Chemical Composition and Biodiesel Production from Snake Gourd (Trichosanthes Cucumerina) Seeds

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Abstract: ***Seeds of snake gourd plant (Trichosanthes cucumerina) was analyzed for proximate and minerals compositions. Extracted oil from the seeds was analyzed for its physicochemical properties and processed to biodiesel using base-catalyzed, batch process method. From the proximate analysis, the seeds were found to have high crude fat content; hence, its oil was investigated for use in biodiesel production. Biodiesel from Trichosanthes cucumerina oil was found to have a moderate kinematic viscosity but relatively high flash point when compared with the standards outlined in ASTM PS 121 Standards for Biodiesel.***

Keywords: Trichosanthes cucumerina, proximate, base-catalyzed, biodiesel.

1. Introduction

The proliferation of household gadgets and industrial machineries involved in the provision of basic human necessities and comfort is putting great demand on the energy sector in all societies. This demand for energy has, for a good part of modern history, been met by the petroleum industry. In fact, Professor Norris R. Shreve, once asserted that; "except for the primary production of food and clothing from our soils, no organic industry is more important to modern technical civilization than the petroleum industry"[1].

The dependence on use of petroleum-based fuels has led to great pollution of the environment, besides petroleum is a non-renewable energy resource. Therefore, the quest for a cleaner and sustainable environment has led to intensive research into alternative, cleaner, renewable and more accessible energy sources. Bio fuels, which are fuels derived from biomass, e.g. biogas, plant-derived ethanol and biodiesel have so far enjoyed much attention in this regard.

Biodiesel is fuel derived by chemically altering vegetable oil through the use of a catalyst and an alcohol by means of transesterificaton reaction. Thus, biodiesels can be referred to, chemically, as alkyl esters.

If bio fuels, especially biodiesel were to satisfy energy requirements sustainably, responsibly and profitably, it is essential to strike a balance between land use for food production and cultivation of energy crops. Thus far, inability to strike and maintain this balance has always been a strong point which critics make against full adoption of bio fuels, including biodiesel. Therefore, in order to reduce pressure on conventional food grade oil supplies, it is expedient to explore new avenues to source for oil in non-food, oil-bearing seeds. Therefore, chemical analysis of oil-rich seeds, such as those of Trichosanthes cucumerina, which hitherto were not considered as major oil crops, is important to ascertain the suitability of their oil for biodiesel production.

Trichosanthes cucumerina is a climbing herbaceous vine with 40-120 cm long fruits. The fruits are pale-green and orange when ripe. Single fruits weigh about 0.5-1 kg, and contain 40-70 seeds. One plant of a traditional cultivar may produces 6-10 fruits per year, while improved cultivars may produce up to 50 fruits per year. In West Africa, the red fruit pulp (from which the seeds are removed) is used as a kind of cheap tomato paste [2]. Little wonder then that the local name for this plant is "Tomato Elejo" in Southwestern Nigeria.

In southwestern Nigeria, large quantities of oil-rich seeds of snake gourd plant, Trichosanthes cucumerina are discarded every harvest season after the red pulp had been consumed in making soup because of little or no knowledge of new uses to which these seeds could be put. Besides the reported environmentally friendlier emissions, improved diesel engine performance, amongst other benefits of biodiesel, it is fitting to explore the possibility of using seeds of Trichosanthes cucumerina as cheap industrial feedstock for biodiesel production because of its high fat content.

Therefore, the aims of this research work were, to carry out proximate and mineral analyses on seeds of Trichosanthes cucumerina, extract oil from the seeds, determine selected physicochemical parameters of the extracted oil, produce biodiesel from the extracted oil, determine some of its physical properties and compare them with ASTM PS 121 Standards for Biodiesel.

