Title

BIOPHYSICO CHEMICAL EVALUATION OF NON-EDIBLE SEEDS SOURCES FOR BIODIESEL PRODUCTION

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In

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LOVELY SCHOOL OF BIOTECHNOLOGY

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ABSTRACT

Bio diesel has become more attractive now days because of its environmental factors, moreover because it is a renewable resource. Biodiesel from edible oils and fats will impact food security and economical values of the country therefore non edible oil sources are preferred. Jatropha, castor, soap nut, kaner and neem are the major source for biodiesel production from non edible oil resources. It has been analyzed that, oil yield of Jatropha is 28%-31%, castor 25%-30%, soap nut with 22%-30%, neem with 28%-30% and kaner with 24%-30% oil yield. During physiochemical analysis it has been estimated that Jatropha has flash point of about 190-205℃, castor190-195℃, kaner 170-190℃, soap nut 200- 200℃ and neem with150- 165℃, where as Jatropha has 200-210℃ fire point, castor200- 210℃, kaner180-200℃, soap nut 205-215℃ and neem170-175℃ respectively. During pour point and cloud point analysis it has been estimated that Jatropha has -1 to -2℃ and 4 - 6℃ pour and cloud point, castor-5 to -8 and 5 to 6℃, kaner -3 to -6 and 10 - 14℃, soap nut-1 to -4 and 2 – 5 and lastly neem with -2 to -4 and 3 - 5℃ respectively. During kinematic viscosity analysis Jatropha had17.06 - 20.49, castor had 19.04 - 20.2, kaner had 39.63 - 40.42, neem had 40.02 – 43.75 and soap nut of about 31.37 - 32.19 respectively. Specific gravity of Jatropha is 0.872 - 0.895, castor 0.897- 0.958, kaner 0.905 – 0.931, neem0.829 - 0.832 and soap nut 0.986 – 0.990. Saponification value of Jatropha is 190 -216, castor 185.83 - 190.36, kaner 230.2 - 265.3, neem186.20 - 188.10 and soap nut190.68 – 191.7. Iodine value of Jatropha is 103.2 -104.46, castor 89.52 – 89.68, kaner 83.69 - 85.68, neem 77.53 - 81.28 and soap nut 91.89 – 92.36 respectively. Hence it may be concluded that Jatropha and castor are the best source for production of non edible oil and for commercial use.

Keywords: Bio diesel; non edible oil; transesterification; physicochemical analysis

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DECLERATION

I hereby declare that this project work entitled "**BIOPHYSICO CHEMICAL EVALUATION OF NON-EDIBLE SEEDS SOURCES FOR BIODIESEL PRODUCTION**" has been prepared by Gagandeep Singh Bhatia under the guidance of Dr. Kuldip Chandra Verma assistance professor of Biotechnology, Lovely Professional University Punjab. No part of this thesis has formed the basis for the award of any degree or fellowship previously.

Gagandeep Singh Bhatia

Date

CERTIFICATION

This is to certify that Gagandeep Singh Bhatia has prepared his thesis under my guidance and supervision entitled **“BIOPHYSICO CHEMICAL EVALUATION OF NON-EDIBLE SEEDS SOURCES FOR BIODIESEL PRODUCTION”** for the award of Masters Degree with Honors of the Lovely Professional University Under my guidance. He has carried out the work at the Department of Biotechnology, Lovely Professional University.

Date **Dr. Kuldip Chandra Verma**

(Supervisor)

TABLE OF CONTENT

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

S.No	Abbreviation	Expanded form
01	ASTM	American society for testing and materials
02	BIS	Bureau of Indian Standards
03	B10	10% biodiesel and 90%petrodiesel
04	B20	20% biodiesel and 80%petrodiesel
05	B100	100%biodiesel
06	CSt	Centistokess
07	FFA	Free fatty acid
08	Ha	Hectare
09	Mha	Million hectare
10	MMT	Million Metric tone
11	MW	Mega watt
12	FAME	Fatty acid methyl ester
13	Mg	Milligram
14	DF	Diesel fuel
15	HC	Hydrocarbons
16	KOH	Potassium Hydroxide
17	SSS-NIRE	Sardar Swaran Singh National Institute of Renewable Energy
18	Kg	Kilogram
19	MNRE	Ministry Of New and Renewable Energy
20	AEC	Atomic Energy Commission
21	CO	Carbon monoxide
22	MW	Molecular weight
23	AOAC	Association of official Agricultural chemists
24	HSDB	Hazardous substance Data Bank
25	℃	Degree of Temperature-Centigrade
26	Wt.	Weight
27	HSD	High speed diesel

CHAPTER-1

INTRODUCTION

INTRODUCTION

In recent years, the energy consumption increases vigorously due to the surplus blast in population which led to an increase in energy demand. Due to the limited resources of fossils fuel, attention is concentrated over renewable sources of energy i.e. alternative renewable fuels (natural occurring). Bio diesel is found to be an alternative to conventional fuel. Hence, biodiesel can be produced from edible sources, but it may lead to create a great impact on food stock and economic resources. The use of edible vegetable oil and animal fats for bio diesel production had recently been of great concern that they will affect the food economy as well as other economical resources. Bio diesel or biofuels is a natural and renewable domestic fuel made from non-edible sources. It holds no petroleum and is completely biodegradable and non-toxic towards environment as well as towards human population. It is viewed as an alternative source for diesel engines as well as for other transportation type vehicles. Hence, all the focus is on oil bearing plant stocks that produce non-edible oils as the feed stocks for bio-diesel production. In 1930s and 1940s vegetable oil were used as an alternative to diesel fuel from time to time **(Nietzsche *et al.,* 1965**). One hundred year ago Rudolf Diesel tested vegetable oil as fuel for motor engine (**Shay *et al.,* 1993**).

Continued use of conventional fuel will increase air pollution and intensify the global warming problems caused by carbon dioxide and other toxic gasses release in environment (**Shay *et al*., 1993**). Recently vigorous hike in crude oil prices, limited sources of fossil fuel and environmental concerns i.e. (global warming, depletion of species and increased health concern). Bio fuel has the potential to reduce the maximum level of environmental pollutants and the level of potential carcinogens present in the environment (**Krawczyk *et al.,* 1996**).There has been a continuous and immense focus on waste vegetable oils and animal fat to make biodiesel fuel (**Demirbas *et al.,* 2006**).

Energy is required for human consumption and economy development on daily basis. India ranks sixth in world in relation of high energy demands and consumption which is accounting for 3.5% of world commercial energy consumption in 2001. During 2004-05 the country imported 95.86 million tons (MT) of crude oil which valued around 26 Billion of U.S dollars (**Dwivedi *et. al*., 2014**). The Indian economy is expectedly growing at the rate of more than 6% per annum, currently 70% of the conventional fuel needs placing a heavy burden on country's economical value and capital investment. The continuous increase in the demand of crude oil will led to increase in price, cause by the limited crude oil availability from the international market which has forced India to move towards the renewable energy resources (**Teddy *et al.*, 2011**). The figure 1 shows the trend analysis of crude oil in India.

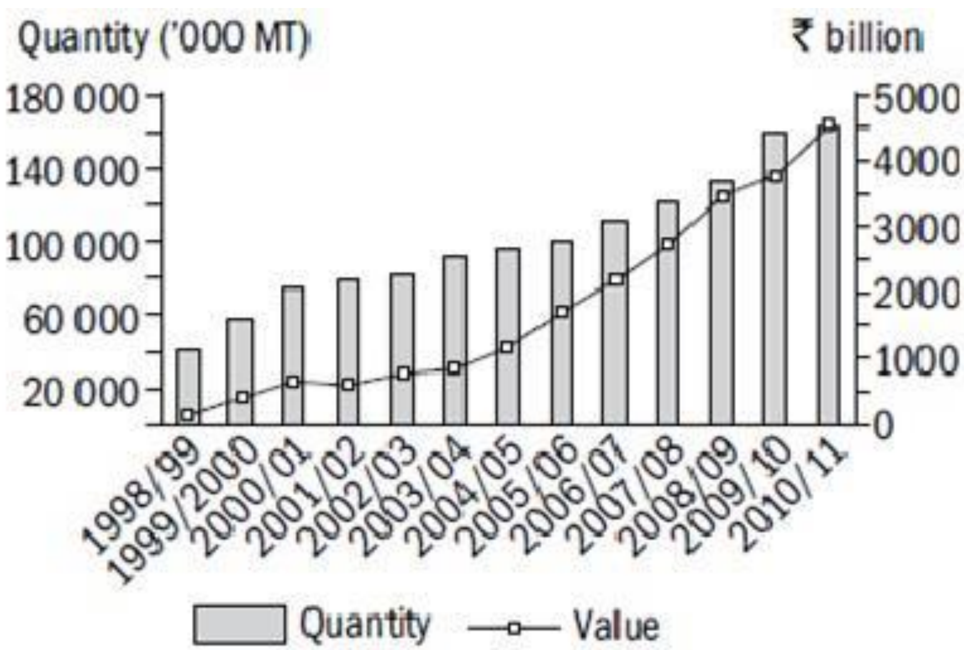

Fig: 1 Trend and quantity of crude oil imported in India (Teddy *et al*., 2011)

CHAPTER-2

REVIEW OF LITERATURE

Review of Literature

Coal is the most abundant and an important fossil fuel in India and still accounts for 55% of India's commercially energy needs. However country has huge potential due to its topographic features and climate turnover advantage, to produce seeds bearing high quantity oil for biodiesel production to overcome demand and diesel requirements from total crude oil (**globalinsight.com/energy 2008**).

