Biofuel Ethanol

towards a greener and secure energy future

Science Research Project

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Abstract

This research project was conducted to determine and measure the purity of alcohol content (ethanol - biofuel) produced from fermented compost made entirely of mixed fruit, compared to mixed vegetables. The literature review reported that ethanol fuel is an alcohol made by fermenting the sugar and starch components of plant materials by using yeast. Ethanol fuel is a renewable fuel to address the environmental concerns for air pollution from vehicles.

Today's high demand for petroleum, which raised the cost of oil dramatically and the need for an alternative, environmentally friendly fuel source created the aim to investigate more about the renewable fuels. According to the literature review (Background information, p4), the fact that alcohol produced from fermented compost in its pure form could be used as a replacement for gasoline was used to research further in this area. The researched articles stated that during the process of ethanol fermentation, glucose and other sugars such as fructose in the compost are converted into ethanol and carbon dioxide. This led to create the hypothesis that compost with high content of sugar and starch should produce more pure ethanol compare to the ones with less sugar, as ethanol is nothing but the product of fermented sugar and starch components of plant materials using yeast. Therefore to conduct this experiment, at least two different composts were essential; one made entirely of mixed fruit with high content of sugar and starch, and the other one from mixed vegetables to see which one will produce purer ethanol fuel.

To determine the validity of the hypothesis the following method were used. The compost made from the mixed fruit was filtered and certain amount of fermented fruit liquid was added into the distillation pot to be heated. The steam was condensed while passing through a cooling chamber. The extracted liquid (alcohol) was collected for a duration of 10 minutes. Then the collected liquid was measured and the alcohol content was read using a hydrometer and recorded to show for potency. The experiment was repeated for three consecutive ten minutes and the data was recorded. The pot was cleaned and new liquid was added into it and the same procedure was repeated for two more times for reliability. The whole experiment was repeated for the compost made of mixed vegetables and the respective data was recorded. The collected data suggested that the same amount of liquid from the compost made of mixed fruit produce more alcohol with higher potency compared to the compost made of mixed vegetables.

The experiment proved that the fermented compost with higher content of sugar and starch produced ethanol with higher potency. The mixed fruit compost is a better candidate for producing ethanol due to its higher content of sugar and starch.

The experiment could have had different results if the duration of the composts fermentation were reduced or increased in order to have a higher content of alcohol. Additionally, the compost with mixed fruit might have given better results if fruits with higher content of sugar or vegetables with higher starch level were chosen. Also, using composts made of just one fruit such as grapes could have extended the experiment further. The outcome would provide type specific alcohol contents to be used in further scientific researches.

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Literature Review - Background Information

The Need for Alternative Fuel Sources

The need for alternative energy sources has increased. In our global society, alternative energy simply means energy that is produced from sources other than our primary energy supply: fossil fuels (McLamb, 2011, p.1). Fossil fuels produced from animals and plants that lived hundreds millions of years ago and became buried underneath the Earth's surface, then they transformed to the materials we use for fuel due to extreme pressure and temperature. We use fossil fuels to make energy. Coal, oil and natural gas are the three kinds of fossil fuels that we have mostly depended on for our energy needs, from home heating and electricity to fuel for our vehicles and transportation. Coal and gas are burnt to generate electricity and oil is used for transportation.

The problem with fossil fuels is that they are non-renewable and they are limited in supply and they will take millions of years to be replaced. This means that the reserves that we have are not going to last forever.

The other problem is that fossil fuels have brought great environmental harm. When fossil fuels are extracted and burnt, they release carbon dioxide into the air. Carbon dioxide is the most important greenhouse gas contributing to climate change leading to global warming. Combustion of fossil fuels is considered to be the largest contributing factor to the release of greenhouse gases into the atmosphere.

Furthermore the high demand for petroleum has raised the cost of oil, which the world now is struggling to afford. The OPEC oil embargo and the resulting supply shock suggested that the era of cheap petroleum had ended and that the world needed alternative fuels. (Essential energy education, 2013, p.10).

By the year 2020, world energy consumption is projected to increase by 50 percent, or an additional 207 quadrillion BTUs. If the global consumption of renewable energy sources remains constant, the world's available fossil fuel reserves will be consumed in 104 years or early in the 22nd century. (McLamb, 2011, p.1)

Therefore the need for an alternative, sustainable and economically viable resources are essential.

Renewable Energy Sources

The followings are some renewable energy sources (Bioenergy, 2013, p.1);

Hydro Energy
Hydropower is the most advanced and mature renewable energy technology and provides some level of electricity generation in more than 160 countries worldwide.

Solar Energy
The Australian continent has the highest solar radiation per square meter of any continent and consequently some of the best solar energy resource in the world.

Ocean Energy
There are two broad types of ocean energy - mechanical energy from the tides and waves, and thermal energy from the sun's heat.

Wind Energy
Wind is a vast potential source of renewable energy and is generated by converting wind currents into other forms of energy using wind turbines.

Bioenergy
Bioenergy denotes the use of organic material as a source of energy for power generation and direct source heat applications in all energy sectors. (Bioenergy, 2013, p.1). Around 10 per cent of the world's primary energy consumption comes from bioenergy. The majority of the world's bioenergy is used directly for heat production through the burning of solid biomass; only 4 per cent is used for electricity generation and another 2.5 per cent is in the form of biofuels used in the transport sector. (IEA Bioenergy, 2008, p.1).

Biofuel

Biofuels are liquid fuels, produced by chemical conversion processes that result in the production of ethanol and biodiesel. Biofuels can be broadly grouped according to the conversion processes (Bioenergy, 2013, p.1):

- First generation biofuels are based on fermentation and distillation of ethanol from sugar and starch crops or chemical conversion of vegetable oils and animal fats to produce biodiesel. First generation technologies are proven and are currently used at a commercial scale.
- Second generation biofuels use biochemical or thermochemical processes to convert lignocellulosic material (non-edible fibrous or woody portions of plants) and algae to biofuels. Second generation technologies and biomass feedstocks are in the research, development and demonstration (RD&D) stage.
- Third generation biofuels are in research and development (R&D) and comprise integrated bio-refineries for producing biofuels, electricity generation and bio-products (such as petrochemical replacements).

