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Production and Characterization of Bioethanol from Snot Apple (Azanzagarckeana)

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ABSTRACT
In this study, Bio-ethanol was produced from snot apple (Azanzagarckeana)) also known as Goron Tula (native name) through fermentation process. The fuel properties (characterization) such as density, specific gravity, kinematic viscosity, flash point, pour, cloud point, calorific valueand octane number of the bio-ethanol were determined and compared with that of gasoline. The results showed that snot apple (Azanzagarckeana) is a veritable source of bio-ethanol production with a percentage yield of 52%.In terms of the characterization of bio-ethanol produced from snot apple (Azanzagarckeana), the density, specific gravity, kinematic viscosity, flash point, pour point, cloud point, calorific value and octane number were found to be 799Kg/m^3, 0.799, 34.82mm^2/s, 12.6^{o}C, -8^{o}C, -6^{o}C, 20.53MJ/Kg and 108.6 respectively. It shows that the values of density, specific gravity, kinematic viscosity, pour point, cloud point and octane number are appreciably higher in comparison with that of gasoline. It means ethanol produced from snot apple can used to blend in different proportions with gasoline to run in petrol engine.

KEYWORDS: Snot apple, Bioethanol, Petrol, Characterization, Engine

I. INTRODUCTION

Energy is crucial for the sustainability of modern societies and its uses are inevitable for human survival. Energy is an essential ingredient for socio economic development and hence, is a true indicator for economic growth. However, the world relies heavily on fossil fuels to meet its energy requirementsof which in the near future it will be exhausted. These forms of energy (Petroleum, natural gas and coal) at present provides almost 80% of the total global energy demand while renewable energy (solar, hydro, biomass and geothermal) and nuclear power contributes only 13.5% and 6.5% respectively of the total energy needs [1]. At this point, energy systems employed for power generation are no doubt overburdened and will be unable to survive with the future energy requirement. The huge quantity of energy being consumed across the world is having an adverse impact on the natural environment. However, fossil fuels as the main source of energy are taking their toll on the environment. It is recorded that those technologies for fossil fuel extraction, transportation, processing and their combustion have harmful impacts; and storage of petroleum fuel, spills and gas leakages causes water pollution [2].

It is undoubtedly that fossil fuels are currently the most economically available source of power for both commercial and personal uses. Though being thought to be inexhaustible, fossil fuels have been used extensively since the Industrial revolution. However, many believed that the world's reliance on fossil fuels for transport is unsustainable. Some experts also believed that the world has already reached its peak for oil extraction and production, and it is only a matter of time before natural gas and coal follow suit. In addition, fossil fuels are the main reason for global warming, a process that practically all climate scientists said we have to deal with not soon, not tomorrow, but now.

Hence, one of the most promising alternative sources of energy is the bioethanol. Bio-energy represents the utilization of biomass as a source for the production of sustainable fuels and

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chemicals [3]. Ethanol has long been considered as a suitable alternative to fossil fuels either as a sole fuel in cars with dedicated engines or as an additive in fuel blends with no engine modification requirement when mixed up to 30%. Today, bioethanol is the most leading biofuel and its global production showed an upward trend over the last 25 years with a sharp increase from year 2000 [4].

From existing literature, there are lots of other alternative fuels presently in use, these includes; methanol, methane, natural gas, propane, hydrogen, etc. Nevertheless, the remarkable fuel characteristics of ethanol distinguish it as a better candidate for automobiles. It has high latent heat of vaporization, high octane number and rating, and emission of toxic compounds on its combustion is low [5]. Thus, when ethanol and gasoline are respectively burned in correct stoichiometric ratios, they have about equal volumetric efficiency. When gasoline is burned, it produces water, carbon dioxide, carbon monoxide and other impurities such as; oxides of sulphur and nitrogen, and heavy metal. On the other hand, pure ethanol is burned to produce carbon dioxide, water and a much lower amount of carbon monoxide. Hence, ethanol will be a better replacement for gasoline [6].

The use of ethanol blended with gasoline was a subject of research in the 1980s, and it has shown that ethanol-gasoline blends were technically acceptable for existing gasoline engines. The relatively high cost of ethanol production at that time meant that the fuel could only be considered in case of fuel shortages. Consequently, there has been renewed interest in the ethanol-gasoline blends with a particular emphasis on emission reductions. An additional factor that makes ethanol attractive as a fuel extender or substitute is that is a renewable resource [7].

