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Manufacturing of Biodiesel via Transesterification of date Seeds based Palm Oil

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Abstract: The production of biodiesel from renewable sources is a promising alternative to conventional fossil fuels. This study focuses on the manufacturing of biodiesel via transesterification of date seeds-based palm oil, a sustainable feedstock derived from the seeds of date palms. The transesterification process involves the reaction of date seed oil with methanol in the presence of a catalyst to produce biodiesel and glycerol. Various factors such as reaction temperature, catalyst concentration, and methanol-to-oil ratio were optimized to achieve maximum biodiesel yield. The physicochemical properties of the produced biodiesel, including viscosity, density, and calorific value, were analysed to determine its suitability as an alternative fuel. The results demonstrate that biodiesel derived from date seed-based palm oil can be a viable and eco-friendly fuel, contributing to reducing reliance on conventional petroleum-based diesel and promoting the use of agricultural waste as a feedstock for energy production.

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I. INTRODUCTION

➢ *Solid Liquid Extraction*

Leaching, or solid-liquid extraction, is a separation technique that uses an appropriate liquid solvent to draw a desired component out of a solid mixture. The procedure is predicated on the idea that some of the constituents of a solid matrix dissolve in particular solvents.After that, the mixture is separated to separate the liquid extract that contains the dissolved component, usually by filtration or decantation.By evaporating, crystallizing, or distilling the solvent, the desired material can be extracted.Caffeine from coffee beans, oils from seeds, and active pharmaceutical components from plant materials are just a few of the sectors that frequently use this technique. Particle size, temperature, mixing, and solvent selection are some of the variables that have a big impact on how effective the extraction process is. Solid-liquid extraction is regarded for its ease of use, selectivity, and variety of uses, ranging from metallurgy to food processing.

II. REACTIVE EXTRACTION

Reactive extraction is a method of separating a particular ingredient from a mixture by combining liquid-liquid extraction with chemical reactions. Reactive extraction uses a reversible chemical reaction between the target component and an extractant (reactive agent) dissolved in an organic solvent, as opposed to traditional extraction, which separates the compounds based only on variations in solubility. Effective separation from the aqueous phase is made possible by the complex that is created by this reaction and is very soluble in the organic phase. Reversing the reaction after extraction—usually by adjusting the pH, changing the temperature, or adding another reagent—allows for the recovery of the desired product.

This method works especially well for extracting substances like carboxylic acids, amines, and antibiotics that are hard to separate using conventional techniques. An amine-based extractant in an organic solvent, for instance, interacts with the acid to generate a complex that can subsequently be broken down to recover pure lactic acid when lactic acid is extracted from fermentation broth. High selectivity, lower energy consumption than distillation, and gentle operating conditions are some benefits of reactive extraction. The selection of the extractant, solvent, reaction conditions, and phase equilibrium are important variables that impact the procedure.

III. TRANSESTERIFICATION

An ester and an alcohol undergo a chemical reaction during the transesterification process, creating a new ester and an alcohol byproduct. Triglycerides from vegetable or animal fats react with an alcohol, usually methanol or ethanol, in the presence of a catalyst to produce fatty acid methyl esters (FAME), the chemical name for biodiesel, and glycerol as a byproduct. This process is essential to the production of biodiesel. A catalyst is typically needed for the reaction, and this can be an enzyme (like lipase), an acid (like sulfuric acid), or a strong base (like sodium hydroxide or potassium

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hydroxide). The yield and reaction conditions are affected by the catalyst selection.

The catalyst and the selected alcohol are first mixed to create a reactive mixture, which is subsequently mixed with the fat or oil. To speed up the process, the mixture is heated to between 50 and 60°C while being constantly agitated. In these circumstances, the triglycerides' ester bonds are broken by the alcohol molecules, releasing glycerol and creating new ester compounds, or biodiesel. Due to differences in density, the liquid separates into two layers when the reaction is finished: glycerol makes up the lower layer while biodiesel makes up the upper layer. After removing impurities such excess catalyst, soap, and unreacted alcohol with water, the biodiesel is dried to the necessary purity.