Biofuels have an important role to play in displacing the types of fuels the world has used in the past.

Biofuels are important for number of reasons:

- Transport is dependent on finite fossil fuels such as oil and petroleum for its energy needs so it is important that we move towards more renewable and sustainable fuels.
- Added to this, transport is the third largest emitter of greenhouse gases and biofuels can significantly reduce transport's carbon footprint.
- Finally, it is important that Australia have domestic energy security. Australia currently imports half of its liquid fuel needs and that figure is rising. It is crucial that we have our own energy supplies so that we are not dependent upon the supply and pricing dictated by world markets.
- Biofuel is much more natural than gasoline and therefore produces far less air toxic emissions, which lead to global warming.
- Since it is made from natural products, biofuel supports agriculture and lowers dependency on oil.
- Burning fossil fuels causes carbon to be added into the environment. On the other hand, the carbon from burning biofuels was already a part of the cycle, which is less detrimental to the environment

Ethanol Fuel

Ethanol is an alcohol, which is made by fermenting the sugar and starch components of plant materials by using yeast. Sugar is distilled to make ethanol. By the time the product stream is ready to leave the distillation tube, it contains highest degree of ethanol by volume. The alcohol level will decrease in the further distillation as the residue from this process, contains non-fermentable solids and water (Ethanol production process, 2013).

Ethanol has many uses: it can be diluted and used for drinking, used in in food and cooking and for other manufacturing purposes. Bioethanol or simply ethanol is also used as an alternative source to generate power. Ethanol can be used as a fuel for vehicles in its pure form as a replacement for gasoline, but it is usually blended with gasoline to improve vehicle emissions. It can be considered as a sustainable and renewable transport fuel. According to Biofuel Association of Australia (Biofuel Association, 2013), "The International Energy Agency predicts that biofuels have the capacity to displace 5.4% of the world's gasoline just by 2013. Global fuel ethanol sales are growing much faster than petrol sales." In Australia, there is support at national and state levels for a greater role for biofuels in transport. However, the Australian Government regulations limit the proportion of ethanol in petrol to 10%. Ethanol is a tool to address the environmental concerns for air pollution from vehicles.

Characteristic

Ethanol (ethyl alcohol) is a clear, colorless liquid with a characteristic, agreeable odor. In dilute aqueous solution, it has somewhat sweet flavor, but in more concentrated solutions it has burning taste. Ethanol is an alcohol, a group of compounds whose molecules contain a hydroxyl group, -OH, bonded to a carbon atom. Elcohol melts at -114 °C, boils at 78.5 °C and has a density of 0.789 g/mL at 20 °C. Its low freezing point has made it useful as the fluid in thermometers for temperatures below -40°C, the freezing point of mercury, and for other low-temperature purposes, such as for antifreeze, in automobile radiators (Chemical of the week,2013).

Fermentation Process

Ethanol has been made since ancient times by the fermentation of sugars. All beverage ethanol and more than half of industrial ethanol is still made by this process. Simple sugars are the raw material, an enzyme from yeast, changes the simple sugars into ethanol and carbon dioxide. The fermentation reaction, represented by the simple equation is actually very complex and impure cultures of yeast produce varying amounts of other substances, including glycerin and various organic acids.

$$C_6H_{12}O_6 \xrightarrow{\text{yeast}} 2CH_3CH_2OH + 2CO_2 + \text{heat}$$

glucose		ethanol		carbon dioxide		
1 kg	→	511 g	+	489 g	+	147 Kcal

Expressed in moles, the equation is as follows:

glucose	→	ethanol	+	carbon dioxide	+	heat
1 mole	→	2 moles	+	2 moles		
(180 g)		(92 g)		(88g)		(26.4 Kcal)

In the production of beverages, such as whiskey and brandy, the impurities supply the flavor. Starches from potatoes, corn, wheat, and other plants can also be used in the production of ethanol by fermentation. However, the starches must first be broken down into simple sugars. An enzyme released by germinating barley, diastase, converts starches into sugars. Thus, the germination of barley, called malting, is the first step in brewing beer from starchy plants, such as corn and wheat.

The ethanol produced by fermentation ranges in concentration from a few percent up to about 14 percent. Above about 14 percent, ethanol destroys the zymase enzyme and fermentation stops. Ethanol is normally concentrated by distillation of aqueous solutions, but the composition of the vapor from aqueous ethanol is 96 percent ethanol and 4 percent water. Therefore, pure ethanol cannot be obtained by distillation. Commercial ethanol contains 95 percent by volume of ethanol and 5 percent of water. Dehydrating agents can be used to remove the remaining water and produce absolute ethanol.

Measuring alcohol content - Hydrometer

A hydrometer is an instrument used to measure the specific gravity or relative density of liquids; that is, the ratio of the density of the liquid to the density of water. The hydrometer is shown in the pictures below while measuring the level of alcohol produced.

A hydrometer is usually made of glass and consists of a cylindrical stem and a bulb weighted with mercury or lead shot to make it float upright. The liquid to be tested is poured into a tall container, often a graduated cylinder, and the hydrometer is gently lowered into the liquid until it floats freely. The point at which the surface of the liquid touches the stem of the hydrometer is noted. Hydrometers usually contain a scale inside the stem, so that the specific gravity can be read directly. A variety of scales exist, and are used depending on the context.