A large population in rural India is still depends upon traditional fuel sources of energy such as firewood, animal dung and biomass (**Hemant *et al.*, 2011**). Carbon released during the biodiesel combustion can be recycled trough the next crop production, therefore no additional burden on environment. Biodiesel is nothing but just methyl or ethyl esters of fatty acids made from edible as well as non- edible oil and animal fats. The main resources for biodiesel production in India from non- edible oil bearing seeds obtained from plant species such as *Jatropha curcas*, *Ricinus communis*, *Azardirachta indica, Sapindus mukorossi* and *Nerium oleander*. **(Panwar *et al.*, 2011).**

Biodiesel is one of the major products one gets originally derived from vegetable oil, non-edible oil seeds and from animal fat. It has been an interesting and productive alternative source to be used in diesel engines because it got similar properties of traditional diesel fuel. India introduces biodiesel as a diesel substitute and for blending with diesel. Early, mainly biodiesel is produced by the economical crops like sunflower, soybean, mustard oil etc. (**Rathore *et al.*, 2011**).

As per the conducted survey by planning commission of India, estimated requirement of petrol diesel is vigorously growing from approximately 10 million tons in 2006 and 12.5 million tons in 2012 and will continuously increase. Center is being playing crucial role in development and promotion of renewable source of energy. The facilities created at the center are highly advanced and unique in India and in south East Asian region. SSS-NIRE is being a major player in renewable resources development based at Kapurthala (Punjab). (**mnre.gov.in 2013**).

Thus, substituting conventional fuel with biodiesel, use with every major and minor modification in diesel engines. One of the attractive feature of the biodiesel is its, biodegradability and been more environmental friendly than the fossil fuels, resulting upon less environmental impacts. Hydrocarbon emissions are usually found to be comparatively low as compared to petroleum diesel. This is because due to the more complete combustion caused by the increased oxygen content in the flame coming from biodiesel molecules. It is recommended to produce biodiesel by using non edible oil source such as Jatropha, castor, gulmohar, neem, kaner, soap nut, mahua, and pongamia etc. and kitchen oil waste. **Bhardawaj *et al*., 2013**

Table1: Production of non-edible oils in India (Sengupta *et al.*, 2013).

S. No.	Botanical name	Local name	Annual productivity (Tons)
01	*Jatropha curcas*	Ratanjyot	45,000
02	*Pongamia Piñata*	Karanj	135,000
03	*Schleicheraoleosa*	Kusum	25,000
04	*Azardirachta indica*	Neem	1,00,000
05	*Shorearobusta*	Sal	1,80,000
06	*Modhuca indica*	Mahua	1,80,000

An emission performance test for various biodiesel formulations including diglyceryl and triglyceryl esters biodiesel blends releasing less regulated and toxic air pollutants compared with biodiesel alone. A study was reported in Indian context if 10% of the total production of castor seed oil is transesterified in to biodiesel than about 79,782 tons of carbon dioxide emission can be saved on annual basis.

Increasing pressure due to surplus blast in population and increasing use of energy in agriculture, industrial, domestic and the public sector is the area of concern. As India continues to grow at the rate of 8-9.5 % annually energy security has become the core issue (**www.dae.nic.in).** Regarding concerns over energy security, government of India has taken multiple steps in recent years for this, which include encouraging private sector participation, a more realistic approach towards increasing the sector, base and improving efficiency in the sector as the whole.

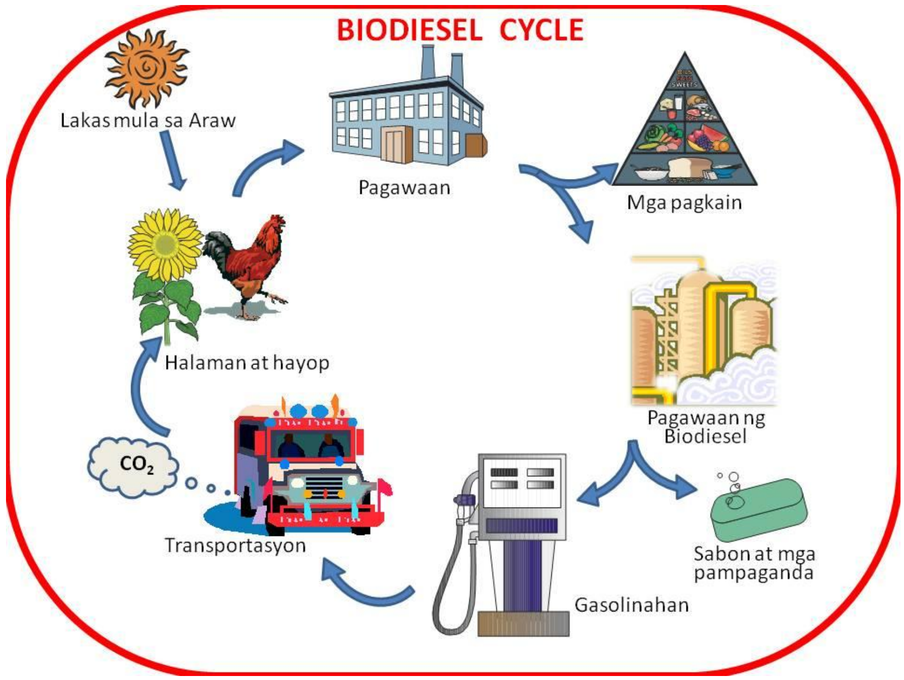

Fig: 2 The biodiesel cycle (www.biodegradabletableware.com).

Fats and oils are typically water insoluble, hydrophobic in nature that are made up of long chain of fatty acids. Fatty acids vary in their carbon chain, length and in number of unsaturated bonds (double bond). Natural vegetables oil and animals fat are extracted in order to obtain crude oil. Crude oil usually contains free fatty acids, phospholipids, sterols, water, odorants and other impurities. Even refined oils and fats also contain free fatty acid. The free fatty acid have some water content have significant effects on the transesterification of glycerides with alcohols.

2. Description of Plant Sources for Biodiesel Feedstock

2.1 Soap nut (*Sapindus mukorossi*)

According to **Mandava *et al*., 1994** reported that saponins from soap nut shells specific gravity 0.980-0.990 and viscosity of 30.37-32.10 can be used for treatment of soil contaminants. Several other studies also showed that soap nut has a great potential as a natural surfactant for washing the soils contaminant with organic compounds. The saponins do not have any toxic effects on human physiology. This pericarp is of great concern and seeds are usually waste.

Castor oil mainly had medicinal uses and other applications. Ricin is highly toxic content making castor a toxic seed plant that is why it cannot be grazed by cattle. Castor is cultivated around the world for industrial chemicals like surfactants, grease, and lubricants, specially soaps, surface coatings, cosmetics, personal care products and in pharmaceuticals. The Indian variety of castor seeds has an oil content found to be of 42% and 48% that can be extracted. India is the world largest producer and exporter of castor oil. According (**Rajagopal *et al*., 1996**) density of castor is 0.993 – 0.956 with 0.022 acid value.

Ratanjyot (*Jatropha curcas)* is a perennial, drought resistant plant. It can survive well either in poor soil or in marginal property soil. Several studies have shown that Jatropha seeds had an immense potential for the production of plant based oil to produce biodiesel with kinematic viscosity 15.2 – 20.09 and flash point190 -220℃ (**Azam and Subramanian, 2005***)*

Yellow Oleander (*Thevetia Peruvian)* oil seeds contain about 60-65% oil content for biodiesel production and good alternative protein source (37%) for live stock feeds with 0.920 – 0.936 density and 210 – 245.3 saponification value (**Ibiyemi *et al., 2006***).

Soap nut /soapberries *(Sapindus mukorossi)* is a seed of soap nut tree basically found in tropical and sub- tropical regions of different parts of world. From ancient times and sages soap berries shells have been cultivated and used for washing purposes. It has been found that the oil from soap nuts is of great potential for bio diesel production. The drupes (soap nuts) contain saponins which are a natural surfactant Recently it has been reported that the glycerol, a by-product of bio diesel production can be further used to produce organic acids such as succinic acid by enzymatic method fermentation. With 880-918 density and 39.9- 49.9 viscosity, the economics of the biodiesel from the soap nut oil can be easily realized on economic scale. (**Chhetri *et al*., 2007**).

Fi*g*: 3 Ripe soapberries (A) and Cracked nut shells of soap nuts (B)

(en.wikipedia.org) **(Chhetri *et al*., 2008)**

The yield in terms of oil content varies from 350-650 kg of oil per hectare, without serving the insecticides, pesticides and fertilizers. (**castoroil.in 2008**). Castor oil is classified by its high content, over 85% of ricinoleic acid. No other non-edible oil contains so other high content of Fatty hydroxyl acids. Castor oil distinguishable property such as has high molecular weight(298), low melting point (5°C), and very low solidification point (−12°C to −18°C) make it Industrially useful, most of all for the highest and most stable viscosity of any vegetable oil. The comparative advantage castor over Jatropha cultivation is that, that castor grows in much shorter period with respect to Jatropha. . Castor (*Ricinus communis*) is a source of castor oil, which has wide range of uses. The seed contents of oil are about 50-60 % of triglycerides and mainly ricinoleic acid at about 89.5% of its contribution, with 0.022 acid value and 19.4 kinematic viscosity (**Shrirame *et al*., 2011**).