The molar ratio of alcohol to oil, catalyst concentration, reaction temperature, time, and mixing intensity are important factors that affect transesterification efficiency. Although greater ratios can boost yield at the expense of higher alcohol recovery costs, the usual alcohol-to-oil molar ratio for full conversion is 6:1. In comparison to diesel made from petroleum, the technique is praised for its ease of use, effectiveness, and ability to produce a renewable, biodegradable fuel that lowers greenhouse gas emissions. In addition to manufacturing biodiesel, transesterification is used to change polymers in the plastics industry, produce flavors and fragrances, and produce esters for the pharmaceutical sector.

An ester and an alcohol undergo a chemical reaction during the transesterification process, producing a new ester and an alcohol byproduct. A catalyst, which could be an enzyme, base, or acid, is usually present during this process. Triglycerides (fats or oils) combine with methanol or ethanol to form fatty acid methyl esters (FAME) and glycerol as a byproduct in the process of transesterification, which is widely employed in many different sectors. this process is particularly important in the manufacturing of biodiesel.

IV. TRANSESTERIFICATION STEPS

➢ *Reactant Preparation*

Impurities are eliminated by pre-treating oils or fats.A catalyst, such as potassium hydroxide (KOH) or sodium hydroxide (NaOH), is combined with alcohol (methanol or ethanol).

➢ *Reaction*

The oil is mixed with the alcohol-catalyst combination. To facilitate the reaction, the mixture is agitated at regulated temperatures, typically between 50 and 60°C.

➢ *Separation*

Two layers are created as a result of density variations following the reaction: Biodiesel (methyl or ethyl esters) is the top layer. Glycerol, the bottom layer, sinks because it is denser.

➢ *Purification*

Alcohol, soap, and any remaining catalysts are rinsed out of the biodiesel. It is possible to further refine glycerol for usage in cosmetics or medications.

➢ *Important Elements Influencing Transesterification*

- Alcohol-to-Oil Ratio: Higher ratios raise recovery expenses while increasing yield.
- Catalyst Concentration: Full conversion is ensured by ideal catalyst concentrations.
- Temperature and Pressure: While too much heat can result in adverse consequences, moderate heating speeds up the reaction.
- Reaction Time: Enough time is required for full conversion; for biodiesel, this is usually one to two hours.

V. DATE SEEDS

The hard kernels inside the fruit of the date palm (Phoenix dactylifera) are called date seeds, sometimes referred to as date pits or stones. Although dates are mostly eaten for their tasty and nourishing meat, their seeds are becoming more and more valued for their potential uses because of their rich chemical makeup and useful qualities. Usually accounting for 10–15% of the fruit's weight, date seeds are rich in dietary fiber, proteins, carbs, lipids (including important fatty acids), and minerals like calcium, magnesium, potassium, and iron. They are useful for health-related applications since they also include bioactive substances such flavonoids, polyphenols, and antioxidants.

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VI. DATE SEED APPLICATIONS AND USES HEALTH AND NUTRITIONAL PRODUCTS

Because date seeds have anti-inflammatory and antioxidant qualities, they are processed into a powder and utilized in health supplements. The seed powder offers a caffeine-free alternative with certain health advantages and is occasionally used in place of coffee.

➢ *Personal Care and Cosmetics:*

Date seed oil is good for skin and hair care products since it is high in antioxidants and vital fatty acids.

➢ *Applications in Industry:*

Date seed oil offers a sustainable substitute for petroleum-based goods and may find application in the

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manufacturing of bio-lubricants and biodiesel.Date seeds' high carbon content also qualifies them for the manufacturing of activated carbon, which is utilized in air filtration and water purification systems.

➢ *Potential for Pharmaceuticals:*

Date seed extracts are attractive prospects for pharmacological research because of studies that indicate they may have antibacterial, antiviral, and anticancer qualities.

➢ *Food Sector:*

In order to increase the amount of dietary fiber and antioxidants in baked products, cereals, and functional foods, date seed flour is being investigated as an ingredient.

➢ *Date Seed Processing:*

Depending on how they are going to be used, date seeds are processed using different techniques. Cleaning, drying, roasting, grinding, and oil extraction (using solvent extraction or cold pressing techniques) are typical procedures. The powdered seeds can be added to food or feed products, and the oil is further refined for industrial or cosmetic usage.

Economic and Environmental Importance: Using date seeds gives value to what is frequently regarded as agricultural waste, lowering its negative effects on the environment and generating employment opportunities, especially in areas that produce dates. The circular economy's tenets of resource efficiency and waste reduction are supported by the sustainable usage of date seeds.