2. Literature Survey

2.1 Oil Seeds as Energy Crops - A Brief History

Vegetable or plant-derived oils have been considered as fuels for diesel engines since the earliest days of the compression–ignition engine. In 1912 Rudolf Diesel wrote;" the use of vegetable oils for engine fuels may seem insignificant today. But such oils may become in the course of time as important as petroleum and the coal tar products of present time." The French Otto company demonstrated a diesel-cycle engine running on peanut oil at the Paris Exposition in 1900. The largest experiment using this type of fuel took place during the close of World War II when the Japanese navy, desperate for fuel, bunkered soybean oil to fire the boilers of the 65,000 tonne Yamoto, the most powerful battleship of its time [3].

In the modern world, practically all tractors and heavy duty vehicles are diesel-powered. Diesel engines have the performance characteristics that more favorably suit farming, as well as, other tough tasks and they are more reliable than spark-ignited engines. The fuel is also safer to store than gasoline. Therefore any factor which threatens the supply, price and quality of diesel fuel if of immediate concern

More recently, the quest for a cleaner and sustainable environment has led to intensive research into alternative and renewable energy sources which include bio fuels. In fact, the second most common liquid bio fuel is biodiesel, which is made primarily from oily plants (such as the soybean or oil palm) and to a lesser extent from other oily sources (such as waste cooking fat from restaurant deep-frying). Biodiesel, which has found greatest acceptance in Europe, is used in diesel engines and usually blended with petroleum diesel fuel in various percentages [4].

From the foregoing, it is obvious that no oil-bearing seed, including, those of Trichosanthes cucumerina should be spared in our quest to meet the growing energy demand.

3. Previous work

As India is deficient in edible oils, non-edible oil is the main choice for producing biodiesel. According to Indian government, policy and Indian technology effects. Some development works have been carried out with regards to the production of transesterfied non edible oil and its use in biodiesel by units such as Indian Institute of Science, Bangalore, Tamilnadu Agriculture University Coimbatore and Kumaraguru College of Technology in association with Pan horti consultants. Coimbatore. Generally a Blend of 5% to 20% is used in India (B5 to B20). Indian Oil Corporation has taken up Research and development work to establish the parameters of the production of tranesterified Jatropha Vegetable oil and use of bio diesel in its R&D center at Faridabad [5].

Rapeseed oil is the preferred oil to use for biodiesel production in most of the European countries. The reason for this is partly because rapeseed produces more oil per unit of land area compared to other oil sources, such as soy beans [6].

From the results of research conducted Dr.Ir.Robert Manurung M.Eng, a lecturer in the Department of Industrial Chemistry Institute of Technology Bandung (ITB), together with his team (Nagayama and Masanori Kobayashi Eiichi from New Energy and Industrial Technology Development Organization (NEDO-Japan):

"Jatropha oil can replace petroleum diesel to power generators. Because jatropha can be grown in almost all regions in Indonesia, the castor oil really help generate electricity in remote areas, this oil can be produced by the communities that need electricity" [7].

4. Methods Approach

4.1 Proximate Analysis

This was carried out on the blended, homogenized and refrigerated seed sample in triplicate. The determinations include; moisture content, crude fibre, ash content, crude protein, crude fat and total carbohydrates (by difference). This stage is required in order to ascertain, the crude fat content of the seed in particular and other major food classes it contains in general. The crude fat content is a reliable estimate of how much oil the seed could yield.

Table 1: Proximate Analysis of Trichosanthes cucumerina Seeds

Parameter (%)	*Result*
Moisture	5.21
Ash	2.93
Crude Fibre	1.14
Crude Fat	51.53
Crude Protein	28.59
Total Carbohydrates	10.60

4.1.1 Determination of Moisture Content

An empty evaporating dish was washed and dried in the oven, allowed to cool in the desiccator and weighed (w1). About 3g of the sample was weighed into the dish and recorded as (w2). The sample plus evaporating dish was transferred into the oven maintained at 105oC and kept there for 3 hours. The sample was then removed, allowed to cool in the desiccator and then weighed. This process was continued until a constant weight was obtained and recorded as (w3) [8].

