PRODUCTION AND OPTIMIZATION OF SUGAR APPLE SEED OIL, AS A SUSTAINABLE AND ECONOMICALLY VIABLE ALTERNATIVE TO OTHER COMMERCIAL OILS.

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Abstract

There is growing interest in natural products and their potential therapeutic applications in various industries, such as the cosmetic, pharmaceutical, and food industries. Sugar apple seed oil has been shown to possess various therapeutic properties. The following where determined in this study peroxide value, free fatty acids (FFA)/Acid, saponification value, specific gravity/density, iodine value, unsaponifiable matter, gas chromatography-mass spectrometry (GC-Ms), Fourier transform infrared (FTIR). The extraction yield of sugar apple seed oil was found to be 54.6%. The peroxide value was 0.375 mol/kg. The free fatty acid content of the oil was found to be 7.57 mg/g. The acid value was 3.785 mg/g. The saponification value of the seed oil was found to be 210.375 mg/g. The specific gravity of sugar apple seed oil was found to be 0.907 kg/m3, and the density was found to be 0.925 kg/m^3. The iodine value of the oil was 0.355 g/100g. The unsaponifiable matter of sugar apple seed oil was found to be 0.05%. The GC-MS analysis of sugar apple seed oil revealed the presence of several compounds, including n-hexadecanoic acid, limonene, octadecadienoic acid, octadecanoic acid, 2-hydroxy-1-(hydroxymethyl)ethyl ester, and n-decanoic acid. N-hexadecanoic acid. From the FTIR peaks identified in sugar apple seed oil at the peak at 700 cm^1 is attributed to the presence of the out-of-plane bending of C-H of aromatics, indicating the presence of aromatic compounds in the oil. Therefore, the results obtained for sugar apple seed oil indicate that it is of good quality and falls within the permissible limits.

Keywords: *Extraction, Sugar apple, seed, Oil*

Background to the Study

Sugar apple (Annona squamosal), belonging to family Annonaceae is commonly found in India and cultivated in Thailand and originates from the West Indies and south America. Sugar apple has been commercially cultivated in Africa, South America, Australia, India, Mexico, in the south and the United States, the Philippines, and Thailand (Pinto *et al.,* 2005) It is mainly grown in gardens for its fruits and ornamental value. It is known as custard apple, sugar apple, sweet après in English, sharifa in hindi, sitaphalam in telugu in India, corossolier, cailleux, pommier cannelle in French (Crane *et al.,* 2016). Its commonly called Gwanda masar in Hausa Language and kribobo in nupe tribe of Nigeria as cited by Muhammad, A. (2018).

One potential research problem for sugar apple seed oil could be, investigating its potential uses and benefits in various industries, such as the cosmetic, pharmaceutical, and food industries. Despite the fact that sugar apple seed has been shown to possess various therapeutic properties, such as antioxidant, antimicrobial, and anti-inflammatory activities, there is limited research available on its potential uses and applications (Mariod *et al.,* 2017). sugar apple is a widely cultivated fruit that has been traditionally used for medicinal purposes in many cultures. It is also known for its nutritional and antioxidant properties. However, there is limited research available on the potential benefits of its seed oil. Secondly, there is growing interest in natural products and their potential therapeutic applications in various industries, such as the cosmetic, pharmaceutical, and food industries. Sugar apple seed oil has been shown to possess various therapeutic properties, including antioxidant, antimicrobial, and anti-inflammatory activities. Investigating its potential uses and applications could contribute to the development of new products with potential health benefits (Parham *et al.,* 2020).

Ushie *et al.,* (2023) studied the physico-chemical content and nutritional value present in the extract of Citrullus colocynthis using the best readily available method. The result shows that the Citrullus colocynthis seed contained 4.93% moisture, 12. 06% crude protein, 4.35% ash and 45.83% crude fibre, 8.16% lipid and 24.67% carbohydrate. The oil was liquid at room temperature with physico-chemical characteristics like iodine value of 11.33, acid value of 3.86(mg KOH/g of oil), saponification value of 171.09 and specific gravity of 0.92.

