Evaluation of the Potentials of Vegetable Oils from Soybean, Melon and Breadfruit Seeds as Biodiesel Feedstock

Odunlami, M.O.*, Folami, N.A., Oso, A.O. and Momoh, P.K.

Department of Chemical Engineering, Lagos State Polytechnic, Ikorodu Lagos, Nigeria
**Corresponding Author*

***Abstract:* - The aim of this work was to extract and characterize the oils from soybean, melon and breadfruit seeds as well as evaluate their suitability for biodiesel feedstock. Soxhlet extraction was employed and physiochemical properties of the oils extracted were carried out using standard analytical methods. The saponification value (mg KOH/g), acid value (mg KOH/g), iodine value (mg iodine/100 g), peroxide value (mg peroxide/kg), refractive index, and specific gravity were found to be 190 ± 0.06, 1.81 ± 0.14, 120 ± 0.10, 6.12 ± 0.23, 1.47 ± 0.16 and 0. 9156 ± 0.12 for soybean oil; 185 ± 0.04, 2.80 ± 0.04, 110 ± 0.12, 5. 20 ± 0.16, 1.473 ± 0.01 and 0.9150 ± 0.03 for melon oil; and 168 ± 0.15, 9.39 ± 0.08, 116 ± 0.12, 8.90 ± 0.08, 1.4718 ± 0.01 and 0.9200 ± 0.05 for breadfruit oil respectively. The FTIR analysis in the study showed the presence of seven different functional groups. Conclusively, the vegetable oils are suitable as biodiesel feedstock which justify the study.**

***Key words:* Evaluation, vegetable oils, breadfruit, melon, soybean and biodiesel**

I. INTRODUCTION

A vegetable oil is a triglyceride extracted from a plant. For this reason, vegetable oils that are solid at room temperature are sometimes called vegetable fats (Purcaro et al., 2016). Vegetable oils are used in biodiesel production, food, soaps, skin products, candles, perfumes, cosmetic products, drying oils, paints and wood treatment products. They are also being used as insulators.

Soybean is a legume of the family of the Papilionaceae, to which other well-known plants belong, such as beans or peas. It derives from Glycine ussuriensis species that grows wild in China and Japan. Soybeans originated in Southeast Asia (Farooq et al., 2016). The amount of oil along with protein are both reported to be nearly 60% of dry soybeans weight. From the total composition, the main biomolecules are protein which accounts for 40% and oil amount accounts for 20%. The residual composition includes 35% carbohydrates and nearly 5% amount of ash. Soybeans comprise approximately 8% seed coat or hull, 90% cotyledons and 2% hypocotyl axis or germ. (Elkadyl et al,1999). Soybeans are a globally important crop, providing oil and protein. Soybean products are used in a large variety of processed foods e.g. soy milk, yoghurt etc (Rosenthal et al., 2001).

Melon (Citrulluscolocynthis) seeds thrive in tropical, subtropical, arid deserts and temperate locations. Egusi melon is an annual, herbaceous, monoecious plant with a non-climbing creeping habit. After planting, they completely cover the soil surface within 3 weeks and flowering starts. Pollination is by insects. Often the fruits are ready to harvest between 90-120 days. Melon seeds are approximately 50% oil and 30% protein; it also contains palmitic, stearic, linoleic and oleic acids. The oil is cholesterol free (Mirjana, 2005). The seeds are used for oil production by extraction. The residue after oil extraction may be ground into meal to make a substitute for meat patties or a dry powder for use as a soup base (Akoh and Nwosu,1992).

Breadfruit (Treculiaafricana) is a multipurpose tree species which belongs to the family moracea and it grows in the forest zone. It is widely grown in Southern Nigeria for its seeds (Onweluzo and Odume, 2008). The raw Treculia africana seed consists of 3.8% moisture, 4.0% ash, 15.9% crude fiber, 15.9% ether extract (fat), 17.7% crude protein and 38.3% carbohydrates (Fayose and Onyekwelu 2007). The wood is suitable for fire wood and charcoal production (Field Survey, 2008). The breadfruit oil could be used for cooking, preparation of soaps in the pharmaceuticals, production of hair shampoo, alkyl resin used in paints and varnish industries due to the drying nature of African breadfruit oil with its high oil yield (Ajiwe et al, 1995). The bran and pulp of African breadfruit have been found to be nutritious for use in livestock feeds (Okafor, 1990). The roots are used as a malaria tonic and worm expeller for children, while the back is used as treatment for cough neck and rheumatism (Irvine, 1981).