$$\% \text{ Moisture Content} = \frac{(\text{weight loss due to dry (g)}) \times 100}{(\text{weight of sample})}$$

$$\% \text{ Moisture Content} = \frac{(w_2 - w_3) \times 100}{(w_2 - w_1)} \quad (1)$$

4.1.2 Determination of Ash

A crucible with its lid was washed, rinsed, dried in the oven and allow to cool in a desiccator. The weight of empty

crucible plus its lid, (w1) was measured using an analytical balance. About 3g of the sample was put into the crucible and covered with its lid. The new weight was taken and recorded as (w2). The crucible with its content was then transferred into the muffle furnace maintained at 550oC and kept there for about 6 hours for complete ashing. The ash obtained plus crucible was allowed to cool in the desiccator and weighed (w3) [8].

$$\% \text{ Ash Content} = \frac{(\text{weight of ash}) \times 100}{(\text{weight of sample})}$$

$$\% \text{ Ash Content} = \frac{(w_3 - w_1) \times 100}{(w_2 - w_1)} \quad (2)$$

4.1.3 Determination of Crude Fat

About 50g of the sample was weighed (w1) into a clean piece of cotton cloth. The sample was then wrapped securely in the cloth by tightening a thread around it. The wrapped sample was then immersed in the thimble of the Soxhlet extractor, using n-hexane and maintained at a temperature of 60oC. This set-up was left in this condition for up to 5 hours so that all the fat in the sample was extracted. The oil was concentrated from the oil-solvent mixture by removing the defatted sample from the thimble and distilling off some, but not all of the solvent from the mixture in the flask. This extract was then exposed to air overnight for complete evaporation of the residual solvent. In the morning, the flask with its content was weighed continuously until a constant weight (w2) was obtained. The flask was then emptied, cleaned thoroughly, oven-dried at 100oC and weighed (w3) [8].

$$\% \text{ Crude Fat Content} = \frac{(\text{weight of extracted fat}) \times 100}{(\text{weight of sample})}$$

$$\% \text{ Crude Fat Content} = \frac{(w_2 - w_3) \times 100}{(w_1)} \quad (3)$$

4.1.4 Determination of Crude Protein

Crude protein determination was carried out, using the micro-kjeldahl method. About 1.0g of the sample was weighed and transferred into the micro-kjeldahl flask. One tablet of catalyst and 10ml of concentrated H2SO4 were added to the sample inside the flask. The flask with its content was heated on a heating mantle inside a fume cupboard for 3 hours until the black solution turned colorless. The clear solution was diluted with distilled water and made up to 100ml. This was followed by distillation. 10ml of the resulting solution from the digest was measured and transferred into a distillation apparatus. Then, 25ml of 40% NaOH was added to the digested sample solution in order to make it alkaline. The cloudy nature of the sample solution after the addition of the 40% NaOH indicates that NaOH was in excess. 25ml of 2% boric acid was pipette into a receiving conical flask; to which 2 drops of mixed indicator was added to produce a pink colour solution. The distillation was carried out with all the joints tightened, making sure that the end of the delivery tube dipping below the boric acid solution. As the distillation proceeds, the pink colour solution of the receiver turned light green, indicating the presence of NH3 [9]. Distillation was continued until the distillate was about 50ml after which the delivery end of the condenser was rinsed with distilled water into the receiving flask. The third step was the titration stage where the received ammonia in the boric acid was titrated against standard 0.01M HCl. A colour change of this solution from light green back to pink due to the presence of the mixed indicator that was earlier introduced in the distillation stage indicated the end point [10]. The titre value was noted and recorded. The final step was to estimate the % Nitrogen in the sample and hence the Crude Protein by multiplying that value by the general factor; 6.25.

$$\% \text{ Nitrogen Content} = \frac{(\text{Titre value} \times M \times 0.0014 \times Df \times Cf \times 100)}{(\text{weight of sample})} \quad (4)$$

where;

M = Molarity of HCl = 0.01M
Df = Dilution factor = 50
Cf = Correction factor = 10
% Crude protein = % Nitrogen x 6.25
6.25 is the general factor of food sample.