➢ *Biodiesel*

Made from natural sources like vegetable or animal fats or recycled cooking oil, biodiesel is a renewable and biodegradable fuel. With minimal modification, it can be utilized in diesel engines as a substitute for petroleum-based diesel. Fatty acid methyl esters (FAME), which are created chemically through a procedure known as transesterification, make up biodiesel. This process produces biodiesel and glycerol as a byproduct by reacting triglycerides (fats and oils) with an alcohol (usually methanol) in the presence of a catalyst (such potassium hydroxide or sodium hydroxide).

➢ *Biodiesel Production Process: Choosing Feedstock:*

Soybean oil, rapeseed oil, palm oil, sunflower oil, animal fats, and leftover cooking oil are examples of common feedstocks. Date seed oil and algal oil are examples of emerging feedstocks that provide sustainable alternatives.

➢ *Reaction of Transesterification:*

Methanol and a catalyst are combined with the selected oil or fat. By heating the mixture to between 50 and 60 degrees Celsius and stirring it, the triglycerides react with the methanol to produce glycerol and methyl esters, or biodiesel.

➢ *Separation*

The mixture splits into two layers following the reaction: Biodiesel (methyl esters) is the top layer. Glycerol, the bottom layer, can be purified for usage in cosmetics and medications.

➢ *Purification*

To get rid of contaminants like soap, catalyst, and leftover methanol, the biodiesel is cleaned. After that, it is dried to satisfy fuel quality requirements like ASTM D6751 (for the United States) or EN 14214 (for Europe).

➢ *Benefits of Biodiesel*

Sustainable and renewable: derived from biological sources that are renewable. Decreased Emissions: When compared to petroleum diesel, it emits fewer sulfur oxides, carbon monoxide, particulate matter, and greenhouse gases. Non-toxic and biodegradable: safer for the environment in the event of spillage. Engine Compatibility: Usually available as mixes like B20 (20% biodiesel, 80% petroleum diesel) or B100 (pure biodiesel), they can be utilized in existing diesel engines without requiring major changes. Increased Lubricity: Prevents wear and tear and extends engine life.

➢ *Obstacles & Things to Think About:*

Feedstock Cost: Biodiesel may be more costly than fossil fuel due to the price of oils and fats. Cold Flow Properties: In colder climates, engine efficiency may be impacted by biodiesel's ability to gel at low temperatures.

Energy Content: Compared to petroleum diesel, biodiesel has a little lower energy content per liter, which results in a modest decrease in fuel efficiency. Land Use Issues: Arguments about food versus fuel and land use problems may arise from the large-scale manufacture of biodiesel from edible oils.

➢ *Biodiesel Applications include:*

- Transportation: Found in automobiles, trucks, buses, and ships.
- Power Generation: Supplies energy to generators so they can produce power.
- Industrial Use: Serves as a lubricant and solvent in industrial operations.
- Heating: As a cleaner burning substitute for heating oil, it can be utilized in heating systems.

VII. LITERATURE REVIEW

pH is one of the more significant variables affecting the amount and properties of extracted pectin. The production of pectin decreased with increasing pH, reaching a maximum of 52.90% at pH 1 and 60 mesh size. The Soxhlet Extraction method has been utilized to guarantee a greater yield with a discernible solvent recovery while maintaining the properties of the constituents.[1]. Because strong acids are corrosive, they can be bad for your health. The liquid waste generated by industrial processes is a strain on the environment, and handling the highly acidic waste can be costly. Pectin is extracted by grinding orange peel into a powder. Pectin was extracted using a range of combinations of citric acid concentrations (pH 1, 1.5, and 2), extraction durations (10, 20, and 30 minutes), and ultrasonic powers (60, 80, and 100%). The maximum pectin production of 20.92% was attained at a pH of 1.5 in a citric acid solution, 100% ultrasound power, and 30 minutes of ultrasound duration.[2].