Hydrometers may be calibrated for different uses, such as a lactometer for measuring the density (creaminess) of milk, a saccharo-meter for measuring the density of sugar in a liquid, or an alcohol-meter for measuring higher levels of alcohol in spirits. An alcohol-meter is a hydrometer which is used for determining the alcoholic strength of liquids. It is also known as a proof and Tralles hydrometer (named after Johann Georg Tralles). It only measures the density of the fluid. Certain assumptions are made to estimate the amount of alcohol present in the fluid. Alcohol-meters have scales marked with volume percent of "potential alcohol", based on a pre-calculated specific gravity. A higher "potential alcohol" reading on this scale is caused by a greater specific gravity, assumed to be caused by the introduction of dissolved sugars. A reading is taken before and after fermentation and approximate alcohol content is determined by subtracting the post fermentation reading from the pre-fermentation reading (Wikipedia, 2013).

Aim

To determine and measure the purity of alcohol content (ethanol) produced from fermented compost made entirely of mixed fruit compared to mixed vegetables.

Hypothesis

That a larger volume with purer alcohol will be produced from fermented compost made entirely of mixed fruit, compared to mixed vegetables. According to literature review Ethanol fermentation is the biological process by which sugars such as glucose, fructose and sucrose are converted into cellular energy and thereby produce ethanol and carbon dioxide. Therefore the fruit compost with higher content of sugar should produce higher content of alcohol.

Materials and Cost

Materials	Cost	
• Scale for measuring the fruit and vegetables	From home	
• 10kg of Fruit (Apple, Mango, Pear, Strawberry, Nectarine – 2kg each)	Free from market	
• 10kg of Vegetables (Eggplant, Squash, zucchini, Potato, 2.5 kg each)	Free from market	
• 15L of water	From home	
• 2 compost bins	$15	
• Portable gas stove	From home	
• Gas cylinder	$5	
• Distillation Pot	$15	
• Cooling Chamber Cylinder Copper legs Thin tube	$20	Copper
• Strip of Rubber and three clamps (To prevent steam from escaping)	$5	
• Measuring cup	Already owned	
• Sieve	Already owned	
• Hose for inlet and outlet connection	Already owned	
• Hydrometer (To measure the purity level of alcohol attained)	$19.85	

Total Cost: $79.85 (some materials were used from home)

Variables

In this experiment, below is the list of controlled, dependent and independent variables:

Controlled Variables

- The amount of fruit and vegetable mixes for the compost.
- The size of the compost bins.
- The amount of water added into the compost bin for fermentation.
- The temperature of water added into the compost bin.
- The location of the compost bins during the fermentation.
- The temperature and light during fermentation.
- The duration of fermentation.
- Mixing the slush on a daily basis for both composts.
- Using same sieve for filtering the composts.
- Collect the same amount of liquid from filtering both composts.
- The heating pot and the same number of clamps.
- The gas cooker.
- New gas cylinder for both experiments.
- Heating energy.
- Hose for cooling chamber.
- Pressure of water going through the cooling chamber.
- Duration of each experiment.
- The measuring cylinder used to collect alcohol.
- Same hydrometer.
- Same bottle for measuring the purity of the alcohol (Diameter and size).
- Measuring the purity at room temperature.

Independent Variable

- Type of compost (Fruit and Vegetable Mix).