II. MATERIALS AND METHODS

2.1. Materials: Soybean (*Glycinemax)*, melon (*Citrulluscolocynthis*) and breadfruit (*Treculia africana)* seeds, filter paper, n-hexane, Potassium hydroxide, Sodium hydroxide, Ethanol, Diethyl Ether, Hydrochloric acid, Acetic acid, Chloroform, Sodium thiosulphate, Wiji's reagent, Potassium iodide, Methanol, phenolphthalein, starch indicator, Sodium carbonate, Sodium silicate, Silver nitrate, Tetra-oxo-sulphate (VI) acid and Potassium dichromate all of which are analytical grade. Soxhlet apparatus, beaker 250 ml, round bottom flask 500 ml, conical flask 250 ml, measuring cylinder, liquid-in-glass thermometer, mortar and pestle, digital weighing balance, retort stand, sieve, specific gravity bottle, separating funnel, stopwatch, Abbe type refractometer (Model 2754 T3- NE, Germany), heating mantle and fume cupboard.

2.2. Preparation of Seed Samples: Soybean, Melon *and* Breadfruit seeds were purchased from Ile Epo Fruits and Vegetables market, Abule-Egba, Lagos State. seeds were deshelled manually to obtain the seeds. The three seeds were dried, sorted to remove foreign materials, pulverized and prepared for extraction.

2.3. Extraction of Oil and Oil Yield Determination: The oil extraction was carried out according to the method described by Okolie et al. (2012). The pulverized seeds (5g) were weighed in triplicate. The weights of the filter papers were noted, followed by the weight of filter paper with the sample, the filter papers were tied with the samples and the oils were extracted using Soxhlet apparatus. The weights of the filter papers with the samples were taken after extraction. The oil yield was calculated as follows:

$$\text{Oil yield} = \frac{\text{weight of the Fp+sampl }\frac{b}{4}\text{extraction} - \text{weig of Fp+sample after ex}}{\text{weight of the sample}} \times 100 \quad (2.1)$$

The specific gravity, refractive index, unsaponifiable matter, acid value, peroxide value, iodine value, saponification value, functional groups and elemental analysis of the three oil samples were evaluated using AOAC (2011) standard methods.

III. RESULTS AND DISCUSSION

3.1 Oil Yield of Soybean, Melon Seed And Breadfruit Seed

As depicted in Figure 3.1, the oil yield for G. max, C. colocynthis and T. africana seeds were 23%, 52% and 7% respectively. The oil content for C. colocynthis seed was higher than for G. max and T. africana seed. However, the oil content for G. max and C. colocynthis seeds indicates that they can be source of oil for industrial application, but the oil yield for T. Africana was low which could discourage its use in industrial application.

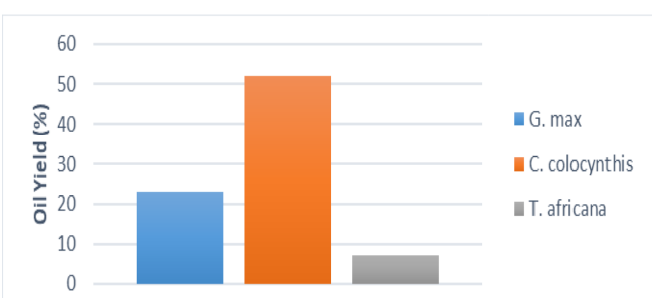

Figure 3.1 Oil Yields of Soybean, Melon and Breadfruit Seeds

3.2 Physical Properties of the Extracted Oil

The physical properties of the oil extracted from soybean, melon and breadfruit seeds are presented in Figures 3.2 (a) - (c). Selected physical properties investigated in this study are specific gravity, refractive index and unsaponifiable matter. The specific gravity obtained for each of soybean, melon and breadfruit seed oil were 0.9156, 0.9150 and 0.9200. The specific gravity for these seed oils falls within the range for convectional seed oils as most oil ranges between 0.89 and 0.92 at 20 °C. The refractive indexes for soybean, melon and breadfruit seed oils fall within the same range which are 1.4700, 1.4730 and 1.4718 respectively. These values are closely related to (1.4680 and 1.4733) reported by Farooq et al. (2015) and Mirjana et al. (2005). According to Pearson (1976) refractive index can be used to check the purity of oils. Unsaponifiable matter is all the substances present in vegetable oil after saponification of the oil (Gopala et al, 2017). The unsaponfiable matter for soybean, melon and breadfruit seed oils falls within the same range which are 0.95%, 0.97% and 0.91% respectively.