Physicochemical parameters are used to measure the quality and purity of oils. Some important physicochemical parameters of oils include. These parameters can be used to determine the shelf life, stability, and nutritional value of oils. (Ahmad *et al.* 2017). The aim of the research project is to investigate the potential uses and benefits of sugar apple seed oil, optimize the extraction and purification methods, and explore its potential as a sustainable and economically viable alternative to other commercial oils.

Materials and Methods

Solvent Selection

Chemical used were of analytical grade. methanol, petroleum ether, conc. H_2SO_4, ethanol, barium chloride, potassium iodide, glacial acetic acid, chloroform, water, sodium

thiosulphate, starch, diethyl ether, alcohol, phenophthalein, NaOH, potassium hydroxide.

Plant Collection

Seeds of sugar apple was obtained from Niger state, Nigeria in the month of October. The seeds were sun dried and thereafter crushed into powder with a mortar and pestle.

Apparatus and Materials

The apparatus and materials needed for the extraction of oil using Soxhlet apparatus are: Soxhlet extractor, round bottom flask, condenser, heating mantle, extraction thimble, solvent used for oil extraction include hexane, ethanol, and petroleum ether, analytical balance, glass wool. filter paper, rotary evaporator: desiccator

Extraction

Sugar apple seeds was dried, crushed and grounded to powder with a mortar, which was then sieved with a sieve of 850 micrometer, thereafter the powder which is obtained was wrapped with filter paper in small portions. And then placed in a round bottom flask before filling with petroleum ether and attached to a Soxhlet apparatus to extract oil from the seed kernels. While doing the extraction, the solvent is used in the ratio of 15 ml/g of seed's powder, and extraction time was 5hr, 6hr for two petroleum ether, and one methanol solvent respectively. The temperature was maintained near about 65-70 degrees Celsius by regulating the magnetic cum heater and stirrer. After extraction, the sample is distilled to remove the petroleum ether. distillation is carried out through the Soxhlet apparatus after the sample wrapped in the filter paper is removed. after distillation the oil extracted remains in the Soxhlet apparatus. and lastly the oil separated is analyzed for peroxide value, acid value, specific gravity, density and saponification value, iodine value, unsaponifiable matter.

Determination of the Peroxide Value

One gram of the oil weigh was into a clean dry boiling tube and while still liquid add 1g powdered potassium iodide and 20ml of solvent mixture (2 vol glacial acetic acid + 1 vol chloroform). the tube was place in a boiling water so that the liquid boil within 30 seconds and allow to boil vigorously for not more than 30 second. the contents were quickly poured into a flask containing 20ml of potassium iodide solution (5%), wash out the tube twice with 25ml water and titrate with 0.002m sodium thiosulphate solution using starch. a blank was performed at the same time.

$$\text{Peroxide value} = \frac{\text{sample} - \text{blank} \times 0.025 \times 100}{1}$$

Determination of the Free Fatty Acids (FFA)/Acid

To determine the free fatty acid, 25ml was mixed with diethyl ether with 25ml alcohol and 1ml phenolphthalein (1%) and care-fully neutralize with 0.1m NaOH. 1-10g of the oil was dissolved in the mixed neutral solvent and titrated with aqueous 0.1m NaOH shaking constantly until a pink color which persist for 15 seconds.

$$\text{Acid value} = \frac{\text{titre(ml)} \times 56.1}{\text{wt of sample use}}$$

Determination of the Saponification Value

To determine the saponification value, 2g of the oil was weigh into a conical flask and add exactly 25ml of the alcoholic potassium hydroxide solution. a reflux condenser was attached and the flask was heated in boiling water for 1hr shaking frequently. 1ml of phenolphthalein (1%) solution was added and titrated hot. The excess alkali with 0.5m hydrochloric acid (titration = aml)

$$\text{Saponification value} = \frac{(b\text{-}a) \times 28.05}{\text{wt(g) of sample}}$$