2.2 Jatropha (*Jatropha curcas*)

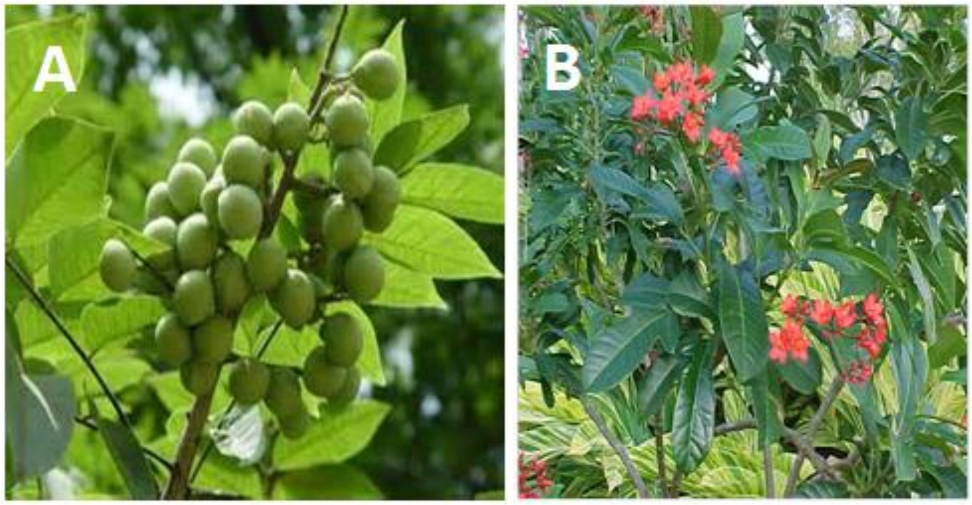

Fig: 4 Jatropha berries (A) and flowering (B)

(**Toptenz.net.com**) (**www.sudano.info**)

According**, Jadon *et al.*, 2012** flash point of Jatropha oil is about 200-240℃, density 840-918 and viscosity 20.09 - 40.29. There are over 300 different species of trees which produce oil bearing seeds thus there is a significant potential for non-edible oil source from different plants for biodiesel production as an alternative to conventional petrol diesel. The two major varieties (*S.mukorossi and S.trifoliatus*) are broadly available in India and other Asian countries. Comprehensive study carried out on the use of various parts of the soap nut tree, it has been found that soap nut has various applications ranging from various treatments up to use as soap bars and detergents and analyzed that, specific gravity ranges from 0.980- 0.990, density 0.891 – 0.918, viscosity 43.6 – 49.9 respectively.

2.3 Castor (*Ricinus communis)*

Fig: 5 Castor kernels (A) and Castor flowering (B) (www.outsidepride.com)

Shikha *et al.*, 2012 reported that, the oil content in of *S.trifoliatus* which is found to be very similar to *S.mukorossi* nuts, which was an average of about 51.8% of seed weight. The soap nut oil has been considered as non-edible oil having a significant potential for bio-diesel production which is a waste. Soap nut fruit shells have been in use as detergent obtained naturally from soap nut kernels for washing and leaching gold ornaments, for bathing and as a traditional medicine preparation**.** It has been found that the use of soap nut seeds as a bio diesel source becomes the "waste –to-energy" scheme Furthermore, planting soap nut trees at barren waste lands provides sink for atmospheric carbon storage as well as feed stock for bio diesel production It has been found that Jatropha seeds can produce 37% of the oil content total of seed weight, which has a very distinctive property that it can burn smoke free as B100 in diesel engines with 0.881 – 0.983 density and 17.6 – 21.68 kinematic viscosity.

Yellow oleander is an evergreen ornamental plant which grows to about 2-6 m in height. The plant belongs to *Apocynaceae* family and is widely found in America, Asia, African continental regions. The plant starts flowering after one year of plantation and there after blossom thrice in a year. (**Oseni *et al.*, 2012***)* with 0.880 – 0.931 density of oil and 170 - 200℃ fire point, kinematic viscosity 40.42, cloud point 14℃, pour point 2℃ respectively.

2.4 Neem *(Azardirachta indica*)

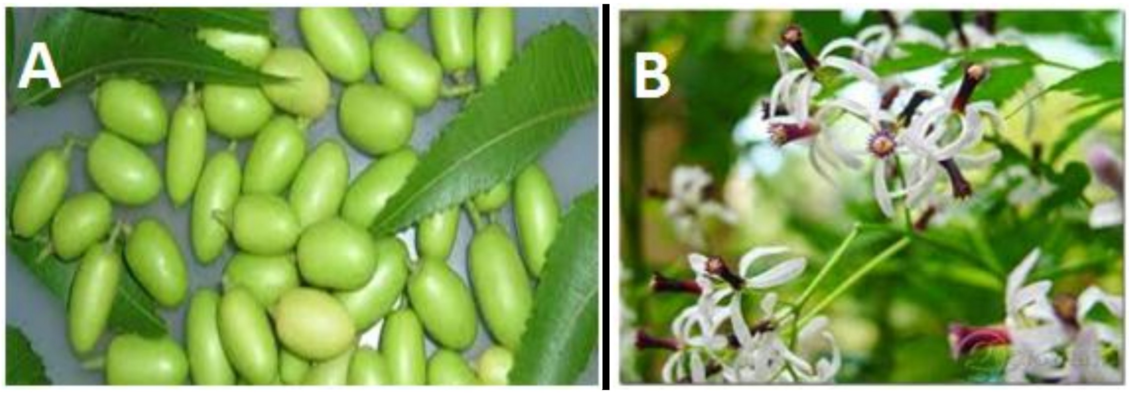

Fig: 6 Fresh Neem kernels (A) and flowering (B)

(www.mythicmaps.net, www.killbugsnaturally.com)

Neem (*Azardirachta indica)* is a tree belongs to *Mahogany* family. It is found abundantly in every part of the country. Neem is the fastest growing tree that can reach up to 15-20 m (about 50-60ft). It is evergreen in India and also popular with the name "The miracle tree". Neem is found throughout India. It is popular village tree. Neem can easily be grown in any type of soil either clay, loamy, sandy, and shallow as well as in dry soil. Uses ranging from shoots stem, and leaves of neem are used to prepare many different medicines, tropical agents and various other products for their properties. They are said to be antifungal, antibacterial, ant diabetic, sedative as well as antiviral. People in India consume its twigs to brush their teeth. Neem bark contains tannins which are used in tanning and dyeing industry **(Heroor and Bharadwaj, 2013)**. With 150 -170℃ flash point and 5 – 1℃ pour point. Neem oil is used for preparing cosmetics, lotions, soaps and shampoo and is useful for skin treatment such as acne treatment. Neem oil is used effectively as mosquito repellent, 38.69 – 42.59 kinematic viscosity **(Gahadwal and Yadav, 2014).**

2.5 Kaner/Yellow oleander (*Thevetia Peruvian)*

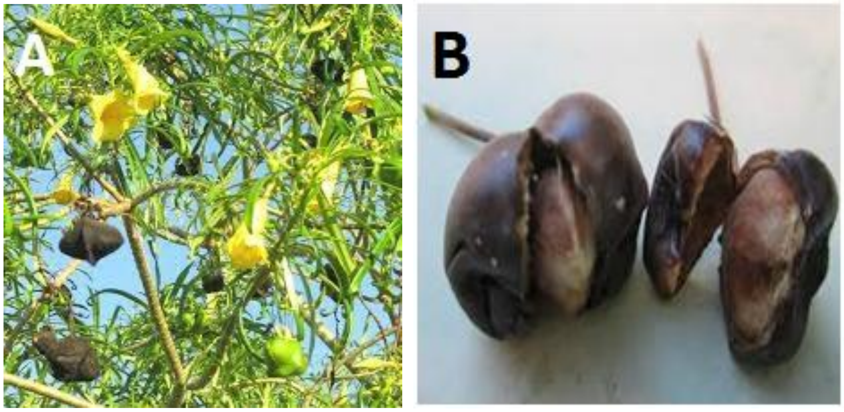

Fig: 7 Yellow oleander blossoms (A) and seeds (B)

The kaner fruits are usually green in color and become black on ripening. The fruit pericarp consists of seed and plant bears milky juice in all organs. Mature fruits seed contain about 60%- 65% oil content (**Wikpedia.org/wiki/cascabela_thevetia**). Kernels are said to be 60%-65% of oil content in it. Kaner is generally not grazed by domestic animals so it can be an optional source of biodiesel production. In India kaner is planted as an ornamental plant and can also be found in wild areas. It doesn't require high rainfall and fertilizers and manure for growth and maintenance.

