DOES THE VOLUME OF WATER, EFFECT THE AMOUNT OF ENERGY RELEASED BY THE COMBUSTION OF A BISCUIT?

AIM

To investigate the effect different volumes of water would have on the energy content of the biscuit and absorption of the energy released from burning a biscuit, hence absorbed by the water.

HYPOTHESIS

It is expected that larger volumes of water such as 300ml will absorb increased amounts of energy released through the combustion of the biscuit whilst smaller volumes of water such as 30ml will absorb a decreased energy from the burning biscuit, causing its temperature rise to be the highest.

INDEPENDENT VARIABLE

Volume of water used to absorb energy released by burning biscuit (mL) (quantitative, continuous)

DEPENDENT VARIABLE

Amount of energy of burning biscuit absorbed by water, determined by temperature increase (quantitative, continuous)

CONTROLLED VARIABLES

- Shape and type of can (qualitative, nominal)
- Initial mass of biscuit (quantitative, continuous)
- Type of biscuit (qualitative, nominal)
- Time given for temperature to increase (quantitative, continuous)
- Distance of burning biscuit from can containing water (quantitative, continuous)

INTRODUCTION

Aim: To investigate whether the volume of water effects the heat content produced by the combustion of the biscuit.

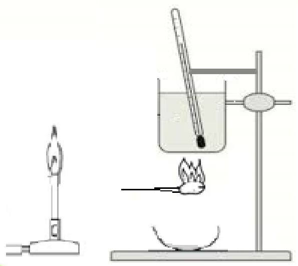
Hypothesis: It is expected that higher volumes of water such as 300ml will have a lower heat content from the combustion of a biscuit however lower volumes of water such as 30mL are hypothesised to have a larger heat content due to increased absorption of energy from the burning biscuit.

Food provides the energy we need for our activities and for the chemical reactions in our body. The energy that a particular food supplies to the body through oxidation, is almost always the same as the energy it releases when it is burnt. Whilst the original experiment aimed to measure the thermal energy released during the combustion of a biscuit, this experiment has been altered to measure the effect on energy content of a biscuit, caused by different volumes of water. This is achieved by changing the independent variable to the volume of water in the can; including volumes of 30mL, 65mL, 100mL, 175mL and 300mL, to which the energy from the biscuit is transferred (this is a qualitative, continuous variable)Through this, the energy content of the biscuit (quantitative, continuous dependent variable), absorbed by the water can be measured. For accurate and reliable results, variables such as; the type of biscuit (qualitative, nominal variable), type of can (qualitative, nominal) and distance of burning biscuit from the can (quantitative, continuous) are kept constant. The reason behind conducting this experiment is to determine whether the energy content stated on the Damora brown rice crackers packet, is correct, and whether variation in the volume of water in the can, used to measure the energy content, affects the calculations.

The energy content of a biscuit is the amount of heat produced by burning one gram of the substance, and is measured in joules per gram (J/g). In the experiment, the combustion of the biscuit is carried out underneath a can of water resulting in most of the heat released by the combustion reaction, to be transferred to the water This is because when the biscuit is burnt with a flame, the chemical energy in the biscuit is converted into the heat energy which is transferred to a known mass of water inside the can. The amount of energy transferred to known volumes of water when the biscuit is burned can be calculated using the relationship: $q = m \times C \times \Delta T$ where, q is the heat energy released by the biscuit, hence absorbed by the known amount of water, m is the mass, hence volume of water, C is the specific heat capacity of the water, 4.18 J/g˚C , and ΔT is the change in temperature that occurs, and is a constant of 10˚C in this particular experiment.

MATERIALS

- Tin can
- 2 packets of Damora Brown rice crackers
- Measuring scale
- Bunsen burner
- Matches
- Crucible
- Retort stand
- Metal tongs
- Thermometer
- 100 ml measuring cylinder
- Stop watch



METHOD

Step 1: Weigh biscuit in evaporating bowl and record its mass. Record the brand and the energy content stated on the packet.