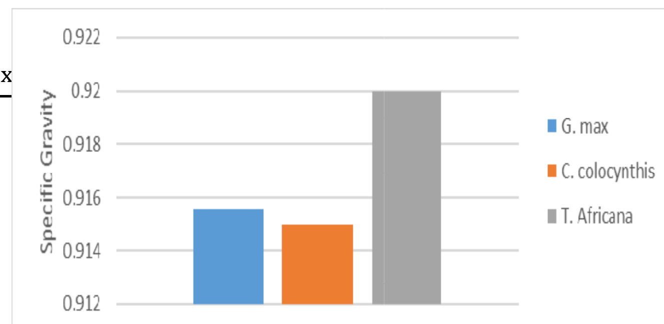

Figure 3.2 (a) - Soybean, Melon and Breadfruit Seed Oil

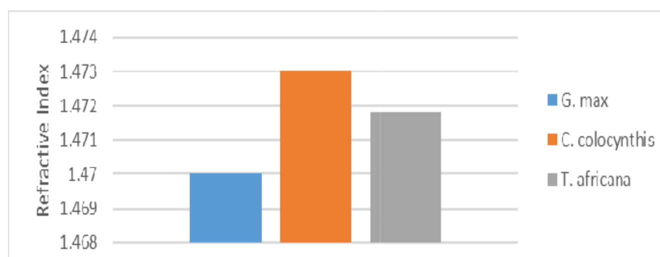

Figure 3.2 (b) Refractive Indexes of Soybean, Melon and Breadfruit Seed Oils

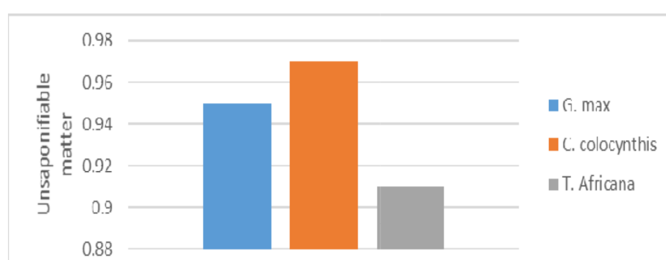

Figure 3.2 (c) Unsaponifiable Matter of Soybean, Melon and Breadfruit Seed Oil

3.3 Chemical Properties of Soybean, Melon Seed and Breadfruit Seed

The chemical properties of the oils extracted from these seeds are presented in Figures 3.3 (a) – 3.3(d). The acid values for G. max and C. colocynthis seed oils are in close agreement with 1.81 mgKOH/g and 2.80 mgKOH/g reported by Adel et al. (2017) and Oti et al. (2017) for G. max and C. colocynthis seed oils respectively while the acid value for T. africana seed oil was close to 9.39mgKOH/g reported by Nwabueze and Emenonye (2016). The acid value indicates the extent at which triglycerides in vegetable oil has been decomposed by lipase action. The low acid value of G. max and C. colocynthis indicates the lower level to which the glycerides in the oil had been decomposed by lipase action (Pearson, 1976). The low acid value of these seed oils shows that they contain low free fatty acids which will make it resistant to oxidation. The high acid value of T. africana seed oil indicates the oil will be more vulnerable to oxidation than C. colocynthis oil and G. max oil.

The peroxide value 5.20 mEq/kg for C. colocynthis is within the range of 5.00 mEq/kg reported by Ndidi et al. (2015); while the peroxide values for G. max (6.12 mEq/kg) and T. africana (8.90mEq/kg) were lower than those reported by Elkadyl et al. (1999) and Ajiwe et al. (1995). Peroxide value measures the degree of rancidity in vegetable oil. According to Pearson (1976), rancidity begins to be noticeable when the peroxide value is well above 10 mg Eq/kg. However these values still fall within the range accepted according to Okene and Evbuomwan, (2015), high oxidative stability is possible when peroxide value is less than 10.00 mg Eq/kg, hence the oils will be resistant to peroxidation during storage.