Determination of the Specific Gravity/Density

To determine the specific gravity/density, 50ml pyrometer bottle was thoroughly washed with detergent water and petroleum ether, dry and weigh. the bottle was filled with water and weigh. after drying the bottle, the oil sample was filled and weighed

$$\text{Specific gravity (S.V)} = \frac{\text{weight of x ml of oil}}{\text{wt of x ml of water}}$$

$$\text{Density} = \frac{\text{weight of oil}}{\text{volume of oil}}$$

Determination of the Iodine Value

the oil was poured into a small beaker and added a small rod and weigh out a suitable quantity of the sample by difference into a dry glass-Stoppard bottle of about 250ml capacity. The approximate weigh in g of the oil to be taken can be calculated by dividing 20 by the highest expected iodine value. 10ml of carbon tetrachloride was added to the oil or melted fat and dissolved. 20ml of wijis solution was added, and the stopper (previously moistened with potassium iodine solution) and was allowed to stand in the dark for 30 minutes. 13ml of potassium iodide solution (10) was added, with 100ml water mixed and titrated with 0.1 thiosulphate solution using starch as indicator just before the end point (titration = aml) blank was carried out at the same time, commencing with 10 ml of carbon tetrachloride (titration = bml)

$$\text{Iodine value (I.V)} = \frac{(b\text{-}a) \times 1.269}{\text{wt(g) of sample}}$$

Note: if (b-a) is greater than 6/2 the test must be repeated using a smaller amount of the sample.

Determination of the Unsaponifiable Matter

The term “unsaponifiable matter” is applied to the substances non-volatile at 100-105 °C

obtained by extraction with an organic solvent from the substance to be examined after it has been saponified. The result is calculated as per cent m/m.

$$\text{Unsaponifiable matter} = \frac{(A-B) \times 100}{W}$$

Where, A = weight, in g, of the residue, B = weight, in g, of the fatty acids in the extract, V = volume, in ml, of NaOH solution, N = normality of NaOH solution, and W = weight, in g, of the material taken for the test.

Gas Chromatography-Mass Spectrometry (Gc-Ms) Determination

The samples were subjected to chromatographic analysis using a Varian 3800/4000 gas chromatograph mass spectrometer equipped with an Agilent equipped with a splitter split/splitless. With a BP5 (30 m × 0.25 mm × 0.25 microns) capillary column. Nitrogen was used as a gas carrier. 1.0 µL volumes were injected using a splitless mode at an injector temperature of 2700C. The oven temperature was ramped from 80 to 2000C (1 minute hold) at a rate of 50C/min. The oven temperature was held at 2800C for 6 minutes following each analysis. The total run time for each sample was approximately 45 minutes. The GC-MS interface temperature was set to 2800C. Mass spectrometry mode was used during analytical scanning from 30–1000 atomic mass unit (amu) for the oil sample. The ion source temperature was set to 2500C. The blank was first injected and was followed by the sample injection. Organic compounds in the samples were identified in Wiley's NIST 08 Mass Spectral Library, if the obtained comparison scores were higher than 95%. Otherwise, fragmentation peaks of the compounds were evaluated, and the compounds were identified using the memory background for the identification of the compounds that appeared in GCMS chromatograms. Contents of individual compound in the extract were given in percent of the total compound in the sample. The chromatograms obtained from the total ion count (TIC) were integrated without any correction for co-eluting peaks and the results were expressed as total abundance. All the peaks were identified based on mass spectral matching (≥ 90%) from both the NIST and Wiley libraries. Only compounds with 90% or greater spectral matching accuracy are reported. No response factors were calculated.

Fourier Transform Infrared (FTIR) Determination

In the FTIR analysis procedure, samples are subjected to contact with infrared (IR) radiation. The IR radiations then have impacts on the atomic vibrations of a molecule in the sample, resulting the specific absorption and/or transmission of energy. This makes the FTIR useful for determining specific molecular vibrations contained in the sample (Kirk and Othmer, 1953). the power was Turn on and the Instrument was allowed to warm-up time of 10-15 minutes. the computer (attached to the system) was turn on. After initialization from the computer double 'MicroLab PC window' icon was click on and waited for it to open. The Start button was clicked to initiate the sampling operation. And to select the method i.e. absorbance or transmittance. the crystal was clean with organic solvent and next was clicked to check the crystal and collecting background. the sample of about 10-15mg was placed. for solids sample it was close and press to make a pellet on top of the crystal, if it's liquid sample

it will remain open to smear on top of the crystal and click next. the sample alignment was check for blue line from red to green region for proper sampling and was put in the sample identity for coding. next was click for sampling. and it was right clicked to pick the peaks and select peaks for labeling by dragging to acquire the wavenumbers as well as transmittance or absorbance.