Step 2: Use a retort stand and clamp to position a can so that its base is about 10cm above a bench mat.

Step 3: Add 30mL water to the can; measure and record its temperature.

Keep all other variables, such as type of can, type of biscuit and the distance between the can and the burning biscuit constant

Step 4: Use tongs to hold the biscuit. Set fire to it with a Bunsen burner. Quickly place the burning biscuit 2 cm below the can.

Step 5: Use the thermometer to stir the water gently. Heat the water until its temperature increases by 10 ˚C.

Step 6: Extinguish the burning biscuit and record the time taken for the temperature of water to increase by 10 ˚C.

Step 7: Allow the remains of the burned biscuit to cool. Weigh it in the same evaporating bowl and record its final mass.

Step 8: Repeat the experiemt three times and caculate average values.

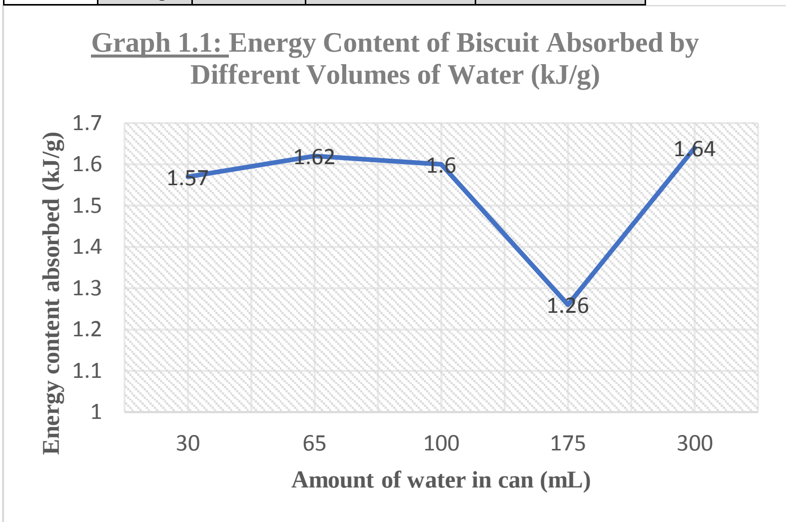
Step 9: Repeat steps 1-8 with 65ml of water, 100ml of water, 175ml of water and 300ml of water.

RISK ASSESMENT

Equipment	Potential hazards	Handling procedures
Bunsen burner	- Flame is very hot and can cause severe burns. - Gas leaks may occur if hoses of the correct sizes are not used. - Rubber hose can be easily melted by the flame of the Bunsen burner	- Avoid inhalation of fumes emitted during heating. - Return to the safety flame when not in use. - Wear lab coats/safety glasses and ensure hair is tied back so hair does not catch on fire. - Use only hoses of the correct size to ensure a comfortable fit on both Bunsen burner and the gas tap. - **Ensure clothing and arms are kept away from the fire**
Crucible	- Retains heat for a long time after exposure to high temperature.	- Discard any chipped or cracked crucibles.
Box of matches	- Box can burn violently if ignited	- Keep dry - Do not return used matches into the box. Discard used matches. - **Keep box away from Bunsen burner?**
Metal tongs	- Possibility of burns as tongs retain heat	- Use heatproof gloves if hot - **Do not touch the tip of tongs exposed to heat**
Retort stand	- Stand may topple over as centre of mass of supported object is often high.	- **Ensure clamps are tightly screwed**