The iodine values of G. max, C. colocynthis and T. africana seed oils were 120 mg I_2/100g, 110 mg I_2/100 g and 116 mg I_2/100 g. These values are in close range with 124.56 mg I_2/100 g, 119 mg I_2/100 g and 111.90 mg I_2/100 g reported by Elkadyl et al. (1999), Mirjana et al. (2005) and Ajiwe et al. (1995), for G. max, C. colocynthis and T. africana respectively. Iodine value measures the degree of unsaturation of vegetable oil. This shows that these seed oils are highly saturated. Saturated vegetable oils have longer shelf life than unsaturated vegetable oils, thereby making them resistant to oxidation. The saponification values for G. max, C. colocynthis and T. africana seed oils were 190 mg KOH/g, 185 mg KOH/g and 168mg KOH/g. The saponification values obtained for the oils are in the range for some vegetable oils ranging from 188 to 196 mg KOH/g. However, there are some vegetables with higher saponification values such as coconut oil [253 mg KOH/g] and butter fat [225 mg KOH/g] (Mestralletet al, 2004). It has been reported by Mestralletet al. (2004) that oils with higher saponification values contain high proportion of lower fatty acids.

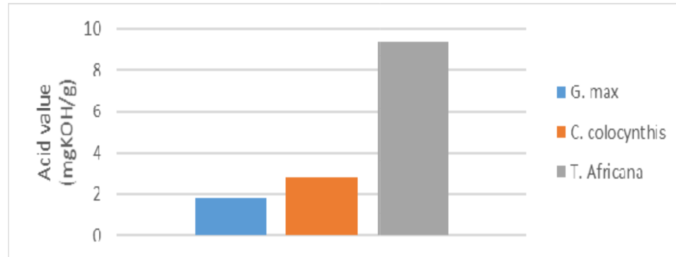

Figure 3.3 (a) Acid Value of G. max, C. colocynthis and T. africana Seed oil

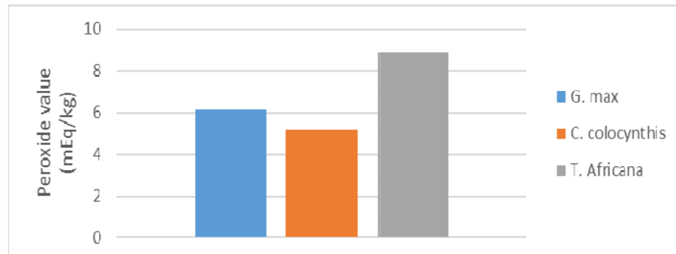

Fig 3.3 (b) Peroxide Value of G. max, C. colocynthis and T. africana Seed Oil

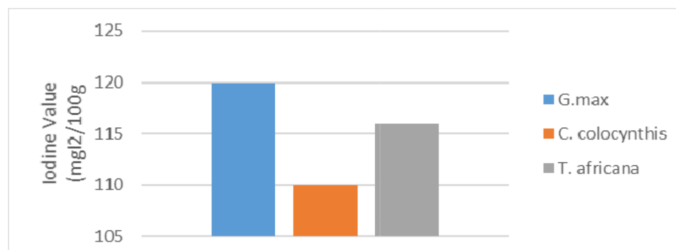

Figure 3.3 (c) Iodine Value of G. max, C. colocynthis and T. africana Seed Oil

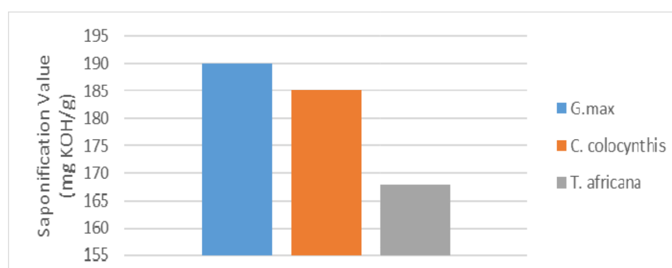

Figure 3.3 (d) Saponification Value of G. max, C. colocynthis and T. africana Seed Oil