4.1.5 Total Carbohydrates Estimation

The Total Carbohydrates content was estimated by difference. The percentage Total Carbohydrates content is equal to the sum of the percentage Moisture, Crude Protein, Ash, Crude Fibre and Crude Fat contents, subtracted from 100.

$$\% \text{ Carbohydrates} = 100 - (\%Mo + \% As + \% Cf + \% Cp) \quad (5)$$

where;

%Mo = Percentage moisture content
%As = Percentage ash content
%Cf = Percentage crude fat
%Cp = Percentage crude protein

4.2 Mineral Analysis

10ml of HCl was added to the crucible to dissolve the ash obtained from ash determination. It was then filtered through the filter paper into a 50ml volumetric flask. The solution was made up to 50ml with distilled water and kept for analysis using BUCK Scientific Atomic Absorption/Emission Spectrophotometer, Model 210 VGP to analyze the sample. The following results were obtained from the analysis;

Table 2: Some Mineral Composition of Trichosanthes cucumerina Seeds

Mineral	*Result (mg/L)*
Sodium	5.06
Potassium	110
Calcium	1.43
Magnesium	0.758
Zinc	0.082
Iron	2.028
Copper	0.068

4.3 Extraction of Oil from the Seeds

Oil was obtained from the sample in batches by means of direct solvent extraction, using n-hexane as the solvent in a Soxhlet extraction apparatus. Each batch of the sample was weighed and wrapped securely in a clean piece of white cotton cloth and immersed in the thimble of the Soxhlet extractor to which n-hexane was filled to 2/3 of the 500ml flask. The Soxhlet extractor was fitted with a reflux condenser, after which the heat source was adjusted to 60oC. This set-up was left in this condition for up to 5 hours so that all the fat in the sample was extracted. The oil was concentrated from the oil-solvent mixture by removing the defatted sample from the thimble and distilling off some, but not all of the solvent from the mixture in the flask. The oil-rich mixture was then exposed to air for complete evaporation of the residual solvent.

4.4 Determination of Physicochemical Properties of Oil

The physicochemical properties that were determined on the extracted oil sample include; Acid value, Free Fatty Acid (FFA), Iodine value, Peroxide value, Saponification value, Unsaponifiable matter, Colour, Relative density (Specific gravity), pH, Smoke point, Flash point, Fire point, Viscosity and Refractive index.

Table 3: Physicochemical Properties of Trichosanthes cucumerina Seeds Oil

Parameter	*Result*
Acid value	2.40
Free fatty acid (FFA)	1.21
Iodine value	34.27
Peroxide value	6.87
Saponification value	317.27
Unsaponifiable matter	1.46
Colour	Greenish-brown
Relative density @ 25oC	0.92
PH	5.83
Smoke point (oC)	73.00
Flash point (oC)	234.00
Fire point (oC)	283.00
Viscosity (centipoises)	276.40
Refractive index	1.48

4.4.1 Determination of Acid Value

About 1g of the extracted oil was weighed into 250ml conical flask. Then 25ml of 95% alcohol was added followed by1ml of phenolphthalein indicator and the solution was then titrated with 0.1M potassium hydroxide (KOH). The color changed from colorless to pink [8].

$$Acid\ value = \frac{Titre\ value \times 56.1}{weight\ of\ sample} \quad (6)$$

4.4.2 Determination of Free Fatty Acid (FFA) Value

The titre values obtained from the acid value determination was used for the determination of free fatty acid for the sample.
1ml 0.1M NaOH = 0.282g oleic acid [7]

$$Free\ fatty\ acid\ (FFA) = \frac{Titre\ value \times 0.282}{weight\ of\ sample} \quad (7)$$