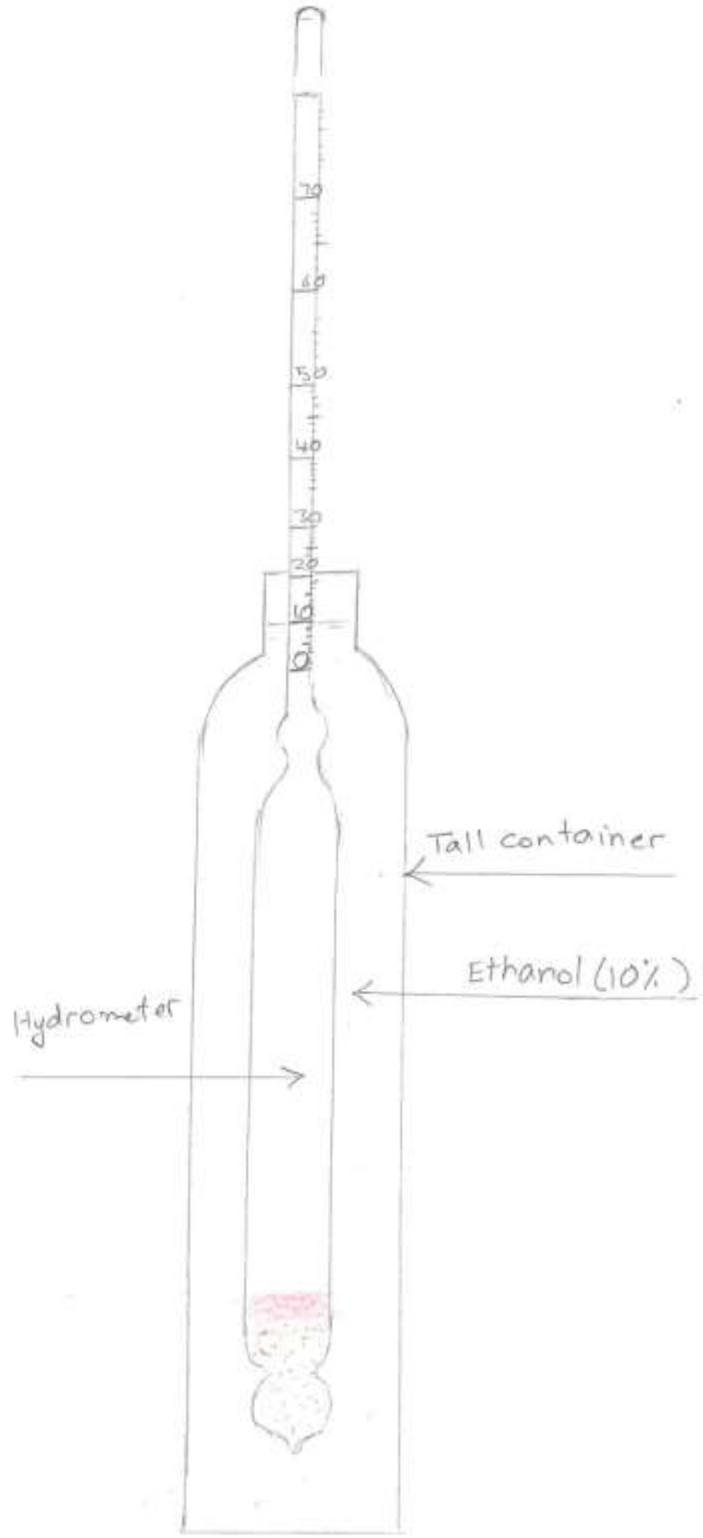
Dependent Variable

- The purity of the alcohol attained.

Method

1. 10kg of fruit and vegetables were weighed and placed into two identical containers with capacity of 60L, each which were labelled accordingly.
2. 15L of tap water with the same temperature was added into each container.
3. The fruit and vegetables were kept at room temperature out of direct sunlight for 3 weeks to ferment.
4. The composts were mixed on a daily basis for 5 min each time.
5. The fermented fruit and vegetable were filtered to form liquid slurry as shown in the diagram.
6. The apparatus for this experiment was built which is explained below and shown in the diagram.
7. The apparatus for this experiment was set up according to the diagram and was run for a test experiment to assure its functionality.
8. 2L of the fruit liquid was added into the distillation pot. The distillation pot was sealed with rubber and three clamps were placed on the lid to prevent steam from escaping.
9. The inlet and outlet nipple screws on the water-cooling chamber were attached to the hoses.
10. A portable gas stove was placed under the pot to provide the required heat for the liquid to evaporate.
11. The gas stove was turned to its highest level to maintain the temperature as one of the controlled variables. A new gas cylinder was used for each compost to assure that the heating energy was kept identical.
12. When the first sign of steam was noticed the cold inlet tap was turned on and was kept running with a constant flow for the duration of the experiment (10 min). This allowed the steam to be condensed and turned back to liquid by passing through the cooling chamber. The flow of water remained constant during the experiment as another controlled variable.
13. The extracted liquid was collected into a measuring cup.
14. The gas stove was turned off.
15. The collected liquid was left until it reached room temperature.
16. The amount of collected liquid was measured and recorded.
17. The collected liquid was transferred to a tall container.
18. The liquid was measured for alcohol content using a hydrometer to show for potency.
19. The results were recorded in a table.
20. The liquid was collected for the duration of 30 minutes in order to collect three sample products in three consecutive 10 minutes intervals.
21. The procedure (steps 8 to 20) was repeated two more times for fruit compost with the same controlled variables. This repetition was to ensure the results were accurate as mistake effects would be lessened.
22. The experiment was repeated from step 2 to 21for the vegetable content with the same controlled variables.

Scientific Diagram - Measuring Purity of Alcohol Content Using Hydrometer



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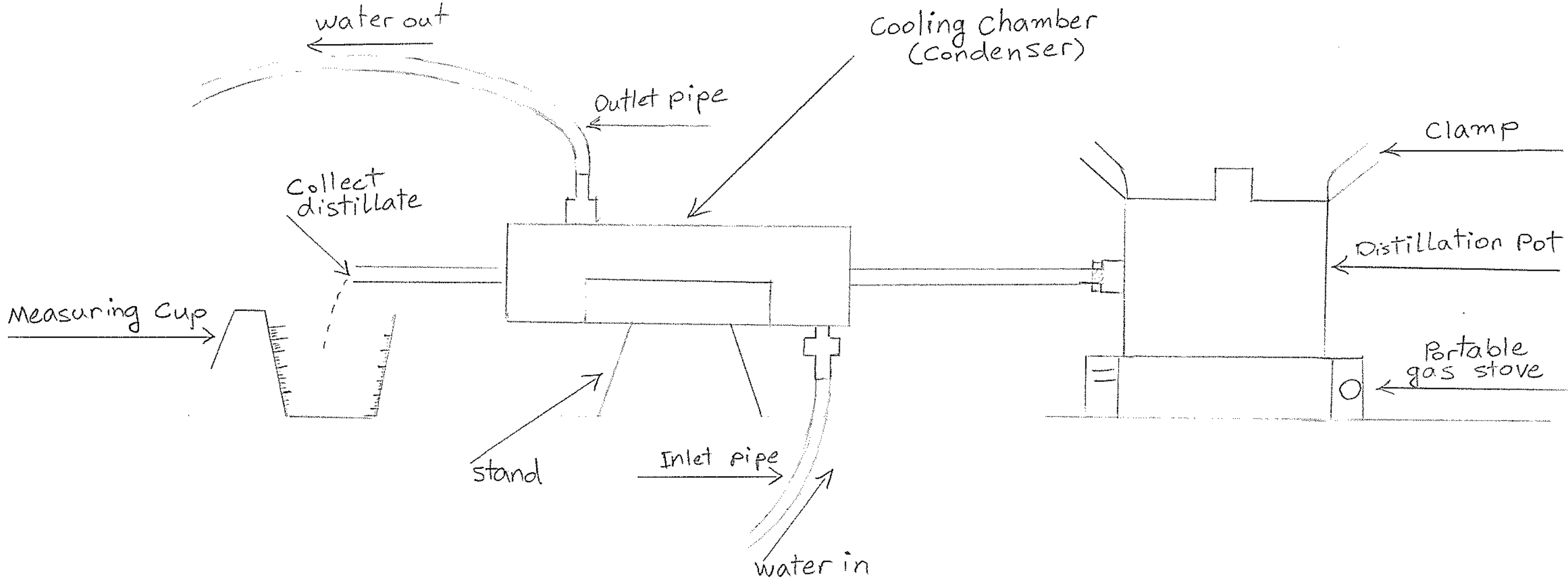
Making the distillation still