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The liquid waste generated by industrial processes is a strain on the environment, and handling the highly acidic waste can be costly. Pectin is extracted by grinding orange peel into a powder. Pectin was extracted using a range of combinations of citric acid concentrations (pH 1, 1.5, and 2), extraction durations (10, 20, and 30 minutes), and ultrasonic powers (60, 80, and 100%). The maximum pectin production of 20.92% was attained at a pH of 1.5 in a citric acid solution, 100% ultrasound power, and 30 minutes of ultrasound duration.[3] When it comes to producing pectin with a standard yield, citric acid and ultrasound are major time and energy saves. To find out how processing circumstances impacted the extraction process, an experimental study was carried out to extract pectin from the peel waste of a citrus fruit variety known as lemons (Citrus lemons). Pectin was extracted using nitric acid at three different temperatures (40, 60, and 80) and PH values (1.0, 2.5, and 4.0). The studies were carried out in a water bath for two hours. To identify the optimal process parameters that would maximize the yield %, the variety under various extraction circumstances was analyzed, and the interaction effects were looked at.[4] Using nitric acid, the cultivar's pectin output ranges from 4.69% to 20.36%. With a drop in PH and a rise in extraction temperature, the pectin yield increased. A maximum yield of 20.36% was attained by the cultivar at 60°C and PH 1.0.[5]Nitric acid extraction worked best at 60 °C for two hours at a pH of 1.0. After 60 minutes at 85 °C and pH 3.0, the sweet lime peel showed the lowest percentage yield (5.1%). However, at a pH of 4.0 and an extraction temperature of 40 °C, the lowest yields of 5.69% were achieved. It was discovered that the optimal extraction process parameters were pH 3.5, temperature 65°C, and duration 67.5 minutes.[6] The interaction effects between these variables were investigated using 3-D visualization and contour plots. The pectin yield increased by 1.5 times as a result of our experimental strategy. The analysis of variance proved the significance of the model. Following both qualitative and quantitative investigation, the final pectin was found to contain the appropriate amounts of methoxyl, hyaluronic acid, and esterification.[7] The functional groups in pectin are identified via FTIR spectroscopy. How two different acids and Soxhlet extraction are used to extract pectin from pumpkin peels. the effect of time on pectin output and to explain the findings of small-scale laboratory tests of esterification degree, equivalent weight, acetyl content, and methoxyl content. Soxhlet acid extraction yielded a greater average yield of pectin (7.72% for nitric acid and 6.80% for citric acid), whereas acid extraction without Soxhlet gave a lower yield (6.24% for nitric acid and 5.36% for citric acid).[8] The acetyl content and equivalent weight of the extracted pectin with nitric and citric acids were 0.43 and 1250 g/mol, respectively.[9] While the methoxyl content was 6.20 and 7.23%, the degree of esterification for both citric and nitric acids was 66.53% and 66.57%. Pumpkin peels are one potential commercial source of pectin.[10] Pectin from powdered lemon peel was extracted using nitric acid at three different temperatures, periods, and pH values: 60, 70, and 80 0 C; 30 minutes, 45 minutes, and 60 minutes; and 1.5, 2 & 2.5 pH, respectively. Using citric and nitric acid as reagents, the pectin output varied between 15.8% and 67.8% and 13.8% and 44.2%, respectively, according to the results.[11] Citric acid at 800C, 1.5 pH, and 60 minutes produced a higher yield under the ideal extraction conditions using both extraction reagents. When nitric acid was used as a reagent to separate the pectin, the results showed that it contained 65.4% anhydrouronic acid, 510 equivalent weight, and 5.45% methoxyl content.[12] The degree of esterification of the isolated pectin indicated low methoxyl pectin. The moisture content and ash content of the isolated pectin were also determined. [13]Biodiesel is a sustainable and environmentally beneficial alternative to conventional fossil fuels. Recycled cooking oil and vegetable and animal fats are among the renewable resources used to make biodiesel.[14] Among its many benefits are improved energy security and decreased greenhouse gas emissions.[15] Beyond its seductive scent, limonene has extensive practical applications as industrial solvents and household cleaners. It is a well-liked choice for eco-friendly formulations due to its low toxicity and biodegradability, which offers a sustainable alternative to conventional chemicals.[16] Because of its solvent properties, limonene effortlessly dissolves oils, resins, and greases, making it a crucial component of paint thinners, adhesive removers, and degreasing agents.[17] The vibrant look of limonene is the result of a chemical ballet between its ten carbon and sixteen hydrogen atoms. [18]The cyclohexene ring, which gives the limonene molecule stability and spatial organization, is its centre. A number of chemical processes that impact limonene's properties and behavior are framed by this repeating structure. [19] All things considered, limonene is a simple yet important chemical component that is used in many different products, ranging from industrial solvents and cleaning solutions to flavourings and fragrances. [20]