3.4 Elemental Analysis of Soybean, Melon Seed, and Breadfruit Seed

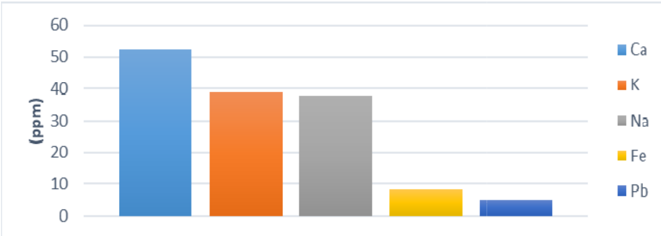

Figure 3.4 (a) Elemental Analysis of Melon seed oil

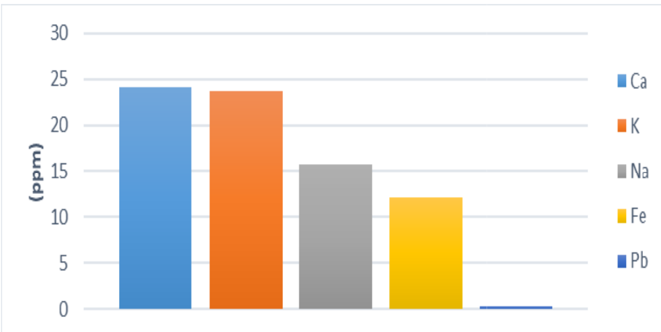

Figure 3.4 (b) Elemental Analysis of Soybean oil

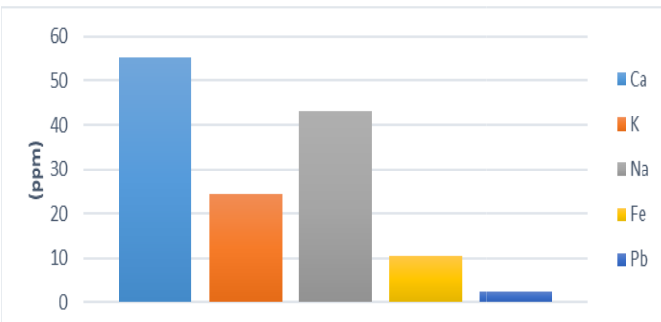

Figure 3.4 (c) Elemental Analysis of Breadfruit Seed oil

Figure 3.4 (a, b and c) shows the elemental analysis of melon seed oil, soybean oil and breadfruit seed oil. The metal with the highest concentration is Calcium (Ca) in the three seed oils with values 24.15371 ppm for soybean oil, 52.413 ppm (melon seed oil) and 55.2273 ppm (breadfruit oil); while Lead (Pb) has the lowest concentration with values 0.2568, 5.1059 and 2.3587 ppm in soybean, melon seed and breadfruit seed oil respectively. The presence of trace metals are important factors as far as the quality of edible oil is concerned. Metallic elements such as Sodium (Na), Potassium(K), Calcium (Ca), and Iron (Fe) are essential for human nutrients mainly for growth. Lead (Pb) poses detrimental effects on health of plants and animals even in relatively small amount (Pehlivan et. al 2008). However, Lead (Pb) and Iron (Fe) in these oils were above the maximum permissible concentration of 0.1 ppm (Adel et al., 2017), hence the extracted oils will be subjected to further treatment to make it edible.

3.5 Fourier Transform Infared Spectrophotometry (FTIR) Analysis

The essence of FTIR analysis is to determine the type and number of functional groups present in the extracted seed oils. The spectral analysis as displayed in the figures below shows the various peaks of the functional group present in breadfruit seed oil, soybean oil and melon seed oil.