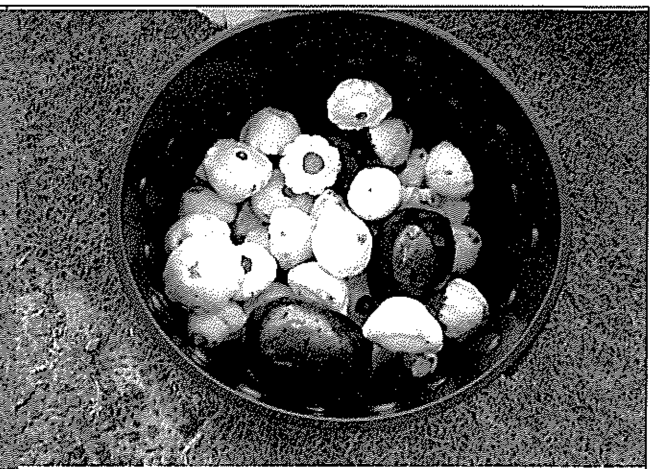
1. A 65mm diameter pipe was cut to 300mm length for the cooling chamber.
2. The ends of the cooling chamber were capped by soldering both ends.
3. Holes were drilled on the body of the chamber at the opposite ends of the cooling chamber at 180 degrees apart for the inlet and outlet.
4. Inlet and outlet pipes were soldered to the drilled holes.
5. The centre at both ends of the cooling chamber were drilled for the inner pipe to run through.
6. A 12.5 mm, diameter pipe was cut to 720mm length for covering the both end of the cooling chamber.
7. A hole was drilled on the side of the aluminium pot.
8. A nipple screw was placed in the drilled hole of the pot.
9. The stand was made by soldering four copper legs to a semi circle tube.
10. The stand was placed under the still to see whether it would fit perfectly.
11. A thin strip of rubber was glued around the inner part of the lid of the pot, to create a perfect seal to prevent steam, form escaping.
12. The cooling chamber was connected on the stand to the pot, which is on the gas cooker.
13. The pot was filled with 2L of normal water to test whether the apparatus works.
14. The inlet and outlet nipple screws were attached to the hoses.
15. Tested to see whether water would turn to steam and then condense back to water, and to discover whether no steam would escape and all the soldered parts were intact.

Scientific Diagram _ Distillation Still



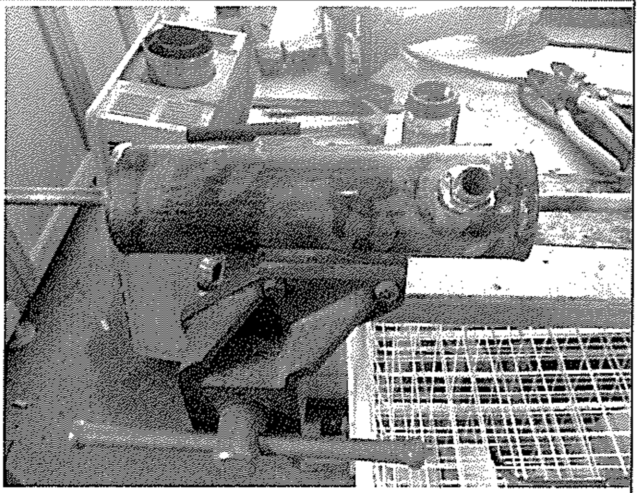
Pictures of the Experiment

Fruits and Vegetables for creating the compost



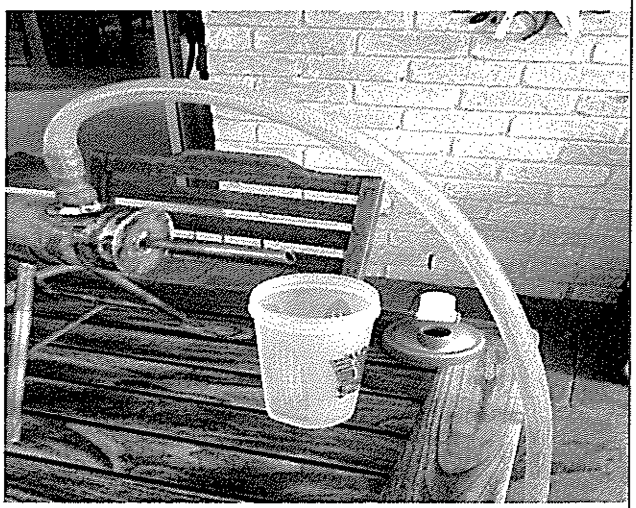
Vegetables mix in the compost bin

Cutting the copper tube for the cooling chamber

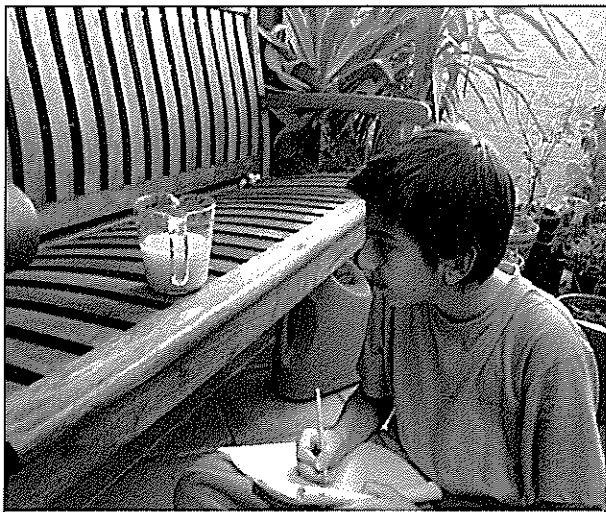


The cooling chamber

Test run of the components by using water to see whether the cooling chamber works