The production and determination of fuel properties of ethanol from Snot apple(azanzagarckeana) will formthe main thrust of this work**.** Azanzagarckeanafound in North-Eastern part of Nigeria; precisely Gombe State is called "Goron Tula". Azanzagarckeanaisadeciduousshrub;thetreecangrowtoaheightof3-15mhighdependingontheclimate condition,thestem diameteratbreastheightofupto25cm[8].The treeismulti-stemmed with straightorcrookedstem,whichis sometimesforkingfromthebase.

Plate 1: Snot Apple

Considerable quantities of Azanzagarckeana fruits are sold in local markets in Botswana, Kenya, Zambia and Zimbabwe. The species is semi domesticated in Botswana, Nigeria, Zambia and Zimbabwe where local people grow the species in home gardens and crop fields. Azanzagarckeana has been identified as one of the few plant species that should be integrated in the domestication process in farming systems in sub-Saharan Africa to support nutritional, medicinal and income security of local communities [9].

II. MATERIALS AND METHODS

2.1 Materials/Equipment

Among the materials and equipment used for this work are as follows;

1) Snot apple
2) Soxhlet extractor
3) Simple distillation apparatus
4) Heating mantle
5) Reaction flask
6) Sample chamber
7) Evaporating tube
8) Siphon

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9) Pressure tube
10) Retort stand
11) Condenser
12) Anti-bomb
13) Distilled water
14) Ice block
15) Yeast
16) Thermometer
17) Digital weight balance
18) Bomb calorimeter

2.2 METHODS

2.2.1 The Production of ethanol from snot apple (AzanzaGarckeana)

The ethanol production processes include; plant collection, chipping of material, mashing of sample into fibre like form, fermentation, filtration, distillation and characterisation. These processes are discussed as follows:

$$C_6H_{12}O_6 + \text{enzymes} \rightarrow 2CH_3CH_2OH + 2\ CO_2 \quad \ldots\ldots\ldots\ldots \quad (1)$$

The sugars (sucrose, glucose, and fructose) are transformed into ethanol by enzymes contained in an ethanologenic microorganism (yeast Saccharomyces cerevisiae).

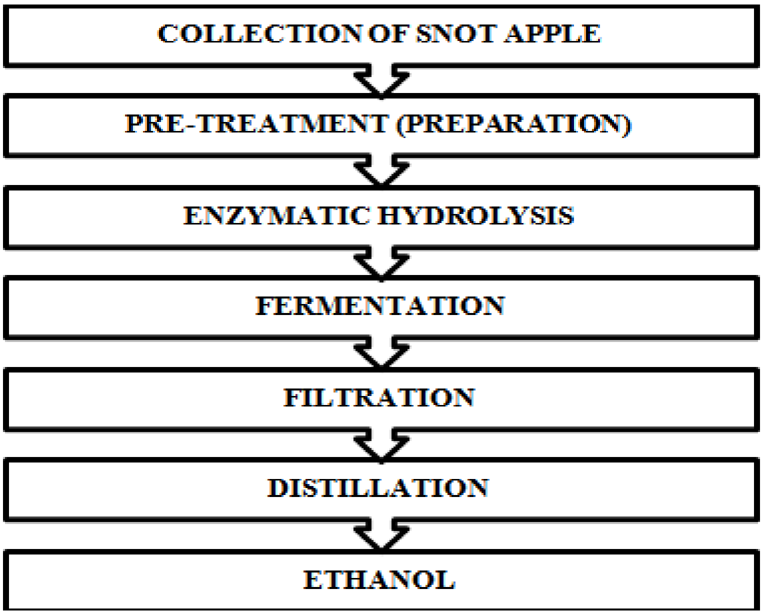

Figure 1:Flow process for ethanol production

2.2.2 Snot apple plant collection

The Snot applefruits were obtained from Tula inKaltungo LGA of Gombe state. The material was collected and packaged before it was transported down to the chemistry laboratory at AbubakarTatari Polytechnic (ATAP), Bauchi State where the ethanol extraction, production and characterization process were carried out.

2.2.3 Mashing of the sample

The sample was mashed into fibre like form in other to enhance faster diffusion of yeast. These include peeling the sample to remove the seed, followed by pounding the shell (which contains the sweetened part) to fibre form to reduce the size.

2.2.4 Sample preparation

A mass of 2.98kg of the mashed sample was placed in a bucket of 0.327kg. 6750ml equivalent to 6.75litres of water was then added to the sample. It was then mixed thoroughly to allow the water to circulate through the mixture evenly.

