incomplete or limited conclusion to the research question can be deduced. 4
	• The report includes sufficient relevant quantitative and qualitative raw data that could support a detailed and valid conclusion to the research question. 5 • Appropriate and sufficient data processing is carried out with **the accuracy** required to enable a conclusion to the research question to be drawn that is fully **consistent** with the experimental data. 5 • The report shows evidence of full and appropriate consideration of the impact of measurement uncertainty on the analysis. 5 • The processed data is correctly interpreted so that a completely valid and detailed conclusion to the research question can be deduced
Moderators Award 5	**Moderators Comment** The report includes sufficient relevant data (both quantitative and qualitative) except for the measurement of the initial glucose content where more samples ought to have been taken and it is a shame the calibration curve was not extended to include the experimental data in its range. The candidate's interpretation is a logical one given the evidence available (significant decomposition of the fruit).

Evaluation: This criterion assesses the extent to which the student's report provides evidence of evaluation of the investigation and the results with regard to the research question and the accepted scientific context.	
Mark	**Descriptor**
0	The student's report does not reach a standard described by the descriptors below.
1-2	• A conclusion is **outlined** which is not relevant to the research question or is not supported by the data presented. • The conclusion makes superficial comparison to the accepted scientific context. • Strengths and weaknesses of the investigation, such as limitations of the data and sources of error, are **outlined** but are restricted to an **account** of **the practical** or **procedural issues** faced. • The student has **outlined** very few realistic and relevant suggestions for the improvement and extension of the investigation.
3-4	• A conclusion is **described** which is relevant to the research question and supported by the data presented. 4 • A conclusion is described which makes some relevant comparison to the accepted scientific context. 4 • Strengths and weaknesses of the investigation, such as limitations of the data and sources of error, are **described** and provide evidence of some awareness of the **methodological issues*** involved in establishing the conclusion. • The student has **described** some realistic and relevant suggestions for the improvement and extension of the investigation.
5-6	• A conclusion is **described and justified** which is relevant to the research question and supported by the data presented. • A conclusion is correctly **described and justified** through relevant comparison to the accepted scientific context. • Strengths and weaknesses of the investigation, such as limitations of the data and sources of error, are **discussed** and provide evidence of a clear understanding of the **methodological issues*** involved in establishing the conclusion. 5 • The student has **discussed** realistic and relevant suggestions for the improvement and extension of the investigation. 5
Moderators Award 4	**Moderators Comment** Despite an experiment that did not turn out as expected, there is very good evidence of insightful and reflective approach resulting in a reasonably sound conclusion. The main weakness comes in the initial assumption that the test will detect glucose production only.

Communication: This criterion assesses whether the investigation is presented and reported in a way that supports effective communication of the focus, process and outcomes.	
Mark	**Descriptor**
0	The student's report does not reach a standard described by the descriptors below.
1-2	**The presentation of the investigation is unclear, making it difficult to understand the focus, process and outcomes.** • The report is not well structured and is unclear: The necessary information on focus, process and outcomes is missing or is presented in an incoherent or disorganized way. • The understanding of the focus, process and outcomes of the investigation is obscured by the presence of inappropriate or irrelevant information. • There are many errors in the use of subject specific terminology and conventions*.
3-4	**The presentation of the investigation is clear. Any errors do not hamper understanding of the focus, process and outcomes.** • The report is well structured and clear: the necessary information on focus, process and outcomes is present and presented in a coherent way. 4 • The report is relevant and concise thereby facilitating a ready understanding of the focus, process and outcomes of the investigation. 3 • The use of subject specific terminology and conventions is appropriate and correct. Any errors do not hamper understanding. 3
Moderators Award 3	**Moderators Comment** The report is well structured providing the necessary information. It could be a more concise (there is a bit of repetition). The terminology is globally correct with a few errors and the conventions are correctly applied in tables and graphs.