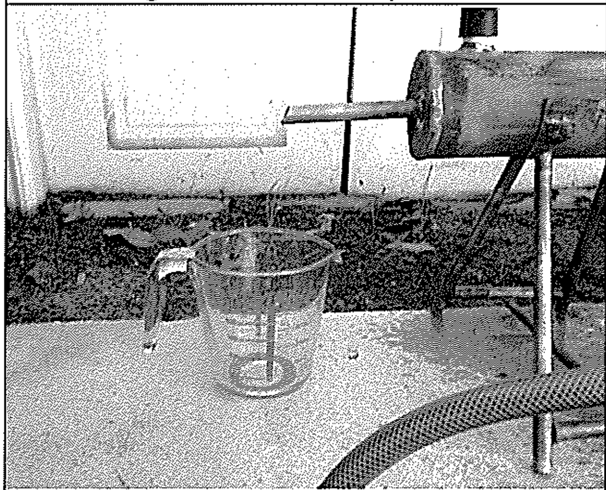


The cooling chamber worked successfully as 50mL was extracted from evaporating the initial test water



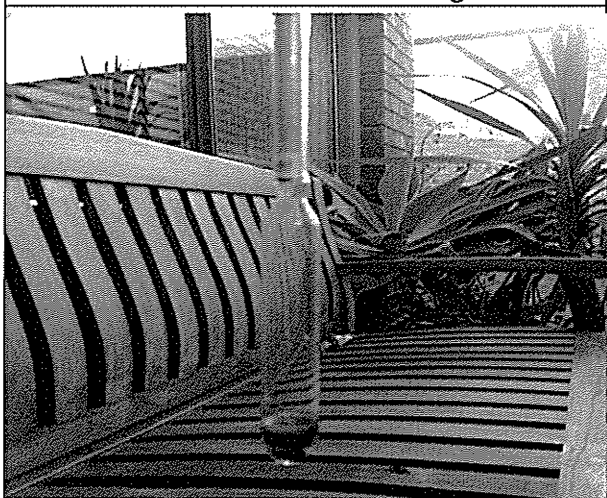
Measuring filtered fruit compost mix.

Experiment in progress.