2.2.5 Maceration / Filtration of the sample

The solution of the mashed sample and water wereleft for one hour before being filtered to separate the chaff from the slurry. The slurry then weighed using an electronic weighing balance, and then transferred to another bucket of same weight.

2.2.6 Fermentation of the sample

The weight of the slurry was recorded to be 9.8kg after which 40g of yeast (Saccharomyces Cerevisiae i.e. baker's yeast) was added to the sample in the bucket. The sample was then stirred for thorough mixing.

The bucket was then covered and sealed tight to prevent air and any unwanted enzyme from entering the bucket and for complete fermentation of the sample to take place in the absence of oxygen. The sample was then left covered for 48hours to ferment.

2.2.7 Filtration of the fermented sample

After fermentation, the sample was filtered to separate the yeast cells and some sediment in the solution. Hence, the filtrate of the sample are dilute solution of bio-ethanol with bits of cellular and other organic compounds which can be distilled.

2.2.8 Distillation of the sample

The filtrate of the sample was then distilled by heating to78.5^{o}C in a simple distillation apparatus for six (6) hours. The heating mantle / boilers were regulated at 78^{o}C because ethanol evaporates at 78^{o}C.

The bio-ethanol was allowed to evaporate during this time and later condensed in a receiver. This process was repeated for three (3) days until the filtrate of the sample was exhausted.

In other to reduce the water content and have good percentage of bioethanol, the distillate was redistilled at a regulated temperature of 78^{o}C. After distillation, the distillate was ignited to demonstrate the presence of ethanol which can be used as fuel [10].

For the ethanol to be useful, the yeast solids and the majority of the water must be removed. This process known as distillation separates the ethanol, but its purity is limited to 95 – 96% due to the formation of low boiling water-ethanol.

The percentage yield of the bioethanol is determined by equation 2.

$$\%yield = \frac{\text{weight of ethanol}}{\text{weight of sample}} \times \frac{100}{1} \quad \text{..................} \quad (2)$$

2.3 Characterization of Bio-ethanol from Snot Apple(Azanzagarckeana) Plant

The following tests were employed for the characterization of the bioethanol:

2.3.1 Determination of density

The density of the bio-ethanol was determined by employing the ASTM D97-93 standard methods [11]. In this case, the weight of a small 25ml empty bottle was determined using an electronic weighing balance. The bottle was then filled to the brim with the ethanol sample and the weight of the bottle with the sample was determined [12]. The density was calculated using the formula below.

$$\text{Density (p)} = \frac{w2-w1}{v} \quad \text{............} \quad (3)$$

Where

W_2 = weight of ethanol and bottle

W_1 = weight of empty bottle

V = volume of the ethanol

2.3.2 Determination of specific gravity

The specific gravity (SG) of a solid or liquid substance is simply a ratio of its density to the density of water at a specific temperature.

Though, it is frequently measured using a thermometer and a hygrometer, the specific gravity calculated as follows:

$$\text{Specific gravity (SG)} = \frac{\text{density of ethanol}}{\text{density of water}} \quad \text{..........} \quad (4)$$

2.3.3 Kinematic viscosity test

Kinematic viscosity is a measure of the resistive flow of a fluid under the influence of gravity. It is frequently measured using a device called a capillary viscometer — basically a graduated can with a narrow tube at the bottom. The viscosity of the sample was determined using the falling sphere method by the nineteenth century physicist George Stokes. This exercise is one of the oldest and easiest ways but not the most accurate. It works on the principle of how fast a steel sphere falls at terminal velocity through a fluid.

The viscosity is determined if the size of the sphere and the density of the liquid (ethanol) is known.

However the formula for determining the viscosity of the sample is given below

$$\text{Viscosity } (\eta) = \frac{2(\Delta\rho g r^2)}{9V} \quad \text{...............} \quad (5)$$

Source: www.physics.info/viscosity

Where $\Delta\rho$ = difference in density between the sphere and the fluid (ethanol)

g = acceleration due to gravity

r = radius of sphere

V = terminal velocity

The sample was poured into the long tube with a stopper at the lower end to prevent the liquid from flowing out.

The distance between the two markers in the tube was recorded to be 0.45cm and the time taken for the sphere to travel from the first marker to the second marker was also recorded to be 0.92seconds. It was however ensured that the ethanol was pour above the marker so as to allow the sphere to achieve terminal velocity.