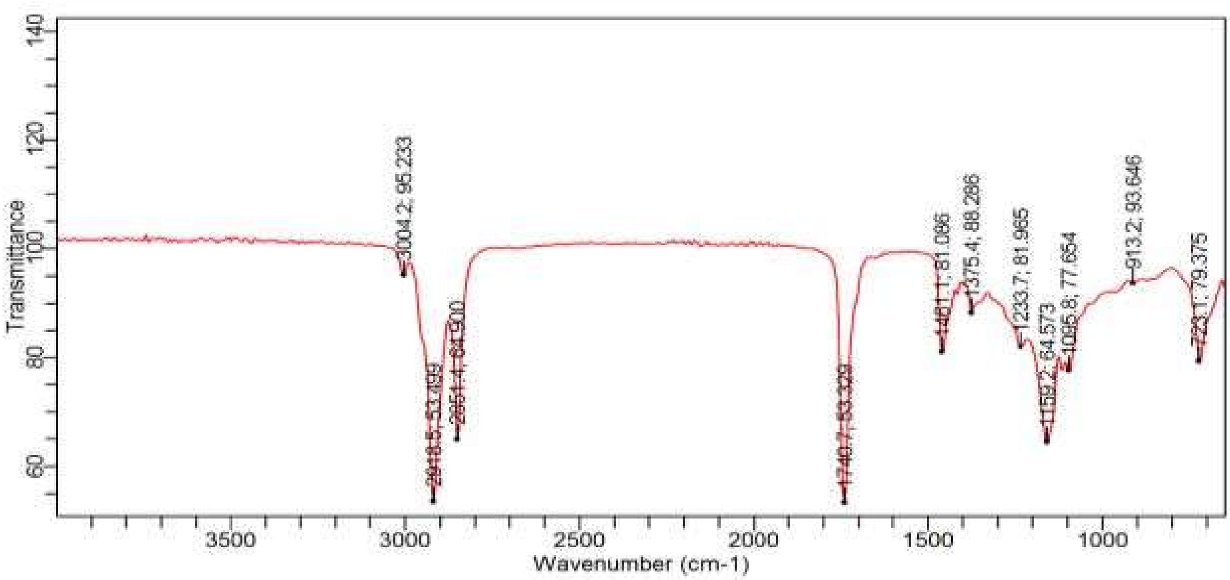

Figure 3.5 (a) Spectral Analysis of Melon seed oil

From Figure 3.5 (a), melon seed oil has a maximum transmittance of 102. Out of the 11 peaks on the result, 3 peaks were recorded on the single bond spectrum, no peak was observed on the triple bond spectrum, 1 peak was observed on the double bond spectrum, while 7 peaks were observed on the finger print region skeletal vibration having C-O, C-N and C-C bonds.

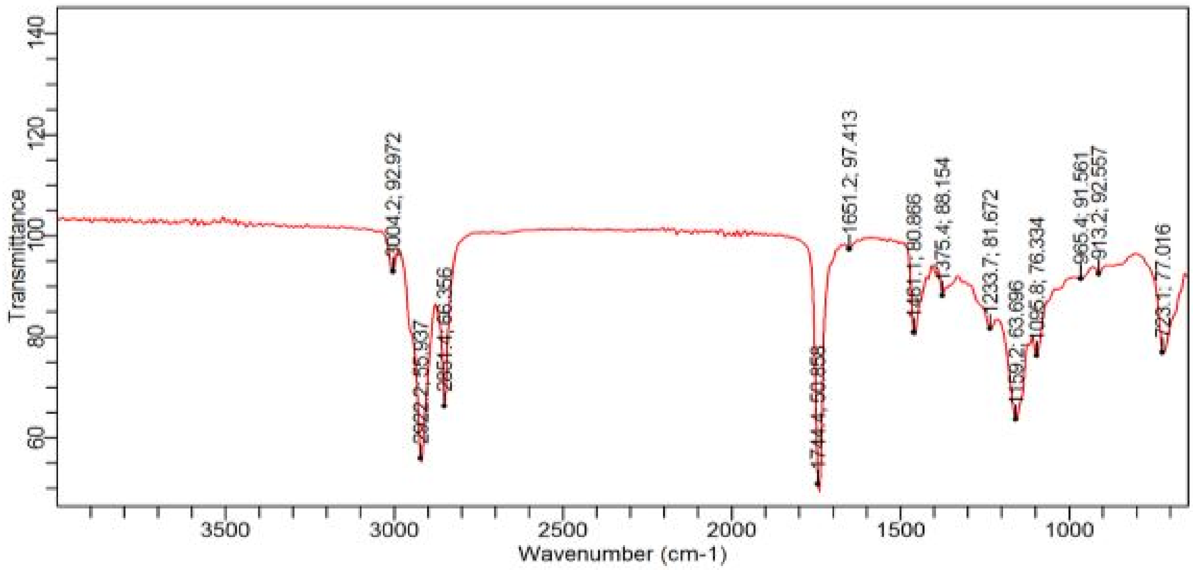

Figure 3.5(b) Spectral Analysis of Soybean oil

In Figure 3.5 (b), Soybean oil has a maximum transmittance of 104. Out of the 13 peaks of the result, 3 peaks were recorded on the single bond spectrum; no peak was observed on the triple bond spectrum, 2 peaks were observed on the double bond spectrum, while 8 peaks were recorded on the finger print region skeletal vibration having C-O, C-N and C-C bonds.