CHAPTER-3

SCOPE OF STUDY

SCOPE OF THE STUDY

India is being located nearer to the equator and is fulfilled with rich natural resources and vast potential of renewable resources. It is the upcoming trend of renewable energy and is running one of the largest programs of renewable resources programs and consumption in the world. Today, India has the significant potential for generating power from renewable energy resources like wind energy, biomass energy, small hydro projects, thermal energy. India ranked as fifth country in the world in relation to wind power energy production after Denmark, German, Spain, and USA with estimated total wind potential of 45195MW (**Dwivedi *et al.*, 2014**). Biomass energy ranked third for power generation after wind and solar renewable energy sources with total potential of 24600 MW (**mnre.gov.in**). To overcome the dependency on the imported crude oil (conventional fuel) we have to initiate the use of other sources of renewable energy like biomass, solar, hydro, geothermal, wind energy.

Biodiesel as an alternative to conventional diesel fuel

Biodiesel has been termed as a clean burning ester based on oxygenated fuel made from natural, renewable sources such as kitchen waste vegetable oil, non-edible oil and from animal fat. The resulting biodiesel is found to be quite similar to the conventional Diesel fuel in its main characteristics and fulfilling the criteria with standards. Biodiesel contains no traces of petroleum products; in fact it is a compatible with conventional diesel engines and can be blended in any proportion with conventional diesel fuel to create a suitable biodiesel blend. The blending level with petroleum diesel is referred as BXX, where XX indicates the amount of biodiesel in the blend i.e. B10 blend is 10% biodiesel whereas and 90% diesel (**Dwivedi *et al.*, 2013**). Biodiesel is an alternative to conventional fuel. Biodiesel production from some non- edible resources like Jatropha, Neem, Kaner, Soap nut and Jatropha.

By looking over their potential for production of renewable biodiesel, significance and taking them in to the considered source, as the best option to overcome petroleum-diesel, thereby declining the dependence on crude oil. To provide energy security to the country and to reduce dependency on imported crude oil, biodiesel has several other benefits such as reduced pollutant emissions, high fuel standards for vehicles, increased employment in the agricultural sector and conversion of waste land in to productive land, increasing global warming issue and other minor issues related.

Biodiesel is a biodegradable fuel and can burn up to 70% cleaner fuel with 93% of lower hydrocarbon, 50% of lower CO, and 45% of lower particulate matter in comparison with conventional diesel fuel (**Dwivedi *et al.*, 2011**). It can be used as partial or complete petro-diesel replacement in unmodified diesel engines. Biofuels are often classified in to basically three generations;

- 1st generation biofuels are often considered as conventional biofuels. They are made from the sources like sugar, starch or vegetable oils.
- 2nd generation biofuels are produced from sustainable feed stocks. Second Generation biofuels are often called "advanced biofuels".
- 3rd generation biofuels are unique type of biofuels because of their production from a unique source such as "algae". These types of biofuels have the higher potential than the 1st generation and the 2nd generation biofuels. (**Biofuels**. **org.uk/biofuels facts**.)
- In certain research work it has been found that B100 reduces ozone smog formation by 50%.
- B100 biodiesel usage is enabled to reduce the exhaust emissions of carbon monoxide by 48% and resulting hydrocarbons by 67 % whereas sulfur emission can be totally eliminated by using B100 type of biodiesel **(www.iowarfa.org/biodiesel _facts**.).

CHAPTER-4

OBJECTIVES OF THE STUDY

Objective of the study

- Collection of different non- edible seeds and oil extraction.
- Bio-Physicochemical characterization of extracted oil for biodiesel production.

CHAPTER-5

MATERIALS AND RESEARCH METHODOLOGY

RESEARCH METHODOLOGY

5.1 Sample collection

Sample seeds were collected from different regions of India of different species. Table 2 includes the different non-edible samples from different regions of India. Samples were studied on the basis of morphological characteristics include size, color and seed coat.

Table 2: Morphological characterization of different non-edible seeds.

S. No.	Sample	State		Seed physical characteristics	
01	*Jatropha curcas*	R.J	M.P	Oval &dark brown in color with smooth shell.	Oval & light brown in color with smooth shells.
02	*Azardirachta indica*	U.P	M.P	Round & tanned in color with hard shells.	Round and dark in color with hard shells.
03	*Ricinus communis*	U.P	M.P	Brown in color with white spots, thin shell.	Dark brown in color with slime thin shells.
04	*Nerium oleander*	U.P	P.B	Dark brown in color with hard shells.	Dark brown in color with hard shells.
05	*Sapindus mukorossi*	U.P	M.P	Round and dark black with hard shells.	Round and dark black in color with hard shells.

5.2 Processing of seeds

Seeds were collected and are cleared manually by hand to remove unwanted materials such as dust, leaves, and other seeds. The pulp of the seed is of no use, so it is removed with the help of knife so than no part of pericarp remain on the seed coat. The seeds are dried for one day in open air under sunlight.

Fig.: 8 Non edible seeds of Jatropha (A) and castor (B)

5.3 Drying and Crushing of seeds

The collected sample were dried in hot air oven for consecutively for 8 hours at 70℃ (depend upon the thickness of the shell). After samples got baked they were crushed by the suitable mechanical method, i.e., depending upon the seed coat and shell thickness, the mechanical blender and mortar and pestle is used.

Fig: 9 Crushed seeds of Jatropha (A) and soap nut (B)

5.4 FLOW CHART

Seeds (50g)

↓

Drying 70℃

↓

Crushing (mortar pestle, mechanical homogenizer)

↓

Oil extraction using soxhlet (70℃ for 8hrs)

↓

Transesterification reaction (65℃ for 2hrs.)

↓ KOH

Settling tank (2hrs)

↓

Impure biodiesel→distiill water washes (3 times)

↓

Impure biodiesel

↓ Sodium sulfate

Drying

↓

Pure biodiesel

Fig: 10 Flowchart for Biodiesel production. (Belewu *et al.*, 2010)

The kernels (50g) were grinded up to a suitable mash size for oil extraction. The sample were wrapped in a fine pore size high quality filter paper as a thimble and loaded in to a Wheatstone soxhlet extractor the method described by **Belewu *et al.*, 2010**.

The reaction was carried out continuously for 8 hrs. The oil content extracted from the extractor consists of oil, impurities and solvent that is *n*-hexane. Solvent was simply recovered by simple distillation method by using distillation unit and operating it at 60℃ until all the miscible solvent is recovered in the form of condensate.

Fig: 11 Oil extractions by Soxhlet apparatus.

According to **Akpan *et al.*, 2014**, 250 ml of normal hexane was poured in to a round bottom flask. 50 gram of sample was placed in a thimble and was inserted in to the center of the extractor. The soxhlet was heated up to70℃ . During the solvent boiling, the vapor rises through the vertical tube in to the condenser at the top. The liquid condense drips in to the filter paper thimble in the center, which contains the solid sample to be extracted. The extract seeps through the pores of the thimble and fill the siphon tube, where it flows back to the round bottom flask. This was allowed to continue for 7 hrs. It was then removed from the tube. Normal hexane is used in extraction of vegetable oils from seeds such as soybean, cotton, flax, safflower etc. (**Bhagya and Srinivas, 1992**). It is also use as alcohol denaturant and as paint diluents. The textile, furniture and leather industries use n-hexane as a cleaning agent. Many petroleum and gasoline products contain n-hexane (**Jorgensen and Chor, 1981**). At the end of the extraction the resulting mixture containing the oil was recovered.

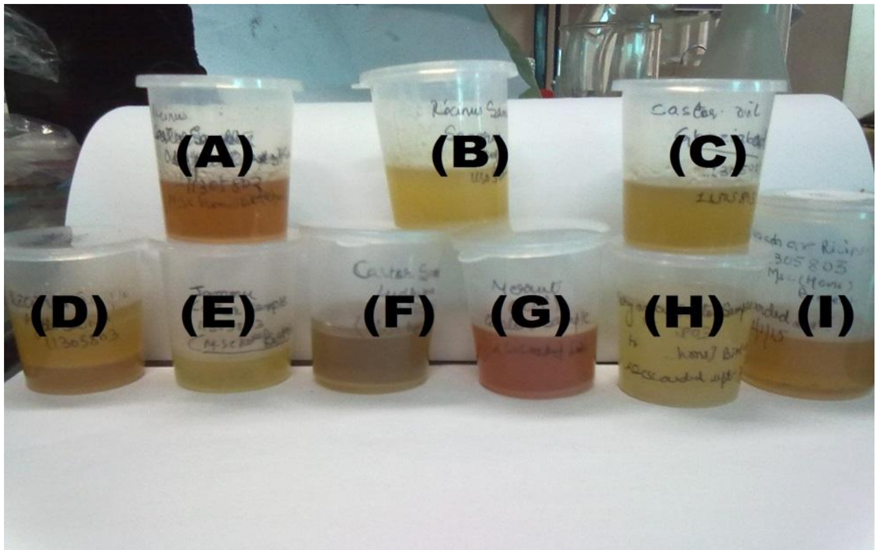

Fig: 12 Extracted non-edible oil from different samples.

(A) Castor U.P,(B) Castor M.P,(C) Jatropha R.J,(D) Jatropha M.P,(E) Kaner U.P,(F) Kaner P.B,(G) Neem U.P,(H) Soap nut U.P (I) Neem M.P.

The oil was filtered by using a fine pore size high quality filter paper to remove solid debris and the distilled residual oil was heated up to 100℃ for 1hr in order to remove any water content from it. The oil was then cooled and stored in sealed plastic bottles.