Results and Discussion

Extracted yield of sugar apple seed oil

Figure 1 shows the chart for the percentage yield of the extract. Sugar apple seed oil is a potential source of edible oil with several physicochemical properties that make it suitable for various applications. The following is a discussion of the physicochemical properties of sugar apple seed oil. The extraction yield of sugar apple seed oil was found to be 54.6%. The yield is a significant factor in determining the commercial viability of the oil. The extraction yield of sugar apple seed oil (54.6%) is within the range reported by (Göhl *et al.* 2019). Of (52.5%), oil yield.

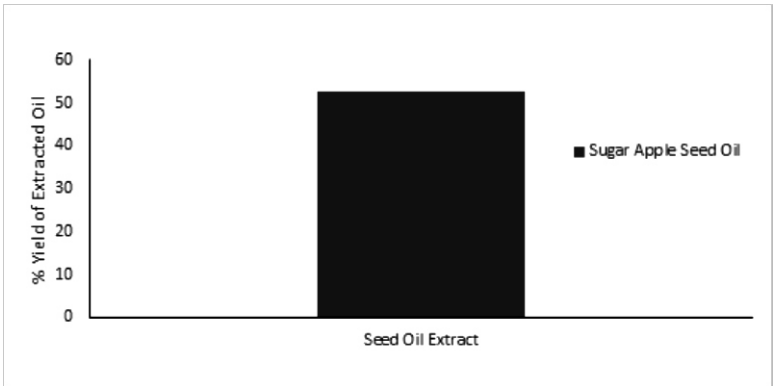

Figure 1. Extracted yield of sugar apple seed oil

Proximate Characterization of the Oil

The peroxide value of sugar apple seed oil was found to be 0.375 mmol/kg as shown on Table 1. This value represents the amount of peroxide present in the oil and is an indication of the oil's oxidative stability. A high peroxide value indicates that the oil is susceptible to oxidation and rancidity. The peroxide value falls within the range reported by (Mansor *et al.* 2016; Diaz-de-Cerio *et al* 2016). From Table 1, the free fatty acid content of sugar apple seed oil was found to be 7.57 mg/g. This value indicates the amount of free fatty acids present in the oil and is an indication of the oil's quality. A high free fatty acid content is an indication of poor-quality oil. The free fatty acid content is an important parameter to evaluate the quality of vegetable oils. In a study by (Göhl *et al.* 2019). the free fatty acid content falls within the range reported in the work.

The acid value of sugar apple seed oil was found to be 3.785 mg/g as shown on Table 1. This value indicates the number of acidic compounds present in the oil and is an indication of the oil's quality. A high acid value is an indication of poor-quality oil. The acid value of different

oils can vary depending on their chemical composition and processing methods. For example, the acid value reported by (Göhl *et al.* 2019). Is also with the range obtained in his work. On the other hand, the acid value of used frying oil was reported to be as high as 10 to 50 mg/g (Echarte *et al.* 2019).

The saponification value of sugar apple seed oil was found to be 210.375 mg/g as shown on Table 1. This value represents the amount of potassium hydroxide required to saponify the oil and is an indication of the oil's fatty acid composition. The saponification value of oils can vary widely depending on their fatty acid composition. For instance, oils with high levels of unsaturated fatty acids typically have higher saponification values compared to oils with high levels of saturated fatty acids (Salimon *et al* 2011). In comparison to other sugar apple seed oils, the saponification value of sugar apple seed oil (210.375 mg/g) is of close range of (191.5 mg/g) (Mansor *et al* 2016). The specific gravity of sugar apple seed oil was found to be 0.907 kg/m3, and the density was found to be 0.925 kg/m3 as shown on Table 1. These values indicate the oil's weight and volume, respectively. According to a study by Diaz-de-Cerio *et al.* (2016), the specific gravity of sugar apple seed oil was found to be 0.92, while the density was found to be 0.925 g/cm3.