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Volume 4, Issue 1 Jan 2022, pp: 447-456 www.ijaem.net ISSN: 2395-5252

A stop watch was provided to record the time taken for the steel sphere to go down the tube when released.

2.3.4 Measurement of the calorific value

This is the energy contained in a fuel, determined by measuring the heat produced by the complete combustion of a specific quantity of it. This is usually expressed in joules per kg. The sample was poured in the capsule and fuse wire was inserted in the bomb calorimeter. The bomb then charged with oxygen from the oxygen cylinder after which it was covered. The calorimeter bucket then filled with 2 litres of water. The bomb then lowered partially in the bucket. The two ignition lead wires were then pushed into the terminals of the bomb head. The wires were oriented away from the stirrer shaft so that they do not tangle. The calorimeter cover was closed and it takes over the running of the test the calorific values of the samples read [13].

2.3.5 Flash point determination

A 150ml conical flask with a branch opening and a cork with an opening to allow the entrance of the thermometer were fitted into the flask and the thermometer put in place. The tip of the thermometer was inserted in such a way that it does not touch the bottom of the flask. The set up was placed on a hot plate. The flask filled with 5ml of bio-ethanol and heated at slow constant rate on the hot plate. The flash pointwas taken at the lowest temperature when the application of the test flame caused the vapour leaving the flask opening to ignite.

2.3.6 Pour point determination

A portion of the bio-ethanol was poured into a test tube and the mercury point of the thermometer with calibration below 1^{o}C was inserted in the test tube. The set up was inserted in a beaker containing ice and left to solidify. When the solidification was confirmed, the test tube was removed and tilted and closely observed till it started to flow.

The lowest temperature at which the sample was observed to flow was recorded as the pour point [13].

2.3.7 Cloud point determination

A portion of bio-ethanol was poured into a test tube and the mercury point of the thermometer with calibration below 1^{o}C was inserted in the test tube. The set up was inserted in a beaker containing ice. The bio-ethanol was observed closely. After some time the bio-ethanol was observed to form a cloud of gel. The temperature was recorded as the cloud point [13].

III. RESULTS AND DISCUSSION

The result of the percentage yield of bio-ethanol from snot apple plant was found to be 52% as shown in Table 1. The physico-chemical properties i.e density, specific gravity, kinematic viscosity, calorific value, flash point, pour point, cloud point and octane rating for petrol and bioethanol are presented in Table 2.

Table 1: Percentage yield of bio-ethanol

S/No	Weight of sample used (g)	Bio-ethanol Content (g)	% of Ethanol
1	2890	1540	53
2	2890	1480	51
3	2890	1517	52
Mean	2890	1512	52

Table 2: Summary of the properties of tested samples

Fuel Properties	Petrol	Bioethanol
Density (Kg/m^3)	737	799
Kinematic Viscosity (mm^2/s)	4.875	34.82
Specific gravity	0.737	0.799

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Calorific Value (MJ/Kg)	47.13	20.53
Flash Point (°C)	26.4	12.6
Pour Point (°C)	-22	-8
Cloud Point (°C)	-18	-6
Octane Number	94.2	108.6

Thephysico-chemical properties of bio-ethanol were within the limit and comparable with the conventional petrol.

3.1 Percentage ethanol yield

The bio-ethanol yield of snot apple(Azanzagarckeana) was found to be 52%. The higher ethanol yield of Azanzagarckeanais an indication that the fruit is a good source of bio-ethanol production compare to corn and cassava plant that provide and ethanol yield of about (35-42)% and (30-40)% respectively [14].

3.2 Density

The densities of petrol and bio-ethanol were obtained at a*98 temperature of 20^0C and are presented in table 2. From the results, thedensities varied from 737kg/m^3 for petrol to 799kg/m^3 for bioethanol. It was also observed that the percentage of the bioethanol is 15.3% heavier than petrol. As a result, the fuel consumption of bio-ethanol is expected to be slightly higher than that of petrol. The density of the obtained bio-ethanol is important in determining the power delivery of the fuel, a higher density for ethanol results in the delivery of a slightly greater mass of fuel and hence more power per unit mass flow. High density ensures high-energy content per unit volume and therefore good fuel economy. Higher density also has disadvantage, this is because at a higher density the flow rate of the fuel will be low and thus affect the rate of combustion. It will affect the performance of pumps and fuel spray atomization [15].