<u>5.5 BIOPHYSICOCHEMICAL CHARACTERIZATION</u>

1. Determination of the percentage of oil extracted

The percentage of oil content can be calculated as; (**Joshi *et al*., 2011**)

$$\%\ \text{of oil} = \frac{\text{Weight of oil obtained in gram}}{\text{Weight of seed taken in grams}} \times 100$$

After the oil has been extracted and its oil yield percentage has been calculated.

2. Physicochemical and thermal analysis

Physicochemical and thermal analysis is carried out according to the ASTM and BIS standards. Biophysicochemical and thermal analysis was carried out of oil samples including specific gravity, flash point, fire point, cloud point, free fatty acid, peroxide value, pour point, cloud point, Iodine value, saponification value, kinematic viscosity and density.

Free fatty acid content was determined as described by (**David *et al.*, 1970**), flash point and fire points (ASTM D-92), moisture content, pour point, (ASTM D-97) and viscosity (IP71/ASTM D-445) was determined by as described by (**Baker *et al.*, 1984**).

3. Transesterification (Alcoholysis)

This process is also known as Alkali Treatment in which the triglycerides of oil react with methoxide ions in presence of alcoholic or basic catalyst. We use KOH as catalyst to produce methyl esters which is known as biodiesel. A catalyst is generally used to improve the reaction rate and yield.

RCOOR’ + R” RCOOR” + R’OH

If methanol is used in above reaction it is termed methanolysis. The reaction of triglyceride with methanol is represented by general equation (**Bhandare and Naik, 2015**).Ethanol, methanol, propanol, butanol and amyl- alcohol can also be used but ethanol and methanol generally used for transesterification. Methanol is widely used for producing biodiesel compared to other alcohols, as it is not expensive, prevent soap formation and reactivity is high even methanol recovery is comparatively easier.

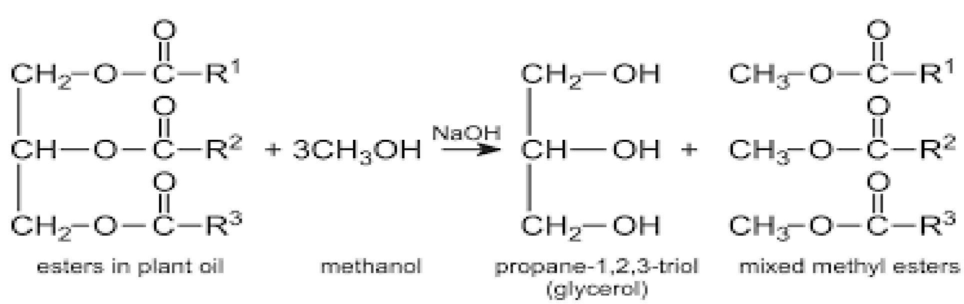

Fig: 13 General overall reaction of transesterification (www.intechopen.com)

The reaction can be catalyzed by alkalis, acids or enzymes. The alkalis include NaOH, KOH, carbonates, and corresponding sodium and potassium alkoxides such as sodium methoxide, sodium propoxide, sodium ethoxide and sodium butoxide. Alkali catalyzed transesterification is much faster than the acid-catalyzed transesterification and is most often used commercially. (**Bhandare and Naik, 2015**).

After the completion of transesterification reaction of triglycerides, the products are the mixtures of glycerol, alcohol, catalyst and di, tri and monoglycerides. The mixture is taken in another 500ml round bottom flak. The amount of catalyst that should be added to the reactor varies on the quantity of the crude biodiesel. Using magnetic stirrer and heating equipment the transesterification reaction is carried out. The transesterification reaction should be carried out carefully with all precautions, so that excessive heating can led to the change in the nature of methyl esters and can also led to the bursting of apparatus.

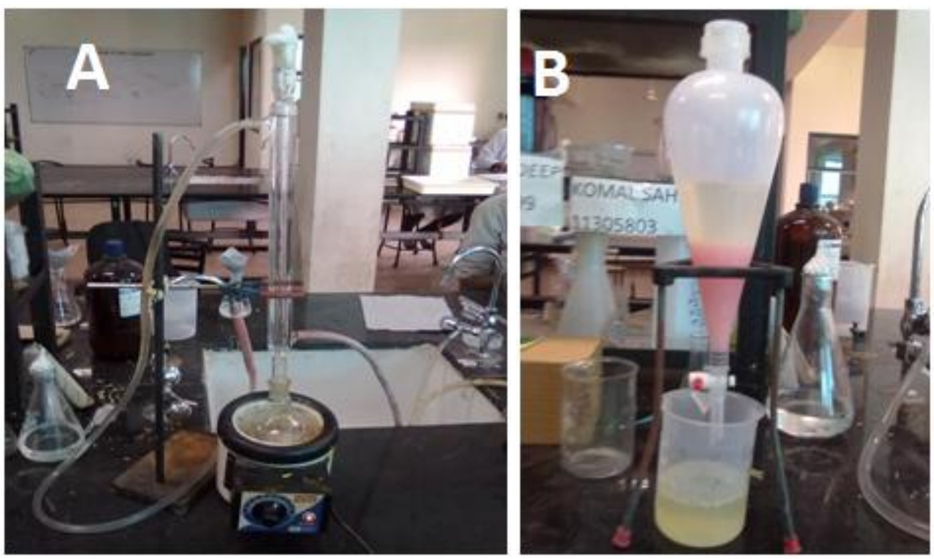

Fig: 14 Refluxing of crude oil (A) and Layer formation of oil (B)

In this step resulted solution from transesterification reaction is allowed to settle down in a separating funnel for 2 hrs. It is clearly visible that a clear layer of methyl ester & glycerol is formed as indicated in fig. No.14 (B) Glycerol being denser settles down below methyl esters & drained off by opening the draining knob of the separating funnel. Thus the methyl esters are separated from glycerol. The collected washes are impurities which are collected and discarded carefully with all precautions.

4. Determination of Moisture Content of the Seeds

According to (**Belewu *et al.*, 2008***)* 50g of the manually picked best sample were collected, weighed and dried in an oven at 80°C for 7hrs and weighed every 2hrs. The procedure was continuously repeated until a constant weight was obtained. At every 2 hours interval, the sample was removed from the oven and placed in the desiccators for 30 minutes to cool down. It was then removed and re-weighed. The percentage moisture of the seed was calculated by the given formula:

$$\textbf{\% Moisture} = 100(W1 - W2)/W2$$

Where, W1 = Original weight of the sample before drying; W2 = Weight of the sample after drying.

$$\textbf{\% Moisture} = \frac{(\text{Initial weight of the oil} - \text{Final weight of the oil}) \times 100}{\text{Initial weight of the oil}}$$

5. Specific gravity determination

Specific gravity is the important measure of the liquid fuel and its properties. To measure the specific gravity, specific gravity measuring flasks are available. Specific gravity measuring flask was wiped with ethanol and dried in oven at 60℃. The weight of the empty flask was taken. After that the flask were filled with given oil sample and properly weighed on digital scale. Sample was again removed and flask was properly washed and wiped with ethanol and filled with distilled water after which the weight was taken again and finally, the specific gravity was calculated by using the given formula; (**Nayak and Patel, 2010**)

$$\text{Specific gravity} = \frac{W_0 - W}{W_1 - W}$$

Where, W= is the weight of the empty flask, W_0 = weight of the flask and the oil content, W_1= weight of the flask and the water content.

6. Determination of Flash point and Fire point.

Fig: 15 Pensky-Martin closed cup apparatus

According to the **ASTM D93 AND BIS IS 1448 PART 21** Flash and fire point of a fuel is defined as the lowest temperature at which fuel is heated under standard conditions which gives off sufficient vapor to ignite on application of testing flame.

The closed cup of brass of flash point apparatus is filled to the mark with test sample then it is heated and stirred continuously at specific rates. An ignition source is directed towards the brass test cup at regular intervals until flash in closed cup apparatus is detected with a pop up sound. That specific point is marked with thermometer and mark as flash point. Generally fire point is detected at 10℃ - 15℃ interval of flash point.

7. Cloud point determination

According to **ASTM D2500** Cloud Point is defined as the temperature at which the crystals of solid biodiesel or haze first become visible at the bottom of the test tube, as the biodiesel starts to freeze, the formation of crystal will start to take place clumping together.

Fig: 16 Haze formations in Jatropha oil

According to the size, crystals will easily pass through filters and can be poured & pumped and used with no problems. As the biodiesel gets colder enough the crystals will get bigger in size and will eventually choke the filters. Temperature is recorded at regular time interval till the lowest temperature at which cloud point is achieved (**Mishra and Mohanty, 2008**)

8. Pour point determination

According to **ASTM D97** the pour point is defined as the lowest temperature at which movement of the fuel sample can be determined. Pour point are always expressed and recorded in multiples of 3℃ . At every 1℃ of cooling of the sample, sample is inspected and when no movement is detected up till 5 seconds, then the test was stopped. 3℃ were added to the temperature where no movement was observed and recorded as the pour point of the sample oil. (**Mishra and Mohanty, 2008**).