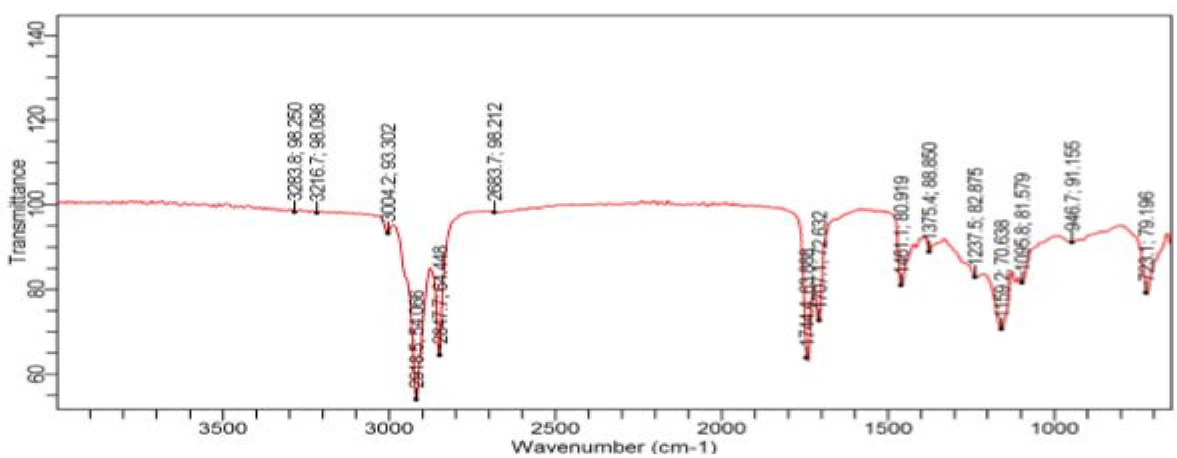

Figure 3.5 (c) Spectral Analysis of Breadfruit seed oil

With reference to Figure 3.5 (c), Breadfruit seed oil has a maximum transmittance of 100. Out of the 15 peaks on the result, 6 peaks were recorded on the single bond spectrum, no peak was observed on the triple bond spectrum, 2 peaks were recorded on the double bond spectrum, while 7 peaks were recorded on the finger print region skeletal vibration having C-O,C-N and C-C bonds.

The FTIR analysis revealed that melon seed oil, soybean oil and breadfruit seed oil have similar functional groups such as alkanes, alkenes, carbonyls, amines, alkyls halides and carboxylic acid except for alcohols which was only present in breadfruit seed oil. The result is similar to those found in Olowokere et al. (2018) for African locust bean seed oil, Olowokere et al. (2019) for Date palm seed oil and Anang et al. (2019) for African star apple seed oil.

IV. CONCLUSION

A vegetable oil is a triglyceride extracted from a plant. Vegetable oils are used in biodiesel production, food, soaps, cosmetic products, drying oils, paints and wood treatment products. In this work, extraction and characterization of oils from soybean, melon and breadfruit seeds were done as well as evaluating their suitability for biodiesel feedstock. Soxhlet extraction was employed and physiochemical properties of the oils were carried out using standard analytical methods. The saponification value (mg KOH/g), acid value (mg KOH/g), iodine value (mg iodine/100 g), peroxide value (mg peroxide/kg), refractive index, and specific gravity were found to be 190 ± 0.06, 1.81 ± 0.14, 120 ± 0.10, 6.12 ± 0.23, 1.47 ± 0.16 and 0. 9156 ± 0.12 for soybean oil, 185 ± 0.04, 2.80 ± 0.04, 110 ± 0.12, 5. 20 ± 0.16, 1.473 ± 0.01 and 0.9150 ± 0.03 for melon oil, and 168 ± 0.15, 9.39 ± 0.08, 116 ± 0.12, 8.90 ± 0.08, 1.4718 ± 0.01 and 0.9200 ± 0.05 for breadfruit oil respectively. The results showed that the vegetable oils are suitable as biodiesel feedstock; therefore, the study is justified.

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