VIII. METHODOLOGY

➢ *Preparation of date seed oil from date seeds*

A number of procedures are followed in order to optimize the yield and quality of date seed oil. The first step in the procedure is pre-treating the date seeds, which entails cleaning them well to get rid of any leftover fruit pulp and contaminants. Following cleaning, the seeds are dried, either in the sun or at low temperatures (50–60°C) in an oven, which lowers the moisture content and is necessary for effective oil extraction. After drying, a mechanical grinder is used to crush or grind the seeds into a thin powder. By increasing the surface area, grinding makes it easier to extract the oil in the next stages.

Various techniques can be employed to extract oil from ground date seeds, contingent on the desired use. By manually pressing the ground seeds at regulated temperatures (below 60°C), the cold pressing method maintains the oil's original flavour, antioxidants, and nutritional value, making it perfect for use in food and cosmetic applications. But compared to other methods, this one produces less oil. The solvent extraction process, which involves mixing powdered seeds with a solvent such as n-hexane, is frequently employed for increased yields. The oil is dissolved by heating the mixture, and the extracted oil is then separated from the solvent by evaporation. Higher yields are obtained using this approach, but solvent residues must be carefully removed,

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Solvent residues must be carefully removed, particularly if the oil is intended for cosmetic or dietary usage. Supercritical CO_2 extraction is another cutting-edge method that extracts oil by using carbon dioxide at high temperatures and pressures. High-purity oil free of solvent residues is produced using this eco-friendly process, making it appropriate for use in luxury cosmetics and medications. To guarantee quality and stability, the oil is purified after extraction. This entails drying to get rid of moisture that can compromise storage stability, degumming and neutralization to get rid of contaminants such phospholipids and free fatty acids, and filtering to get rid of any last bits of solid material. In the last stage, the oil's fatty acid composition, antioxidant activity, and other physicochemical characteristics are characterized and tested to ensure that it is suitable for a range of uses. Date seed oil's high oleic acid, antioxidant, and essential fatty acid content makes it valuable for use in the food industry (as a cooking oil or dietary supplement), pharmaceuticals (for its possible anti-inflammatory properties), cosmetics (as a moisturizer and anti-aging ingredient), and biodiesel production (as a sustainable feedstock).

Fig 1 Raw dates

Fig 2 Date seeds

IX. RESULTS

Fig 3 Date oil extracted from date seeds

Fig 4 Biodiesel from date oil

Table 1 Amount of oil extracted with varying amount of solvent and orange peels at 40 Degree Celsius

Amount of solvent (methanol) ml	Weight of peel powder (gm)	Volume of oil (ml)
25	45	1.2
50	65	1.8
75	85	2.3
100	105	3.4
125	125	4.6
150	145	5.4
175	165	6.8
200	185	7.2
225	205	8.4
250	225	9.8