9. Kinematic viscosity

The kinematic viscosity is an important characteristic of the fuel oil to be measured. The kinematic viscosity is used to determine the resistance or the shear flow applied by liquid to the flowing surface. **ASTM D 445-06** standard method was used. The Oswald viscometer was filled up to the marked brim, i.e. its bulb, fill sample and the aspiratory force was drawn up to the upper mark of the viscometer. The viscometer was placed in to a hot water bath with constant temperature bath set at 40°C and allowed approximately 10 minutes for the sample to come to the bath temperature at 40°C. The aspiratory force was then applied to the thinner arm to draw the sample slightly above the upper mark. Than the liquid is allowed moving freely applying the sheer force to the surface of viscometer, the lower timing mark was recorded. (**Mishra and Mohanty 2008**).

Dynamic viscosity is defined as the resistance to shear flow within a liquid. Kinematic viscosity is the measure of the time taken by the liquid to flow through an orifice under gravity. Both are measured by the international method using the time of flow in an Ostwald viscometer at 40.℃ . At this temperature the dynamic (Absolute) and kinematic viscosity of water is 0.6531centipoise and 0.658 cSt (centistokes). The S.I unit for dynamic viscosity is Pascal-second when 1cP=0.001 Pa.sec.

Kinematic viscosity = constant x time (sec) (constant =0.015mm^2/S^2)

Kinematic viscosity = Dynamic viscosity/ Density

$$V = \mu / \rho$$

Centistokes = Centipoises / Density

Where η=dynamic viscosity Pa.s and kinematic viscosity is mm^2/s, ρ = kg/m^3

Water at 20℃ has kinematic viscosity is of about 1 cSt(centipoises)

10. Iodine value

Iodine value is the measure of the degree of the unsaturation of the oil. Higher iodine value shows the degree of unsaturation of fats and oils. Oil (1 g) was weighed accurately and transfers in to a 250 mL of iodine flask and dissolves in chloroform (10 mL). Wij’s reagent (10 mL) was pipette. The flask was tightly lid and kept in darkness for one hr. with intermittent shaking. Then 15% of potassium iodide solution (5 mL) and 25 mL of distilled water were added to the flask and mixture was shaken well. The liberated iodine was titrated with 0.1 N sodium thiosulphate solution in to the flask, using fresh starch solution as an indicator. A blank titration was also conducted. Iodine value is the measure of degree of an unsaturation of the oil. Higher iodine value indicates higher unsaturation of fats and oils. (**Joshi *et al.*, 2011**)

Vol. of sodium thiosulphate used = (blank - test) ml

$$\textbf{Iodine value} = \frac{\text{Eq.wt.of iodine x vol.of } Na_2S_2O_3 \text{ x Normality of } (Na_2S_2O_3) \text{ x}100\text{x}10^{-3}}{\text{Wt. of oil sample used for analysis (g)}}$$

Eq.wt. of Iodine =127

Normality of sodium thiosulphate ($Na_2S_2O_3$) =0.1

11. Saponification value

Saponification value shows the presence of triglyceride level is normal or not which can be further used for the production of soap and shampoo. Oil (1g) of oil was weighed accurately and transferred into a 250 mL round bottom flask. Freshly prepared 0.5 N alcoholic potassium hydroxide solution (25 mL) was added to the sample by means of pipette and the mixture was refluxed on a reflux condenser gently for 1 hr. at 60℃. Then the flask was mildly cooled and few drops of phenolphthalein indicator was added, till the light pink color is obtained. Now the contents are transferred in to a titration flask and were titrated with 0.5 N hydrochloric acid solutions (HCL). A blank titration was also carried out simultaneously. (**Joshi *et al.*, 2011**)

1. Saponification value or number of fat = mg of KOH consumed by 1g of fat
2. Weight of KOH= Normality of KOH ×equivalent weight×vol. of KOH in ml.
3. Vol. of KOH consumed by 1g of fat=[Blank-Test] ml

$$\textbf{Saponification value} = 28.05 \times \frac{\text{Titer value}(x-y)}{\text{Wt. of the sample}}$$

HCL Mol.wt.36.5

Wt. of the sample =1g

Blank value is X

Y is the value obtained by sample titration.

12. Acid value

25 ml of diethyl ether and 25 ml of ethanol was mixed in a 250ml beaker. Oil **(**1g) of the pure oil was weighed accurately and transferred in to a 250 mL conical flask. The content was cooled and the contents titrated with 0.1N alcoholic sodium hydroxide solution using phenolphthalein as an indicator. A blank titration was also conducted side by side. (**Joshi *et al*., 2011**)

$$\textbf{Acid value} = \frac{\textbf{Titer value x 56.1 x normality}}{\textbf{Weight of the sample (g)}} \textbf{ (mgKOH/g)}$$

13. FFA (Free fatty acid value)

According to **Mishra and Mohan, 2008** the amount of free fatty acid value (FFA) was calculated according **ASTM-D664-04** as being equivalent to half the value of the acid value, that is;

$$\textbf{FFA} = \frac{\textbf{Acid value}}{\textbf{2}} \textbf{ (mgKOH/g)}$$

14. Peroxide value determination

According to **Umaru and Aberugaba, 2012** Peroxide value is an important characteristic of an oil quality. This value is an indicator of the oil stability to the oxidation. One gram of sample was weighed into clean dried tube, 0.5 g of KI powder was added to the oil and 10ml of the solvent mixture i.e. (glacial acetic acid and chloroform in2:1), than the hot tube was placed in to the boiling water bath so that liquid mixture boils with in 30 sec's and allow to boil the mixture vigorously further 30sec's. The content was quickly poured in to a flask containing 10ml of 5% potassium iodide. than the mixture was titrated with 0.2 M sodium thiosulphate using fresh 1% starch solution as an indicator. The blank titration was carried out simultaneously.

The peroxide value can be calculated by using the given formula;

$$\textbf{Peroxide value} = \frac{\textbf{Titer value of sod. Thiosulphate} \times \textbf{molarity of sod. Thiosulphate}}{\textbf{Weight of the sample (g)}}$$

Titer value=sample titer-blank titer

Sample titer value= value obtained by sample titration

Blank titer= value obtained after blank titration.

CHAPTER-6

RESULT AND DISCUSSION

Results and Discussion

The characteristic fuel properties such as kinematic viscosity, density, gravity, saponification value, iodine value, acid value, flash and fire point and other parameters of non-edible oil are compared with ASTM standards and with diesel fuel properties. Different ASTM parameters like ASTM D664 acid number, ASTM D2500 cloud point, ASTM D93 flash point, ASTM D445 kinematic viscosity and other parameters have been analyzed. According to the table No. 3 it has been analyzed that two major oil bearing samples from different states are; Jatropha (RJ) with 33.42% yield maximum following Jatropha (MP) with 30.16% yield which is found similar to the **(Nayak *et al*., 2010)**

Table 3: Determination of oil yield from different non edible sources.

S.No.	Sample	Region	% oil yield
01	Jatropha	(RJ) Udaipur	33.42
02	Jatropha	(MP) Jhansi	30.16
03	Neem	(UP) Agra	24.36
04	Neem	(MP) Gwalior	27.12
05	Castor	(UP) Agra	23.62
06	Castor	(MP) Gwalior	28.68
07	Kaner	(UP) Agra	19.15
08	Kaner	(PB) Punjab	23.69
09	Soap nut	(UP) Agra	16.26
10	Soap nut	(MP) Gwalior	21.13

∗Above shown data is the mean value of the three replicates.

∗ RJ (Rajasthan), MP (Madhya Pradesh), UP (Uttar Pradesh), PB (Punjab)

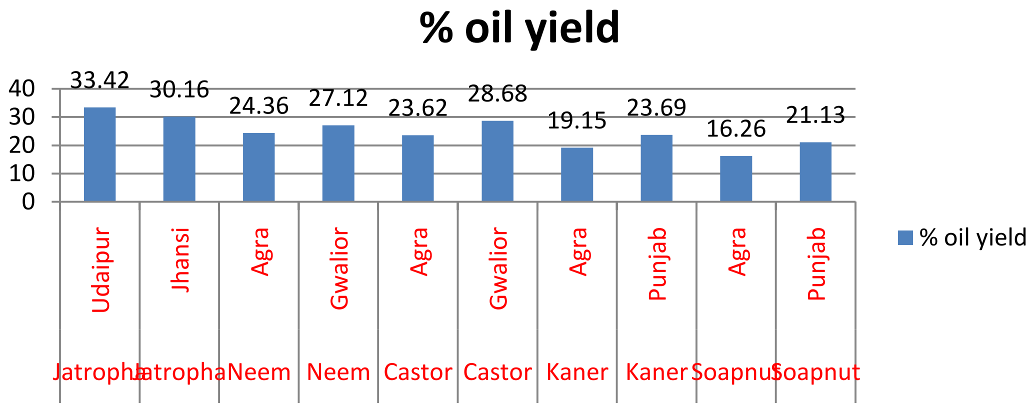

Fig: 17 Percentage of Oil yield of different samples

Flash and fire point are the important parameters of liquid fuel. The flash point of the petroleum diesel is defined as the lowest temperature at which the fuel will ignite and release energy in terms of heat. A fuel with lower ignition value is marked as the best fuel with ignitable properties. Fire point is defined as the point at which fuel will catch fire and burn completely.

Table 4: Determination of Flash and Fire point of the non- edible oils.