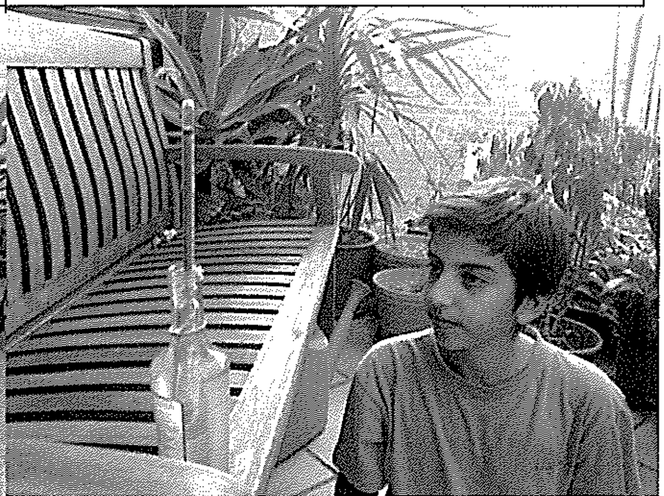


Alcohol collected from the cooling chamber

Extracted 250 mL of alcohol



Hydrometer



Measuring level of alcohol content

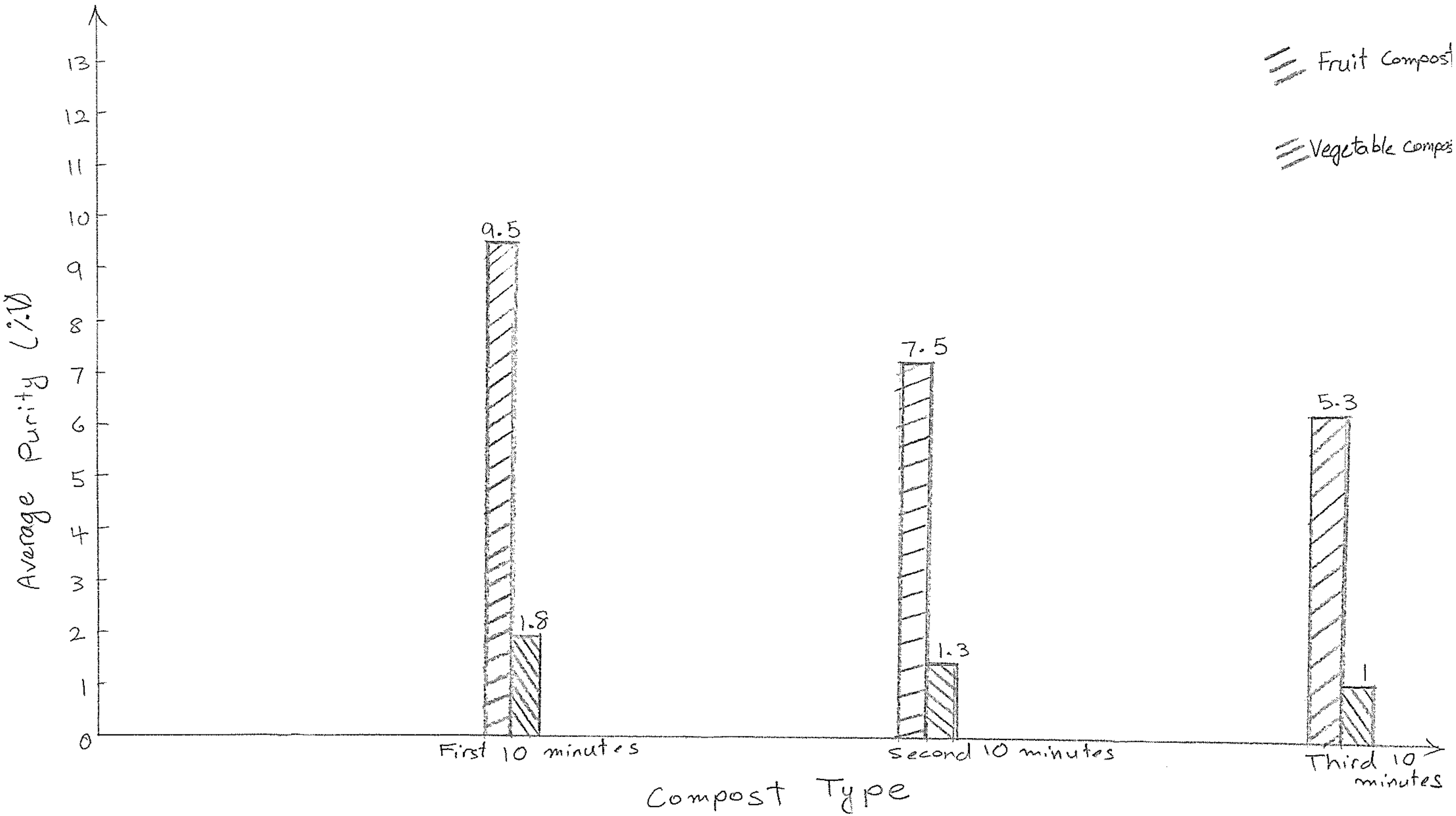
Results

The extracted results are shown in the below table.

Alcohol level in the extracted alcohol content from fermentation of fruit/vegetables				
Trial	Fruit Compost		Vegetable Compost	
	Amount Extracted (mL)	Alcohol Purity (%V)	Amount Extracted (mL)	Alcohol Purity (%V)
Trial 1 - First 10 minutes	280	10	300	2
Trial 1 - Second 10 minutes	240	8	270	1.5
Trial 1 - Third 10 minutes	260	5	250	1
Trial 2 - First 10 minutes	300	9	250	2
Trial 2 - Second 10 minutes	290	7.5	250	1.5
Trial 2 - Third 10 minutes	270	6	260	1
Trial 3 - First 10 minutes	290	9.5	270	1.5
Trial 3 - Second 10 minutes	280	7	280	1
Trial 3 - Third 10 minutes	310	5	270	1
Average First 10 minutes	**290**	**9.5**	**277**	**1.8**
Average Second 10 minutes	**270**	**7.5**	**267**	**1.3**
Average Third 10 minutes	**280**	**5.3**	**260**	**1**

Data Graph : Bar Graph

Purity of ethanol content produced from fermented compost made of mixed fruit, compared to mixed vegetables during distillation



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Risks – Hazards – Precautions

The risks were examined and documented in two different categories. The first part is the generic risks which will have impact on the outcome of the experiment and the second category is the risks and hazards to the person who conducts the experiment or people around.

Risk	Description	Reduction Plan
No alcohol extract due to fruit/ vegetable choices	The fruit and vegetable choices might not be the right ones to extract alcohol.	Choose fruit / vegetables, which contain some, sugar or starch.
No alcohol extract due to the wrong proportion of water and fruit/vegetable mix	The amount of water placed with the fruits to create the compost can play a major role in the amount of alcohol received at the end of the experiment.	The right amount of water must be placed in proportion to the amount of fruit in each compost bin otherwise the compost may become diluted and as a result there might not be much alcohol content.
No alcohol extract due to the wrong compost location and temperature	The light and temperature of the location that fruit and vegetable pots are placed for fermentation might not be right.	The pots must be placed in a place with no direct sunlight.
Overflow of compost placed into the pot	Excessive amount of filtered compost placed into the pot might overflow once it is heated.	This can be avoided by filling the pot up to its half capacity.
Burns to the hands	The initial steam passing through the cooling chamber before the alcohol begins to drip out might cause minor burns due to heat if it comes into contact with skin.	Avoid holding the hands in front of the steam or use safety gloves if needed.
Bursting of the pot due to pressure	The pot could burst due to an immense amount of pressure built up by a large amount of filtered compost in the pot.	This can be avoided by filling the pot up to its half capacity. The distillation pot was sealed with rubber and three clamps to avoid steam scaping from the pot while controlling the pressure.
Burns hands due to soldering once the cooling chamber is built	Soldering the parts of the cooling chamber together is a very dangerous task.	This task needs to be done by an adult or with supervision.
Breathing problem	Alcohol has a strong smell and some might be allergic to it and it might cause breathing issue.	Avoid close contact and use mask if required.
Irritation of face, eyes or skin	Eye, facial or skin irritation might occur if contact with alcohol.	Avoid close contacts or safety mask.

Discussion

This experiment was set up to determine and measure the purity and amount of alcohol (ethanol) content produced from fermented compost made entirely of mixed fruit, compared to mixed vegetables. The alcohol level of extracted liquid was precisely measured.

The results of this experiment showed that the compost with mixed fruit produced the highest level of alcohol content with purity of 9.5% (the first 10 min) compared to the vegetable compost with just 1.8% purity, thus supporting the hypothesis. This trend was demonstrated in the repeated attempts and similar pattern was confirmed. This observation highlighted the fact that composts with higher level of sugar and starch are a better producer of alcohol (ethanol). The outcome of this experiment also reflects those from the literature review (Bioenergy, 2013, p.1): "First generation biofuels are based on fermentation and distillation of ethanol from sugar and starch or chemical conversion of vegetable oils and animal fats to produce biodiesel. First generation technologies are proven and are currently used at a commercial scale."