The iodine value of sugar apple seed oil was found to be 0.355 g/100g as shown on Table 1. This value represents the degree of unsaturation of the oil and is an indication of its fatty acid composition. The iodine value of sugar apple seed oil is relatively low compared to other vegetable oils, which typically have iodine values ranging from 50 to 200. This suggests that the oil has a low degree of unsaturation and is less susceptible to oxidation. Which also is within the range reported by (Göhl *et al.* 2019). The unsaponifiable matter of sugar apple seed oil was found to be 0.05% as shown on Table 1. This value represents the amount of non-saponifiable compounds present in the oil, such as sterols, tocopherols, and hydrocarbons. The unsaponifiable matter content in oils can vary greatly and is dependent on the oil source and extraction method. The unsaponifiable matter obtained in this work fall within the range reported by (Göhl *et al.* 2019; Mansor *et al* 2016).

According to FAO/WHO, the permissible limits for peroxide value in edible oils are 10 meq O2/kg oil, free fatty acids are 2.0%, and acid value is 4.0 mg KOH/g. Therefore, the results obtained for sugar apple seed oil indicate that it is of good quality and falls within the permissible limits. Other studies have also reported similar permissible limits for peroxide value, free fatty acids, and acid value in edible oils. For instance, in a study on the quality evaluation of some commercial vegetable oils, the permissible limits for peroxide value were found to be between 5-10 meq O2/kg oil, for free fatty acids between 1.5-5%, and for acid value between 0.5-5 mg KOH/g (Duru and Ekere, 2015). In another study on the quality evaluation of sunflower oil, the permissible limits for peroxide value, free fatty acids, and acid value were reported to be 15 meq O2/kg oil, 0.1%, and 1.0 mg KOH/g, respectively (Knothe *et al.* 2010).

Table 1: Result on the proximate characterization of the oil

S/N	Parameters	Results	WHO/FAO Limits
1	acid value(mg)	3.785mg	0.6 – 3.0 mg
2	density(kg/m^3)	0.925kg/m^3	No limit
3	free fatty acid(mg)	7.57mg	0.5-5.0%
4	iodine value(g)	0.355g	120 g I2/100g
5	peroxide value(mmol)	0.375mmol	10 meq O2/kg.
6	saponification value(mg)	210.375mg	No Limit
7	specific gravity(kg/m^3)	0.907kg/m^3	No Limit
8	unsaponifiable matter (%)	0.05%	No Limit

GC-MS Analysis of Sugar Apple Seed

The results from Figure 2, the GC-MS analysis of sugar apple seed oil revealed the presence of several compounds, including n-hexadecanoic acid, limonene, octadecadienoic acid, octadecanoic acid, 2-hydroxy-1-(hydroxymethyl)ethyl ester, and n-decanoic acid. N-hexadecanoic acid, also known as palmitic acid, is a saturated fatty acid that is commonly found in plant oils. The high percentage of n-hexadecanoic acid in sugar apple seed oil indicates that it is a significant component of this oil. This finding is consistent with previous studies on the fatty acid composition of seed oils from various plants, which have also shown high levels of n-hexadecanoic acid. Limonene is a terpene that is commonly found in citrus fruits and is known for its distinctive aroma. It has been reported to have various biological activities, including antioxidant and anti-inflammatory properties (Ribeiro *et al*. 2019). The presence of limonene in sugar apple seed oil suggests that it may also possess some of these beneficial properties. Octadecadienoic acid, also known as linoleic acid, is an essential polyunsaturated fatty acid that is required for various biological processes in the body. It is commonly found in plant oils, including seed oils (Chakraborty *et al.,* 2023). The presence of octadecadienoic acid in sugar apple seed oil indicates that it is a good source of this essential fatty acid. Octadecanoic acid, also known as stearic acid, is a saturated fatty acid that is commonly found in animal fats and some plant oils. Its presence in sugar apple seed oil indicates that it contains a mixture of both saturated and unsaturated fatty acids, which is typical of many plant oils. 2-hydroxy-1-(hydroxymethyl) ethyl ester is a compound that is not commonly found in plant oils, and little is known about its biological activity. Further studies are needed to determine the potential health benefits of this compound. N-Decanoic acid is a medium-chain saturated fatty acid that is commonly found in plant and animal fats. It has been reported to have various biological activities, including antimicrobial and antifungal properties (Lin *et al.* 2011). The presence of n-decanoic acid in sugar apple seed oil suggests that it may also possess some of these beneficial properties.