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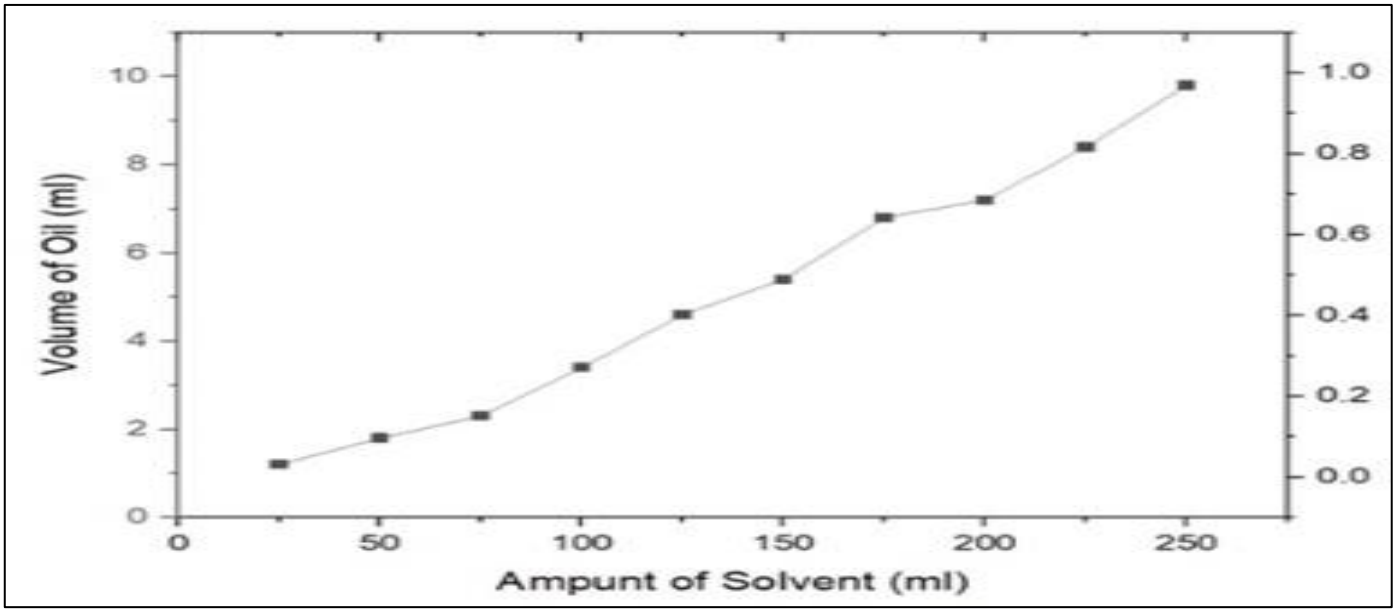

Fig 5 Ampunt of Solvent (ml)

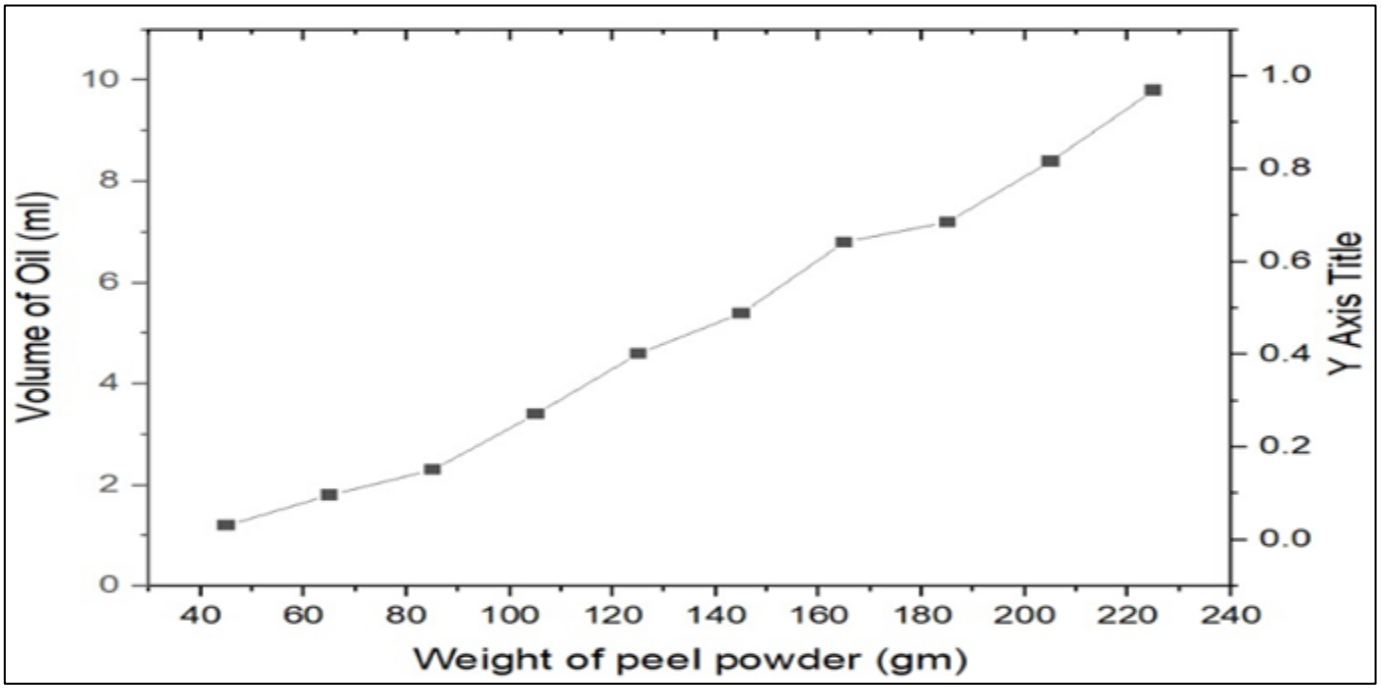

Fig 6 Weight of Peel Powder (gm)