4.4.3 Determination of Iodine Value

About 0.35 g of the oil sample was weighed into a dry 250ml conical flask followed by 10ml of chloroform and the flask was shaken to dissolve the oil. A 20ml aliquot of Wij's solution was pipette into the flask. The flask was covered with a cotton wool moistened with KI and kept in the dark at room temperature for 30 minutes. A blank containing all the reagents except the sample was prepared. 20ml of 20% potassium hydroxide was pipette and made up to 100ml into the solution. The iodine liberated from the solution was back titrated with 0.1M sodium thiosulphate solution (Na2S2O3) using 1ml of 2% starch indicator. The blue black coloration disappears to colorless. The blank titration was carried out at the same time [8].

$$Iodine\ value = \frac{(b-a) \times M \times 126.9}{weight\ of\ sample} \quad (8)$$

where;
b = Titre value of blank
a = Titre value of the sample
126.9 = Molecular weight of Iodine
M = Molarity of sodium thiosulphate solution

4.4.4 Determination of Peroxide Value

This test was carried out in the dark. About 1g of the oil sample was weighed into a clean boiling tube and 20ml of solvent mixture (20ml acetic acid + 20ml carbon tetrachloride) was added and boiled for 60 seconds. The content was poured into a titration flask containing 20ml of 5% potassium iodide (KI) and titrated with 0.002M sodium thiosulphate solution, using starch indicator (a ml). Blank titration (b ml) was also carried out [8].

$$Peroxide\ value = \frac{(b-a) \times 0.002 \times 1000}{weight\ of\ sample} \quad (9)$$

where; a = titre value of sample
b = titre value of blank.

4.4.5 Determination of Saponification Value

About 1g of the oil sample was weighed into 250ml conical flask followed by 25ml of alcoholic potassium hydroxide and refluxed for 30 minutes with occasional shaking. 1ml of phenolphthalein indicator was added to the solution and titrated while hot with 0.5M HCl solution. The blank was also carried out. The colour changed from pink to colourless [8].

$$Saponification\ value = \frac{(b-a)\times 56\times M}{weight\ of\ sample} \quad (10)$$

where b = Titre value of blank
a = Titre value of the sample
M = Molarity of HCl = 0.5M

4.4.6 Determination of Unsaponifiable Matter

1ml of 3M KOH solution was added to the titrated (neutralized) liquid in the sample flask from the earlier saponification value analysis in order to make it alkaline again. This alkalized solution was then transferred to a separating funnel and washed once with distilled water. It was then extracted 3 times with 50ml of petroleum ether for each extraction. The combined ether extracts were washed with 100ml distilled water and filtered. The residue was then oven-dried to a constant weight at 80oC for about 3 hours [10].

$$\%\ Unsaponifiable\ matter = \frac{wf\times 100}{wi} \quad (11)$$

where;

wf = weight of washed, oven-dried extract
wi=weight of oil taken for the determination of saponification value.

4.4.7 Determination of Color

The oil sample was poured into a clear, transparent glass tube and viewed under white light. The colour was assigned to it by visual inspection.

4.4.8 Determination of Relative Density (Specific Gravity)

This is the ratio of the weight of the oil sample in grams to that of equal volume of water. A density bottle with its stopper was weighed (w1), filled with the oil, covered with its stopper and re-weighed (w2). The density bottle was washed, drained, filled with water and weighed (w3).

$$\text{Relative density} = \frac{(w_2-w_1)}{(w_3-w_1)} \quad (12)$$

4.4.9 Determination of pH

The pH meter was calibrated, using buffers 4 and 9. The pH meter electrode was immersed into solution of buffer 4, allowed to equilibrate and adjusted to read 4. It was removed from the buffer solution, rinsed and wiped gently with a clean piece of soft tissue paper. This process was repeated for the buffer 9. It was thereafter immersed in the oil sample, allowed some time to equilibrate after which the readings were taken and recorded.

4.4.10 Determination of Smoke Point

A crucible was filled with the oil sample. A thermometer was clamped on a retort stand in such a way that its bulb was not allowed to touch the bottom of the crucible. The oil was then heated continuously on a hot plate until it gives off a thin but continuous stream of bluish smoke [8]. The temperature at this point was taken and recorded as the smoke point.