	Sample										
Parameters ASTM D93	J (RJ)	J (MP)	C (UP)	C (MP)	K (UP)	K (PB)	N (UP)	N (MP)	S (UP)	S (MP)	Diesel HSD
Flash point °C	190	205	190	195	190	170	165	150	210	200	56
Fire point°C	200	210	200	210	200	180	175	170	215	205	59

∗Above shown data is the mean value of the three replicates

∗HSD (High speed diesel)

It has been estimated that the flash and fire point according to the ASTM D93 standard value and it was found that the Jatropha of MP, soap nut of (UP) and soap nut of (MP) has the highest flash point of all of the samples that is; 205,200 and 210 respectively. Where as it has been estimated that the soap nut of (UP), castor of (MP), Jatropha of (MP), Jatropha of (RJ), castor of (UP), Kaner of (UP) and soap nut of (MP) has the highest fire point that is; $215℃, 210℃, 210℃, 205℃ 200℃$ *and* $200℃$ respectively. The flash point of soap nut was found similar to the **Jadon *et al.*, 2012**.

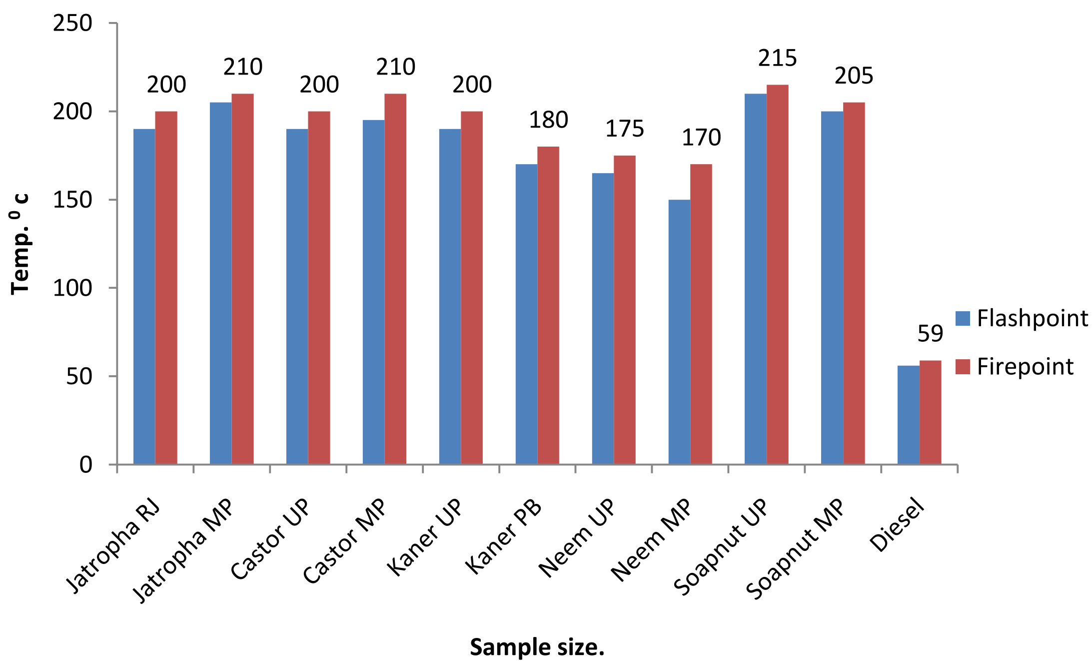

Fig: 18 Graphical representation of Flash and Fire point of non- edible oil.

Pour point and cloud point are the important properties of a liquid fuel. Pour point of the liquid is defined as the property at which the liquid becomes semi solid and loses its flow characteristics at certain temperature. In crude oil of higher pour point is associated with the high glycerin and other impurity content. Whereas the cloud point is defined as the temperature at which impurities or wax in biodiesel form a cloudy appearance. The presence of the oily waxes clogs the filters and chokes the injectors in the engines. Therefore, cloud point indicates the tendency of the oil to plug filters or small orifices at cold operating temperatures.

Table.5: Determination of the pour point and cloud point of non -edible oil.

S.No.	Sample	Location	Pour point℃ ASTM D97	Cloud point℃ ASTM D2500
01	Jatropha	RJ	-2	4
02	Jatropha	MP	-1	6
03	Castor	UP	-8	-2
04	Castor	MP	-5	-6
05	Neem	UP	-9	-4
06	Neem	MP	-15	-2
07	Kaner	UP	2	7
08	Kaner	PB	-1	10
09	Soap nut	UP	-2	1
10	Soap nut	MP	-4	3
11	Diesel(HSD)	-----	6	8

∗Above shown data is the mean value of the three replicates

∗ HSD (High speed diesel)

∗(RJ) Rajasthan, (UP) Uttar Pradesh, (MP) Madhya Pradesh, (PB) Punjab.

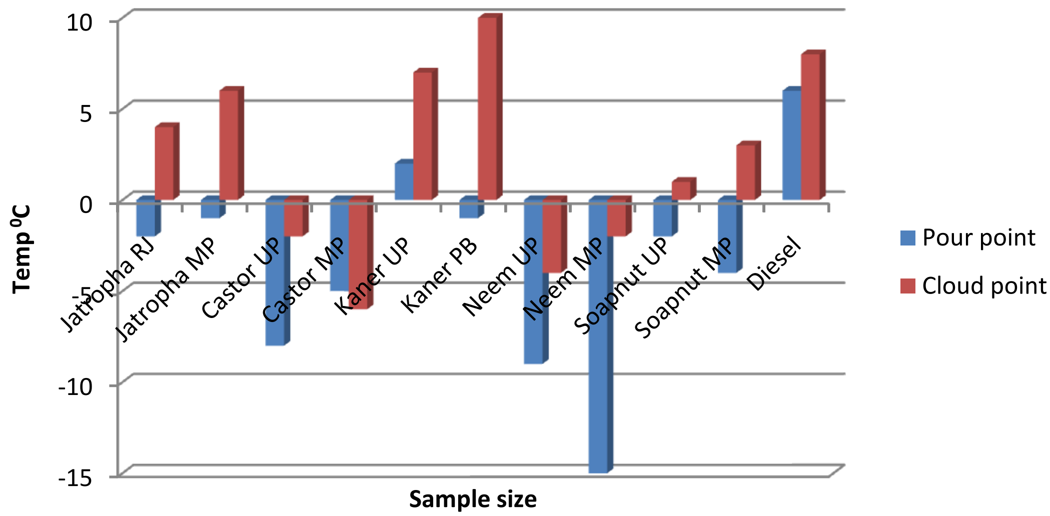

Fig.:19 Graphical representation of biochemical characters cloud & pour point of non- edible oil.

In the estimation of the pour point and the cloud point it has been found that the pour point of two desired samples i.e. Neem of MP has the lowest pour point value 15 °C following neem of UP i.e. -9°C $and - 8$°C respectively. Whereas it has been found that the cloud point of desired four sample is the lowest i.e. castor of MP -6°C, following neem of UP -4°C, castor of UP and neem of MP has the third lowest record in temperature of the cloud point -4 and -2°C. During investigative study of pour point of biodiesel of Neem, it has been recorded as similar to the **Aransiola *et al*., 2012**.

Table No.6: Different chemical parameters of bio diesel

Sample Ligand											
Parameters	J(RJ)	J(MP)	C(UP)	C(MP)	K(UP)	K(PB)	N(UP)	N(MP)	S(UP)	S(MP)	HSD
Kinematic viscosity at 40℃ mm^2/s ASTM-D445-06	20.49	19.06	19.4	20.2	40.42	39.63	40.2	42.75	32.1	31.37	4.5
Density g/cm^3	0.881	0.883	0.993	0.962	0.92	0.83	0.912	0.965	0.891	0.82	0.839
Specific gravity 40℃ ASTM D1298	0.895	0.863	0.958	0.897	0.828	0.905	0.829	0.832	0.986	0.990	0.828
Saponification value mgKOH/g	190	210	185.83	190.36	265.3	230.2	188.1	186.23	190.68	191.1	188-193
Iodine value mg/g	104.46	106.5	89.68	89.52	83.69	85.68	81.28	77.53	92.36	91.89	----
Acid value mgKOH/g	11.1	13.26	1.14	1.36	4.7	3.6	13.25	11.57	15.6	14.98	----

∗ Above shown data is the mean value of the three replicates

∗HSD (High speed diesel)