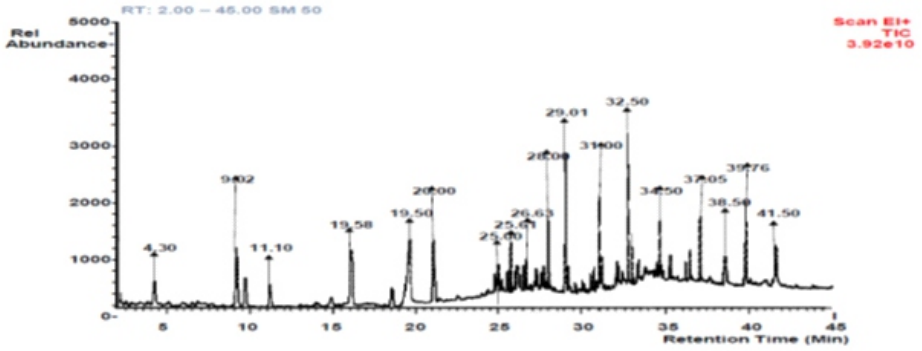

Figure 2: GCMS spectrum regions of sugar apple seed oil

Table 2: Results of gems peaks identified in sugar apple seed oil

Peak #	RT	Compound Detected	Mol. Formula	MW	Peak Area %	Comp. wt%	m
1	4.30	Hexanoic acid	$C_6H_{12}O_2$	116	1.83	2.84	41, 60, 116
2	9.02	Octanoic acid	$C_8H_{16}O_2$	144	4.60	5.26	43, 60, 144
3	11.18	Pyrazine, 2,5 -dimethyl-	$C_6H_8N_2$	108	0.99	1.73	42, 81, 108
4	15.98	β-Myrcene	$C_{10}H_{16}$	136	4.86	2.22	41, 93, 136
5	19.50	β-Pinene	$C_{10}H_{16}$	136	4.31	1.21	43, 93, 136
6	17.32	Hexadecanoic acid, 2-hydroxy-1-(hydroxymethyl)ethyl ester	$C_{19}H_{38}O_4$	330	6.16	6.90	43, 98, 330
7	25.00	α-Pinene	$C_{10}H_{16}$	136	7.33	1.31	41, 69, 154
8	25.61	Decanal	$C_{10}H_{20}O$	156	4.28	5.92	43, 57, 156
9	26.63	n-Decanoic acid	$C_{10}H_{20}O_2$	172	5.53	6.65	41, 60, 172
10	28.00	Undecanoic acid	$C_{11}H_{22}O_2$	186	5.19	6.58	43, 60, 186
11	29.01	Limonene	$C_{10}H_{16}$	136	9.78	14.31	68, 93, 136
12	31.00	Octadecanoic acid	$C_{18}H_{36}O_2$	284	7.34	8.20	43, 73, 284
13	32.50	n-Hexadecanoic acid	$C_{16}H_{32}O_2$	256	13.14	15.95	43, 73, 256
14	34.50	2,6-Octadienal, 3,7 -dimethyl-, (E)-	$C_{10}H_{16}O$	152	7.97	3.41	41, 69, 152
15	38.50	Butane, 1 -(2,2-dichloro-1-methylcyclopropyl)-3-methyl-	$C_9H_{16}C_{l2}$	195	2.75	2.74	43, 58, 185
16	39.76	9,12-Octadecadienoic acid (Z,Z)-	$C_{18}H_{32}O_2$	280	6.72	8.95	41, 67, 280