RESULTS

Table 1.1: Effect of Volume of water on Energy content of Biscuit absorbed				
Volume of water	*Trial*	*Change in mass (g)*	*Change in temperature (°C)*	*Energy content (kJ/g)*
30 mL	Trial 1	1.01	10	1.24
	Trial 2	0.60	10	2.09
	Trial 3	0.80	10	1.57
	Average	0.80	10	1.57
65 mL	Trial 1	1.58	10	1.72
	Trial 2	1.72	10	1.52
	Trial 3	1.75	10	1.55
	Average	1.68	10	1.62
100mL	Trial 1	2.67	10	1.57
	Trial 2	2.59	10	1.61
	Trial 3	2.61	10	1.60
	Average	2.62	10	1.60
175mL	Trial 1	6.53	10	1.12
	Trial 2	4.55	10	1.61
	Trial 3	6.35	10	1.15
	Average	5.81	10	1.26
300mL	Trial 1	6.92	10	1.81
	Trial 2	8.41	10	1.49
	Trial 3	7.63	10	1.64
	Average	7.65	10	1.64



As can be seen in the table on the left and graph below, the volume of water inside the can, has insignificant effect on the energy content of the biscuit absorbed by the water. This is obvious as normally the energy content released by the biscuit, hence absorbed by the water seems to be consistently within the range of 1.57kJ/g to 1.64kJ/g, with minimal variation. Inconsistent to such results is the energy content of biscuit absorbed by 175mL of water, in trial 1 and 3, of 1.12kJ/g and 1.16kJ/g respectively. The change in mass for the two trials is bigger than the change in mass obtained in trial 2. A possible explanation for such inconsistent results may be the large amount of energy from the biscuit, lost to the environment in the time the biscuit is taken from the Bunsen burner to the can. This causes an increase in the change of mass of the biscuit, as a result, decreasing the energy content absorbed by the water. Hence due to loss of energy to the environment, an increased change mass occurs, resulting in a lower energy content absorbed.

DISCUSSION →716

Through conduction of the experiment, it was aimed to investigate the effect of different volumes of water on the absorption of the released energy content of the burning biscuit. This was done by alternating the volume of water inside the can, which absorbed the energy released by the combustion of the biscuit. By measuring the change in mass of the biscuit required for the temperature of the water to increase by 10°C the energy content released by the biscuit was estimated. Unlike expected, varying the volume of water appeared to have a very minimal effect on the energy content absorbed from the biscuit. Although the change in mass of the biscuit increases as the volume of water increases, the energy content absorbed by the water, appears to remain within a small range. This is due to the formula $q = (m \times C \times \Delta T)/1000$ [Taylor, N, Chemistry 2, 2017] used to calculate the kilojoules of energy released by the biscuit which is presumed to be equal to the energy absorbed by the water in the can. The value obtained is then divided by the change in mass. Therefore, despite the increased change in mass for experiments with increased volumes of water, the energy content absorbed does not vary greatly as a larger volume leads to a larger number of kilojoules of energy released by the biscuit, divided by an increased change in mass. Therefore, whilst predicted otherwise it was determined that the volume of water inside the can has no effect on the energy content released by the biscuit because a biscuit of the same brand and mass, contains the same ingredients, hence the energy content within the biscuit is expected to be the same. The water inside the can only serves to absorb the energy released by the biscuit therefore changing the volume of this water would have no effect on the release of energy by the biscuit. This can be seen in the results which show that the average energy content absorbed by the control group, with 30mL of water, 1.57 kJ/g varies only slightly to the average energy content absorbed by 65mL of water, 1.62kJ/G, the average energy content 1.60 kJ/g absorbed by 100mL of water, and also, the average energy content absorbed by 300mL of water, of 1.64 kJ/g.

Inconsistent to such results was the average energy content absorbed by 175mL of water which was a lot lower than the control group, at 1.26 kJ/g. Such results are expected to have been obtained due to errors in conduction of trial 1 and trial 3 which produced larger changes in mass than expected. An increased change in mass may have been obtained due to delay in carrying the burning biscuit from the Bunsen burner to the can. The biscuit starts burning, hence converting chemical energy into heat energy, resulting in a change of mass (as the heat energy is lost to the environment) as soon as it is ignited by the Bunsen burner. Hence delay in carrying the biscuit from the fire to the can results in an increased change in mass, and the energy released by the combustion of this mass (burnt not below the can) of biscuit is lost to the environment. This can be seen in trial 1 and trial 3 of the experiment with 175mL of water, which had a change in mass of 6.53g and 6.35g respectively. Such changes in mass, resulted in decreased energy contents of 1.12 kJ/g and 1.15 kJ/g respectively. On the other hand, results obtained in trial 2 are expected to be consistent to the other experiments with different volumes of water as a change in mass of 4.55g resulted in an energy content absorption of 1.61 kJ/g. Therefore, if the results of trial 1 ad trial 2 were to be eliminated from the experiment of 175mL, then consistent results could be produced, and graph 1.1 above, would appear to be more like a straight line due to a fairly constant dependent variable which would then be within the range of 1.57kJ/G to1.64kJ/g.