The data for the experiment were first taken from measuring 2000 mL of fruit liquid filtered from the fermented compost and heated for 10 minutes. The collected liquid from distillation after passing through the cooling chamber was measured to 250mL for this duration. While the distillation was under process, further extracted liquid was collected in different containers for the next two consecutive 10-minute intervals. The results were 240 mL and 250 mL. Although the volumes of the extracted liquid (from three 10 min) were almost in the same range however the alcohol content in each one were different. The first extract had higher level of alcohol content of 10%(Trial 1) (volume %), the second container (240 mL) was 8% and the third container (250 mL) had purity of 5%. The findings of this experiment agreed with that of literature review (Ethanol production process, 2013), which stated that by the time the product stream is ready to leave the distillation tube, it contains highest degree of ethanol. This also demonstrated the fact stated in the literature review (Chemical of the week, Ethanol, 2013) that ethanol (78.5 °C) has lower boiling point than water (100°C) which means early steam contains more alcohol molecules than water molecules. The alcohol level decreased in the further distillation (the next two 10 minutes intervals) as the residue from this process contains non-fermentable solids and water. This was clearly shown in the results obtained for fruit liquid. Similar pattern of results occurred when the experiment was repeated for compost made of mixed vegetables. The alcohol content produced via distillation process was at a lower level (1.8%) compare to the fruit compost (9.5%) thus proving the validity of the hypothesis. The findings is based on the scientific fact that simple sugars are the raw material, an enzyme from yeast, changes the simple sugars into ethanol and carbon dioxide and as the fruit mix contains more sugar than the vegetable compost in results the extract from the fruit mix contains the higher level of alcohol content.

The findings of both experiments displayed in Data Graph 1 agreed with that of the hypothesis, which stated that a larger volume with purer alcohol would be produced from fermented compost made entirely of mixed fruit, compared to mixed vegetables.

Some of the experimental limitations of the experiment were that it could have used a hydrometer with written larger incremental reading lines. As when the hydrometer was put in the thin and tall container with alcohol content it floated and making it difficult to read the accurate level of purity. The experiment could have had a better distillation set in order to avoid steam escaping from the pot. This could change the amount of alcohol content during the distillation process. The consistency of heat in both experiments may have made a difference to the amount of energy required for evaporation to start. Some other limitations were that probably wider variety of samples for making different composts could have had more replications resulted in data accuracy. Human errors is another factor in this experiment, for example error in reading the purity level, in collecting the sample in a certain time span and measuring the volume.

In order to overcome these limitations, more investment needed to acquire better and more accurate equipment such as a better hydrometer to facilitate the reading of alcohol purity. A better designed distillation set to avoid steam from escaping. A better energy source to provide consistent heat required during distillation process in both experiments. Wider variety of fruit and vegetables could be used to have more replication if there was more time, which would also decrease the effect of mistakes and human errors.

One difficulty of the experiment was that to know the time duration needed for composts to be fermented as if less time was allowed it might had ended with not producing any alcohol in distillation process and if the composts were remained for a longer period then the alcohol purity level for both composts would not be distinguishable. Another was that the composts in the bin needed to be mixed regularly and that the lid had to be lifted off, allowing air (oxygen) penetrating into the compost and affecting the fermentation.

Areas of further research could be experiment with a greater variety and/or combination of fruits and vegetables. Also possibly experiment using individual fruit/vegetable with deferent level of sugar/starch content to compare the level of purity of extracted ethanol and rank them to specify type specific alcohol contents to be used in further scientific researches.

Conclusion

The aim to determine and measure the purity and amount of alcohol fuel produced from fermented compost made entirely of mixed fruit, compared to mixed vegetables was successfully achieved through the collection of data and results of the experiment. The results clearly demonstrated that the alcohol content in the compost made of mixed fruit is higher than the compost made of vegetable due to the higher level of sugar content in the fruit mix. From the collected data and results it can be concluded that the hypothesis was supported. The average alcohol content produced from fruit compost was 9.5% (first collection) compare to 1.8% for vegetable compost, which makes the compost made entirely of mixed fruit to be a better candidate for producing ethanol using fermentation process.

Log Book

6th Feb- Brainstorming of ideas for the experiment began.

7th Feb- Further brainstorming of ideas was done.

8th Feb- Further brainstorming of ideas was done.

9th to 11th Feb- Many experiments were planned, and elimination of ideas occurred.

12th to 13th Feb- The idea of extracting alcohol by fermenting and distilling compost was thought of and related research about the topic was done.

14th Feb- The Parent approval form and the 'Project Outline' Google doc was completed and submitted.

16th to 20th Feb- Research of experiment was done which included finding out what type of fruit and vegetables to place into the composts.

25th to 28th Feb- More research was conducted about how to make the cooling chamber for the experiment.

5th March- Work on Google docs was done (due at the end of the week).

6th March- More work on background information and finding valid sources for the Google doc was done

7th March- The second and third Google docs were completed and submitted.

12th March- The next Google doc was worked on and more research was done.

14th March- The hypothesis for the experiment was made.

16th to 18th March- The 'Hypothesis' Google doc was worked and submitted. Fruit and vegetable composts were created.

19th to 21st March- The 'Method Google doc was worked on and submitted, which included finalising the right amount of fruit and water to be left to ferment over a three week period.

23th March- Research was done and the equipment was bought for making the cooling chamber.

24th March – The cooling chamber was built and was connected to the distillation pot.
Each compost were mixed for two minutes each day over two weeks.

9th April- The experiment for both fruit and vegetable compost was conducted and data were recorded in a table.

11th April- The Aim, Hypothesis and Method were checked and formatted correctly.

12th April- All of the sources were cited correctly and placed into a reference list.

13th April- The graph was accurately drawn according to results attained.

14th April- The background information was extended due to more information being discovered which was not known before.

21st April- The discussion and abstract were started. More research was conducted on Ethanol fuel fact to complete the background information.

28nd April- The 'Abstract' Google doc was completed and submitted.

30th April- Last check of project was done to make sure the correct tense and information were used in the text.

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