3.3 Specific gravity

The specific gravity of thebio-ethanol has a percentage of15.3% higher than petrol. Bio-ethanol has low heating value, (Almost 10% lower than petrol) on weight basis because of presence of substantial amount of oxygen in the fuel but at the same time bio-ethanol has a higher specific gravity [16].

3.4 Kinematic viscosity

The kinematic viscosity of bio-ethanol is more compared to petrol. It was observed that the bio-ethanol is more viscous than petrol. Viscosity is measure of the flow resistance of a liquid. Fuel viscosity is an important consideration when fuels are carburetted or injected system into combustion chambers by means of fuel system. If viscosity is too low, the fuel will flow too easily and will not maintain a lubricating film between moving and stationary parts in the carburettor or pump. If viscosity is too high, it may not be possible to atomize the fuel into small enough droplets to achieve good vaporization and combustion [17]. The viscosities of bio-ethanol are within acceptable range for spark ignition engine.

3.5 Calorific value

The calorific value of bio-ethanol blends was found to be 26.6% lower than petrol. However, these variations could be attributed to the chemical composition in the fuel samples, and the presence of oxygen molecules in the molecular structure of petrol and bio-ethanol. It can be seen from the table 2, that the higher the density of fuel samples the lower calorific value, and furthermore, with the increase in volumetric proportion of bio-ethanol in the blends, the calorific value decreases. Hence, these suggest that bio-ethanol density is significant effect on the calorific value of the resulting fuel mixture [18].

3.6 Flash point

Table 2shows the flash point of sample tested. It was observed that flash point for bio-ethanol is 12.6%. The flash point varies with fuel volatility, and is not related to engine performance. Never the less the flash point relates to safety precautions that must be taken into consideration when handling fuel samples. The flash point is a measure of volatility and residual alcohol in the fuel, and is the determinant of flammability classification of materials. It provides an indication of fire risk in storage under ambient condition. A fuel become difficult to handle if the flash point falls below 130^{0}C limit set by the ASTM standard [19]. It is a parameter to know the impact of hazards during travel or fuel storage. Therefore, the ethanol produced from snot apple falls below the 130^{o}C and does not have impact of hazards when travelling with it or stored in a tank.

3.7 Pour and cloud points

The values of the pour and cloud point of the bio-ethanol sample is shown in table 2. It could be seen from the results that the pour point for petrol is -22^{o}C and bio-ethanol is -8^{o}C. However, the pour point of the bio-ethanol is higher than that of Petrol. The cloud point was found to be -18^{o}C for petrol and -6^{o}C for bio-ethanol. The pour and cloud points of heavier fuels are important in view of their higher boiling range. Nonetheless, it was also noted that the pour-ability of petrol is not a problem, as it within the range of lower boiling fuel specified in the standard guideline for fuel properties. Based on these results it should be stated that the fuel produced form snot apple can be used in cold regions because of its pour-ability (16].

3.8 Octane rating

The octane rating of bio-ethanol presented in table 2, and was found to be 108.6 higher than that of petrol fuel (94.2). Higher octane ratings correlate to higher activation energies: the amount of applied energy required to initiate combustion. Since higher octane fuels have higher activation requirement, it is likely that a given compression will cause uncontrolled ignition, otherwise known as auto-ignition or detonation [20].

IV. CONCLUSION

The following conclusions are made based on the outcome of the research work:

i. Ethanol was successfully produced fromsnot apple (Azanzagarckeana) fruit also known as "Goron Tula by the locals" where the resulting glucose in the plant was converted to ethanol through yeast fermentation process with an appreciable bio-ethanol yield of 52%
ii. The physico-chemical properties of the bio-ethanol produced form Azanzagarckeanawere found to be slightly at variance with petrol.
iii. The density and specific gravity of the bio-ethanol were found to be 15.3% higher than petrol sample.
iv. The kinematic viscosity of the tested bio-ethanol sample was found to be higher than petrol
v. The pour point and cloud point of the ethanol were found to be 62.64% and 66.66% higher than petrol sample.
vi. The flash point of the bio-ethanol was found to be 46% lower than petrol.
vii. The octane rating of the bio-ethanol was found to be higher than petrol.
viii. The calorific value of the tested bio-ethanol was found to be 26.59% lower than petrol.