The energy content stated on the Damora rice crackers packet was 17.8kJ/g. This is almost 11 times larger than the energy contents that were obtained by conducting the experiments and calculating the energy content absorbed by the water. Such inaccurate results were obtained because the calculations of energy content assume that all the released energy from the combustion reaction is transferred from the burning food to the volume of water. However, substantial heat losses occur when the experiment is performed, therefore it should be considered that the values calculated for the energy content are a lot lower than it should be. For example, although the distance between the biscuit and the can was aimed to be kept constant, this often varied, resulting in unreliable results. This is because if the biscuit was not held directly under the can, the heat energy released by the combustion of the biscuit was more likely to be lost to the environment instead of being absorbed by the water. This resulted in less energy absorption by the water inside the can, contributing to the small energy content obtained through the calculations. Also affecting the results was the delay in carrying the rice crackers from the Bunsen burner, where it was ignited, to the can where the energy released was to be absorbed by the water. During the period of taking the burning biscuit to the can, the biscuit was burning, hence the mass was changing. The energy released during this period was released into the environment instead of being absorbed by the water. This results in a smaller energy content through calculations as the total change in mass is measured, without consideration of the mass of biscuit for which the energy is lost to the environment whilst carrying the biscuit to the can of water. It must also be considered that some energy must have been absorbed by the can, or the tongs the crackers were held with, also causing the loss of some energy. This reflects the way the body digests its food. As seen in the experiment, the oxidation of food does not transfer the food's complete energy content into useful energy required by the body. This is because chemical energy in the food can be transferred to different forms of energy, including heat energy which is lost from the body.

In further experiments, the food should be burned in an enclosed space with an ample supply of oxygen, for energy determination to be more accurate, with little energy lost to the surroundings. For example, the can could have been insulated by materials such as aluminium foil, or a bomb calorimeter, an insulated container, could have been used for the combustion of the biscuit with minimal heat loss. In further experiments, the time the biscuit is held above the Bunsen burner should also be limited to ensure that minimal change in mass of the biscuit occurs, whilst it is not under the can of water. This would increase the validity of the results. The use of a temperature probe, to measure the change in temperature may have also resulted in an increased accuracy of results. Finally, through conducting more trials, especially for the experiment which produced inconsistent results, 175mL of water, the reliability of the experiment could be increased.

ERRORS

- Distance between can and biscuit
- Distance from lighting biscuit to putting it under can
- **This reflects the way the body digests its food. As seen in the experiment, the body doesn't digest all of the food hence not all the energy in transferred into useful energy that the body requires to function.**
- **maybe talk bout how the biscuit is releasing energy**
- **like the bonds are breaking releasing energy as the biscuit is combusting**

IMPROVEMENTS

- Use temperature probe for accurate temperature calculations
- Control initial temperature of water
- Bomb calorimetry

CONCLUSION

In conclusion, the aim was achieved as the effect of different volumes of water on the energy content of the biscuit and absorption of the energy released from burning a biscuit was investigated. It was determined that the volume of water inside the can, has minimal effect on the absorption of the energy content released by the combustion of a biscuit. This is because the water, no matter what volume, only serves to absorb any energy released by the biscuit. Therefore, the hypothesis was refuted as it was concluded that larger volumes of water do not necessarily absorb more energy than smaller volumes of water.

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