4.4.11 Determination of Flash Point

Heating of the oil sample in smoke point determination was continued until sufficient vapor was produced which ignited momentarily on application of a test flame [8]. The temperature at this point was taken and recorded as the flash point.

4.4.12 Determination of Fire Point

Heating of the oil sample in the flash point determination continued until the oil gives off sufficient vapor to form a mixture with air, which causes burning for a period of more than one minute on application of a test flame [8].

4.4.13 Determination of Viscosity

The oil was sample was filled into the upper glass bulb of a jacketed viscometer, whose temperature was maintained at 40oC, to the upper calibration mark with the aid of a syringe and needle. The device was stopped with a rubber bung at the end near the lower bulb to prevent the flow until the upper bulb was filled to the mark. After noting the temperature, the rubber bung was removed and a stopwatch was started simultaneously. The time, in seconds, required for the volume of liquid between the upper and lower calibration marks to drain from the upper bulb into the lower bulb was measured. The time elapsed was used in conjunction with the formula (as shown below) supplied by the manufacturer of the viscometer bulb to determine the viscosity in centipoises.

$$Viscosity = \frac{flow\ time\ (mins)\times oil\ relative\ density\times 1.000}{17.196} \quad (13)$$

The unit of viscosity measurement in the device is centipoises.

4.4.14 Determination of Refractive Index

The refractive index was determined with a refractometer. The prism of the refractometer was wiped clean with a tissue

paper was moistened with acetone. A drop of the oil sample was placed on the prism surface and clamped. Viewing through the telescope, the control knob was adjusted so that the path of view coincided with the dark part as indicated in the cross wire. The refractive index was read directly from the calibrated scale as observed through the telescope and recorded.

4.5 Production of Biodiesel from Trichosanthes cucumerina Seed Oil

Production of biodiesel was done in small batches; using 60ml of oil for each batch on laboratory scale. 60ml of filtered and dried oil was measured into a reactor vessel which was maintained at 50oC to improve the oil's miscibility with the alcohol. 0.41g of potassium hydroxide pellets was weighed, completely dissolved in 20ml methanol. This potassium hydroxide-methanol solution was used to carry out the base-catalyzed trans-esterification of the oil. This mixture was added to the oil in the reactor vessel and the entire content was brought to a temperature of 60oC. This mixture was maintained at this temperature for one hour with consistent mixing in the reactor vessel.

After an hour, the mixture was transferred into a separating funnel and left there overnight for good separation of the products. The products separate out into the denser glycerin phase at the bottom, while the lighter biodiesel phase was on top.

The glycerin was drained off into a beaker while the biodiesel was then drained into another beaker, washed with warm water and placed in the oven at 105oC for 1hour to remove all traces of water. The biodiesel was removed from the oven to cool down in a dessicator. Its volume and some physical properties were determined. It was finally poured into a sample bottle and labeled, "SGS BIODIESEL". This process was repeated for several batches until about 200ml of biodiesel was generated.

Physical properties of the biodiesel, such as; flash point, kinematic viscosity and relative density were determined, using procedures prescribed by ASTM and compared with published standards as presented in Table 4. The refractive index of the biodiesel was also determined and compared with that of the oil from which it was produced.

Table 4: Comparison of Selected Physical Properties of Biodiesel from Trichosanthes cucumerina Seeds Oil ("SGS BIODIESEL") with ASTM PS 121 Standard for Biodiesel **[14].**

Property	*ASTM PS 121 Standard for Biodiesel**	*"SGS BIODIESEL"*
Flash point (oC)	100 – 170	205
Kinematic viscosity (centipoises at 40oC)	1.9 – 6.0	3.73
Relative density	0.88 (minimum)	0.92
Refractive index	No available data	1.47

5. Results and Discussion

The proximate composition for Trichosanthes cucumerina seeds as presented in Table 1, show that the oil seeds have high crude fat content (51.53%), which is quite higher than (43.5%) and (47.7%) as reported by earlier researchers [11], [12]. Hence, it has a very good potential as industrial feedstock for biodiesel production.