REFERENCES

[1]. Soetaert, W. and Vandamme, E. J. (2009). Biofuels. Wiley Series in Renewable Rosourcesed A John Wiley and Sons (Belgium: Ltd. Publications)

[2]. Munear, T. and Asift, M. (2005). Energy supply, its demand and security issues for developed and emerging economies.Renewable and Sustainable Energy Review.**1**:26-27

[3]. Fukuda, H., A. Kondo and S. Tamalampudi, (2009). Bioenergy: Sustainable fuels from biomass by yeast and fungal whole-cell biocatalysts. Biochemistry Engineering Journal. 44: 2-12.

[4]. Talebnia, F., Karakashev D. and Angelidaki, I.(2010). Production of bioethanol from wheat straw: An overview on pretreatment, hydrolysis and fermentation. Bioresour. Technol., 101: 4744-4753.

[5]. Grabys, J., Pikūnas, A., and Pukalskas, S. (2012). Influence of Composition of Gasoline - Ethanol Blend on Parameters of Internal Combustion Engines,Journal of KONES, Internal Combustion Engines. 10, pp 3-4

[6]. Fikret Y. k., Bedri Y., (2004). The use of ethanol–gasoline blend as a fuel in an SI engine, Renewable Energy 29

[7]. Walker, J. (2006). Ethanol Production from biomass.Journal on the World watch Institute and Center for American progress 7, pp. 30

[8]. Orwa, C., Mutua, A., Kindt, R., Jamnadass, R. and Simons, A. (2009). Agroforestree Database: a tree reference and selection guide version 4.0 http://www/worldagroforestry.org/af/treedb/

[9]. Alfred, M. (2017). Azanzagarckeana fruit free; Phytochemistry, Phamacology, Nutritional and primary health care applications as Herbal medicine: 11: 115-123.

International Journal of Advances in Engineering and Management (IJAEM)
Volume 4, Issue 1 Jan 2022, pp: 447-456 www.ijaem.net ISSN: 2395-5252

[10]. Nelson, D. L., Cox, M. M. (2000). Lehninger Principles of Biochemistry, 3rd ed., worth publishing, Cranbury, New Jercy USA, pp 85-86.
[11]. ASTM (1991) **ASTM Standard parts 17 and 18, American Society of Testing and Materials,**Philadelphia, Pennsylvania.
[12]. Hougen, O. A., Kenneth, M. W. and Ragatz, R. A. (1976). Chemical Process Principles, Part-1 (John-Wiley & sons, New York), pp 40
[13]. Anonymous (2015). Octane rating. Retrieved April 15, 2015, from;http://www.ethanolrfa.org/library/two :html
[14]. Uduak, G. A., Adamu, A. A., and Udeme, J. J. I. (2008). Production of ethanol fuel from organic and food wastes. Applied energy, 18, pp 19-20
[15]. Anonymous, (2007). Determination of fuel properties. Retrieved of February 9, 2015 form: http://www.chevron.com/products/prodserv /fuels/bulletin/diesel
[16]. Kheiralla, A. F., Mohamed, M. E., Mathani, Y. H., Mohammed, A. H. and Hind, I. (2003). Experimental determination of fuel properties of Ethanol/Gasoline Blends as bio-fuel for SI engine, ICMAR 2012, pp 2-3.
[17]. Hamrock, B. J. (1994). **Fundamentals of fluid film lubrication**. McGraw Hill, Inc., pp 32.
[18]. Atasie, V. N., Adinhanmi, T. F. and Ojiodu, A. (2009). Proximate analysis and physic-chemical properties of groundnut (Arachishypogaea L.)Pakistan Journal of Nutrition.**8**(2), 194-197
[19]. Emmanuel, I., Bello, T., Mogaji, S. and Makanju, A. (2011). The effects of transesterification on selected fuel properties of three vegetable oils, Journal of Mechanical Engineering Research.**3**(7), 218-225.
[20]. Yamin, J., Abu-Zaid, M. and Badran, O. (2006). Comparative performance of spark ignition engine using blends of various methods percentages with low Octane number gasoline. International Journal of Environment and Pollution.**23**(3), 336-334.

APPENDICES

APPENDIX A

Plate 2: Snot Apple ready for preparation

APPENDIX B

Plate 3: Preparing the Snot Apple for Ethanol Extraction

APPENDIX C

Plate 4: Separation of the chaff and liquid of Snot Apple

APPENDIX D

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Volume 4, Issue 1 Jan 2022, pp: 447-456 www.ijaem.net ISSN: 2395-5252

Plate 5: Extraction of Ethanol through simple Distillation Method

APPENDIX E

Plate 6: Ethanol Extracted from Snot Apple