FTIR Peaks identified in sugar apple seed oil

From the FTIR peaks identified in sugar apple seed oil as shown on Figure 3 at the wavenumbers of 700, 961.7, 1110.7, 1155.5, 1230.0, 1379.1, 1401.1, 1744.4, 2855.1, and 2922.2 cm^{-1} correspond to specific functional groups present in the oil. The peak at 700 cm^{1} is attributed

to the presence of the out-of-plane bending of C-H of aromatics, indicating the presence of aromatic compounds in the oil. The peak at 961.7 cm^{-1} is assigned to the deformation of C-H out-of-plane in trans-alkenes. The peak at 1110.7 cm^{-1} corresponds to the stretching vibration of C-O-C ether linkage. The peak at 1155.5 cm^{-1} is due to the stretching of the C-O-C ether linkage. Table 3 Shows the organic compounds present in sugar apple seed oil. The peak at 1230.0 cm^{-1} corresponds to the C-O stretching of esters. The peak at 1379.1 cm^{-1} is attributed to the deformation of C-H in plane of CH3. The peak at 1401.1 cm^{-1} corresponds to the asymmetric stretching of CH_3. The peak at 1744.4 cm^{-1} is attributed to the stretching of C=O bond in esters, indicating the presence of fatty acid esters. The peaks at 2855.1 and 2922.2 cm^{-1} correspond to the symmetric and asymmetric stretching vibrations of CH_2, indicating the presence of fatty acids in the oil. Overall, the FTIR analysis of sugar apple seed oil indicates the presence of various functional groups that are characteristic of fatty acids and esters, as well as aromatic and ether compounds.

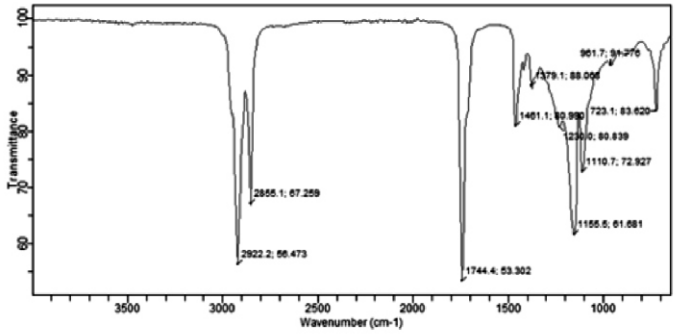

Figure 3: FTIR Peaks identified in sugar apple seed oil
Table 3: results of ftir peaks identified in sugar apple seed oil

S/N	**Wavenumber, cm^{-1}**	**Bond**	**Functional Group**
1	700	C-H	ALKYNE
2	961.7	O-H	CARBOXYLIC ACIDS
3	1110.5	=C–H	ALYNE
4	1155.5	C–N	ALIPHATIC AMINES
5	1230.0	C–N	ALIPHATIC AMINES
6	1379.1	C–H	ALKANES
7	1401.1	C–H	ALKANES
8	1744.4	C=O	ESTERS, SATURATED ALIPHATIC
9	2855.1	C–H	ALKANES
10	2922.2	C–H	ALKANES

Conclusion

Based on the discussion, several conclusions can be drawn: the physicochemical properties of sugar apple seed oil suggest that it has potential for various applications, but some parameters exceed the FAO/WHO permissible limits for edible oils. The extraction yield of 54.6% suggests a relatively efficient extraction process, while the low peroxide value indicates that the oil is fresh and has not undergone significant oxidative degradation. However, the high levels of free fatty acid and acid value suggest that the oil may require

further processing or refinement before it can be used as an edible oil.

The sample analyzed using GCMS contains sixteen different compounds, including n-Hexadecanoic acid, Limone, Octadecadienoic acid (Z,Z), Octadecanoic acid, and n-Decanoic acid, with varying composition weights. The FTIR results suggest that the sample contains several functional groups and bonds, such as C-C-H, O-H, =C-N, C-N, C-H, C=O, and C-H. However, the specific compound(s) present in the sample cannot be determined without further information and analysis. Both GCMS and FTIR are powerful analytical techniques used to identify and quantify the components and functional groups of a sample, but additional analytical techniques may be required to confirm the identity of the compounds. Careful interpretation and analysis of analytical results are necessary to draw accurate and meaningful conclusions about the sample being analyzed.

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