The crude protein was found to be (28.59%), which is comparable with (30.10%) as reported earlier [12]. This indicates that the seeds cake which is obtained after fat extraction is a potential source of cheap protein for compounding livestock feed. The total carbohydrate content was found to be (10.60%). The ash content is (2.93%). The moisture content of (5.21%) is not very desirable, considering storability of the seeds. This is so because; high moisture content increases the susceptibility of these seeds to microbial infestation and fungal growth, when they are under storage.

The mineral composition in (mg/L) for Trichosanthes cucumerina seeds as presented in Table 2, confirms the presence of some macro-nutrients like: sodium (5.06), potassium (1.10), calcium (1.43) and magnesium (0.758) which further enhances the nutritional credibility of Trichosanthes cucumerina seeds cake as a potential source of livestock feed ingredient. With respect to the micro-nutrients, the iron content (2.028) is remarkably high when compared to zinc (0.082) and copper (0.068), which indicates that using the seeds cake as a livestock feed ingredient could reduce the susceptibility of animals that are fed with it to iron-deficiency anaemia [13].

The physicochemical parameters of the oil extracted from Trichosanthes cucumerina seeds as shown in Table 3, indicates that the oil has a very high saponification value of (317.27 mg KOH/g). This value is higher than that which was reported for palm kernel oil (242 – 250 mg KOH/g) and coconut oil (246 – 260 mg KOH/g) [15]. The higher saponification number indicates that more alkali will be required to make soap from the oil, hence, this oil is not recommended for soap production.

The percentage yield of biodiesel from Trichosanthes cucumerina seeds oil on the average was 63.33% (v/v). This average percentage yield was determined by adding all the percentages yield of all batch processes divided by the number of batches of drained, washed and oven-dried biodiesel that was processed. This is very remarkable in view of the fact that, the main aim of this research is to produce biodiesel from the oil of Trichosanthes cucumerina.

Besides this impressive yield, biodiesel derived from snake gourd seed oil exhibit remarkable conformity with some selected ASTM PS 121 Standards for Biodiesel [14]. Table 4 shows some of these major comparisons.

It is obvious, form the comparison of properties of "SGS BIODIESEL" with ASTM PS 121 Standard for biodiesel in Table 4 that, "SGS BIODIESEL" has a very high flash point of 205oC which is far greater than the upper recommended limit for biodiesel. This shows that "SGS BIODIESEL" cannot be used directly as a fuel in diesel engines, but must be blended to the correct flash point. Its relative density (0.92) was found to be above the minimum benchmark. The kinematic viscosity (3.73 centipoises) is satisfactorily within the approved range for biodiesel. Since refractive index is a measure of identity, purity, degree of unsaturation and average chain length [10], the observable decrease in the refractive index (from 1.48 to 1.47) of Trichosanthes cucumerina seed oil when compared with "SGS BIODIESEL" suggests that a chemical alteration of the oil by trans-esterification had taken place.

6. Conclusion

This research work has given insight into proximate composition, mineral content and physicochemical parameters of the oil of Trichosanthes cucumerina seeds. It shows that these seeds contain very high fat content, moderate crude protein content with an array of essential and trace minerals. These properties qualify Trichosanthes cucumerina seeds for use as cheap industrial feedstock for vegetable oil production, livestock feed formulation and most importantly biodiesel production.

7. Future Scope

Further research work should focus on the following areas to improve on the current work; determination of appropriate blending ratio with petroleum diesel, effects of temperature variation, other types of catalysts, reaction time, reactor speed, sample pretreatment on overall biodiesel yield, quality and stability during storage. The production of biodiesel from Trichosanthes cucumerina., using the methods described in this paper could also be scaled up and tested in diesel engines. Such work should seek to find out possible effects of its use on the engines, in order to determine necessary engine modifications.

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9. Authors Profile

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