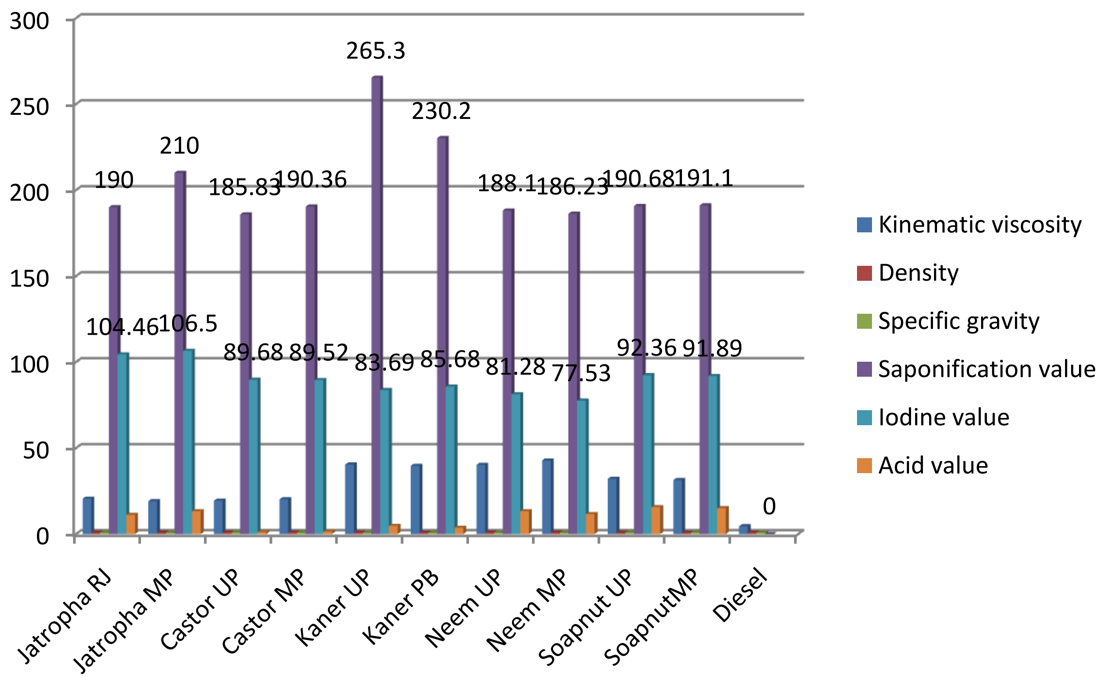

Fig: 20 Determination of the different chemical parameters of non-edible oil.

According to the data given in Table No. 6 it has been found that the Kinematic viscosity of the two samples has been tracked as the highest i.e. 42.75 and40.42, Neem of MP and kaner of U.P respectively which is similar to the **Obetta and Orukotan, 2012**. These samples yield the highly viscous oil which is an important parameter of oil lubricity.

Density is one of important parameter of oil content and lubricity. In the analysis it has been found that the density of two samples was marked as highest, 0.993 of castor of UP similar to the **Sreenivas *et al.*, 2011** and 0.965 of Neem of MP found similar to the **Radha and Manikandan, 2011**.

Specific gravity is one of the important parameter of the oil which increase or decrease the sheer flow of the oil lubricity with increase or decrease in temperature. In the above findings it has been mentioned that the two samples were marked with highest specific gravity i.e. 0.990 of soap nut of MP and 0.985 of soap nut of UP which is equivalent to the **Jadon *et al.*, 2012**. Saponification value is one of the important parameter of the crude oil. Depend upon the saponification value oil quantity and quality varies from species to species. Yield of the byproduct i.e. soap and shampoo depend upon the saponification value of the oil. From the above findings the two samples were found to be the highest yielding saponification value i.e. kaner of UP with 265.3 and kaner of PB with 230.2 respectively. This is found similar to the **Yarkasuwa *et al.*, 2013**.

Iodine value is one of the important characteristic of the oil. In quantitative analysis we came to know that two samples were yielding the highest value i.e. Jatropha of RJ with 104.46 and Jatropha of MP with 106 respectively which is found to be similar to the **Nayak and Patel, 2010**. During the test performance a known excess of iodine, usually in the form of iodine monochloride, is allowed to react with the known weight of the oil or fat and then the amount of iodine remaining untreated is determined by titration. The more iodine is attached higher will be the iodine value. Saturated oils, wax and fat take up no iodine so their iodine value is zero but unsaturated oils, fats and wax take up iodine so they got consecutively higher iodine value.

Acid value is one of the important characteristic properties of the oil content. Acid value determines the use of oil as biodiesel. In quantitative analysis of the oil it has been recognized that the two samples are yielding out the higher result i.e. soap nut of UP is 15.6 and soap nut of MP 14.98 in comparison to others which is found to be as similar as mentioned by **Chhetri *et al.*, 2008**. Iodine value is defined as the wt. of KOH in mg needed to neutralize the organic acids present in one gram of fat. An increment in the amount of FFA in a sample of oil or fat indicates hydrolysis of triglycerides. Hydrolysis of triglyceride produces glycerol.

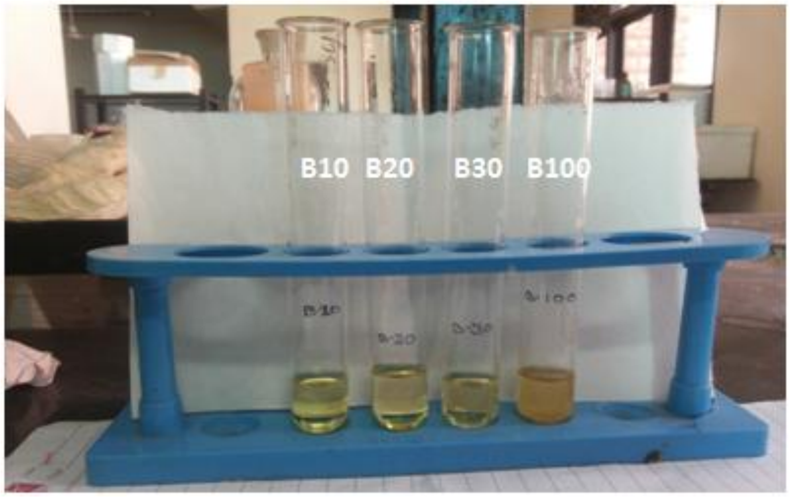

Fig: 21 Different blends of biodiesel B10, B20, B30 and B100

CHAPTER-7

CONCLUSION

Conclusion

Based on the physiochemical evaluation of different non edible seeds collected from different regions, morphological characteristics and the oil yield, it has been found that the oil % yield of Jatropha of Udaipur (RJ) is highest from where as Jatropha of Jhansi (MP) gives second highest yield where, as it has been estimated that the lowest yield yielding samples were, soap nut of Agra (UP) and secondly kaner of Agra (UP). Hence, Jatropha as a major oil yielding crop for biodiesel production has a bright future perspective and led to the replacement of conventional fuels in Indian economy.

It has been found that Soap nut of UP has the highest flash point and Jatropha of MP has the second highest flash point respectively. It has been found that soap nut of Agra (UP) has the highest fire point and second highest is of Jatropha of MP. But as on other side it has been analyzed that the lowest flash point is of Neem of MP and Neem of UP whereas, the lowest fire point were analyzed is of Neem of UP. Hence the lowest flash and fire point oil samples need special blending with oil and should be stored precariously.

During the analysis of pour and cloud point it has been found that the pour point of Neem of MP was found to be the highest in comparison with other samples. Second highest is of Neem of UP respectively. In the investigative study of cloud point it was discovered that, that the cloud point of castor of M.P and the Neem of U.P were recorded as the highest in comparison with others which fall in the category of standard quality of biodiesel. Hence biodiesel obtained from castor and Neem can be stable at the lowest temperature and will not form crystals in the engine filtration system.

During the investigative study of the kinematic viscosity which is an important characteristic of a liquid oil. It has been found that the highest value has been yield by neem of MP following kaner of UP where, as lowest value was of Jatropha of MP and castor of UP respectively. Hence, those samples which are yielding a very high viscosity yield can be used as a lubricating agent in industrial purpose.

In the comparative analysis of the saponification value of the oil content it was analyzed that the kaner of UP has the highest saponification value following kaner of PB.

Hence those samples which are yielding a very good yield of saponification value can be used as in the soap formation or in the shampoo industry, whereas the lowest saponification value was of Neem of M.P and Neem of UP respectively.

In the investigative study of the iodine value it was analyzed that the iodine value of the Jatropha of R.J and Jatropha of M.P yield the highest value respectively. Whereas the lowest yield of the iodine value was found to be Neem of M.P and U.P which also fall in to the category of standardize value.

In the investigative analysis of the acid value of the oil content it has been analyzed that the soap nut of U.P and soap nut of M.P yields the highest acid value and which falls under the standard category of the ASTM and EN standards value should be max for pure biodiesel.

During the investigative study and the comparative analysis between all the samples it has been found that Jatropha, castor and kaner is best suited for bio diesel production but as kaner gives a very high saponification value and very high viscosity it is not suitable for blending purpose therefore kaner can be used as lubricating agent and as a raw material for soap industry where as Jatropha and castor oil yield is higher in comparison with other samples and has a very distinct property of flash and fire point make them suitable for biodiesel production.

Hence, certain samples consist of appropriate and suitable value for biodiesel production and certain non -edible oils have property of producing very high viscous oil therefore their application can be varied as an engine and industrial lubricating agent without any toxic effect and can be replenished again.

CHAPTER-8

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Appendix;

1.Starch solution preparation

1% starch Indicator Solution preparation. Weigh 1g of starch and dissolve in to 10ml hot boiling distill water. Stir well and pour in to 100ml distill water. (Always fresh starch indicator solution is prepared).

2. 0.5 N HCL preparation.

For 0.5N HCL, 18.25 ml 100% HCL dissolved in 1ltr of distill water.

9.14 ml in 500ml of distill water.

3. Preparation of 95% ethanolic KOH

2.85 g of KOH dissolve in 4ml of distill water. (Total makeup vol. 5ml)

95ml absolute alcohol (Total vol. makeup 100ml)