Table 2 Amount of oil Extracted with varying amount of solvent and orange peels at 50 Degree Celsius

Amount of solvent (methanol) ml	Weight of peel powder (gm)	Volume of oil (ml)
25	45	1.7
50	65	2.4
75	85	3.5
100	105	4.2
125	125	5.3
150	145	6.1
175	165	7.2
200	185	8.3
225	205	9.2
250	225	10.5

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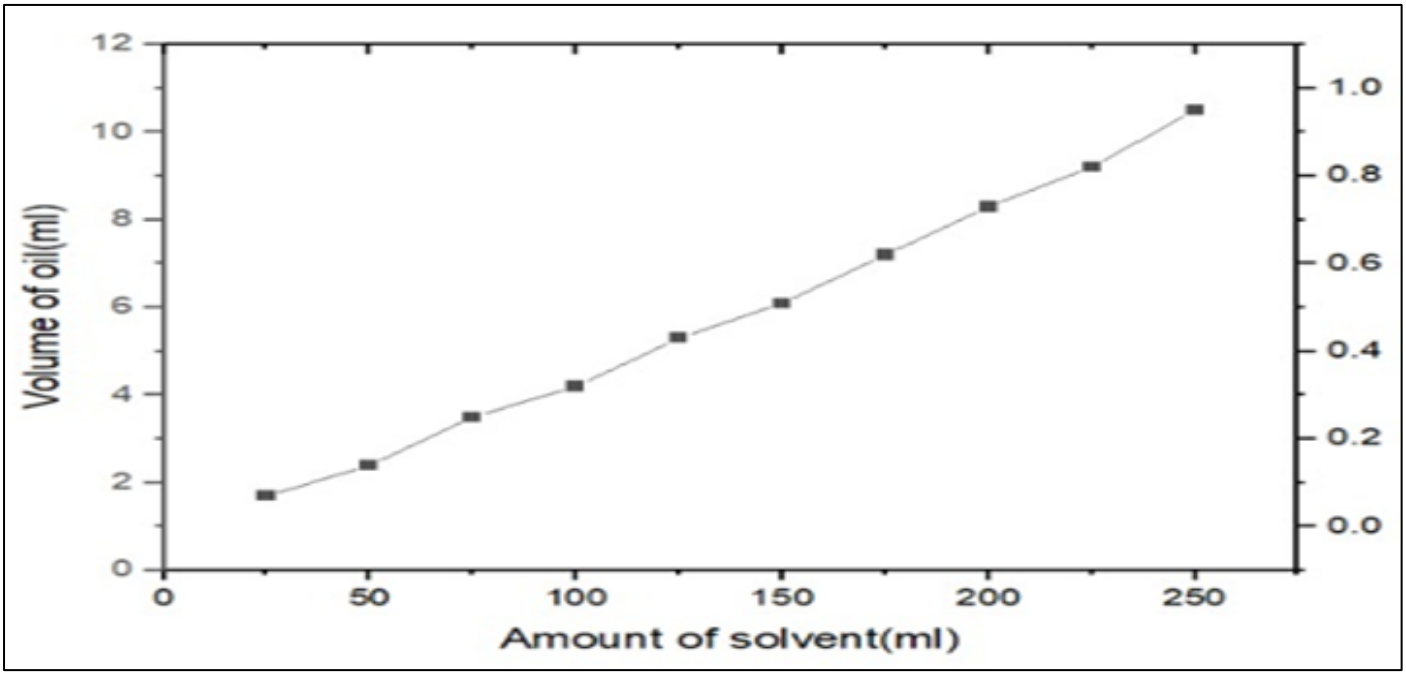

Fig 7 Amount of Solvent (ml)

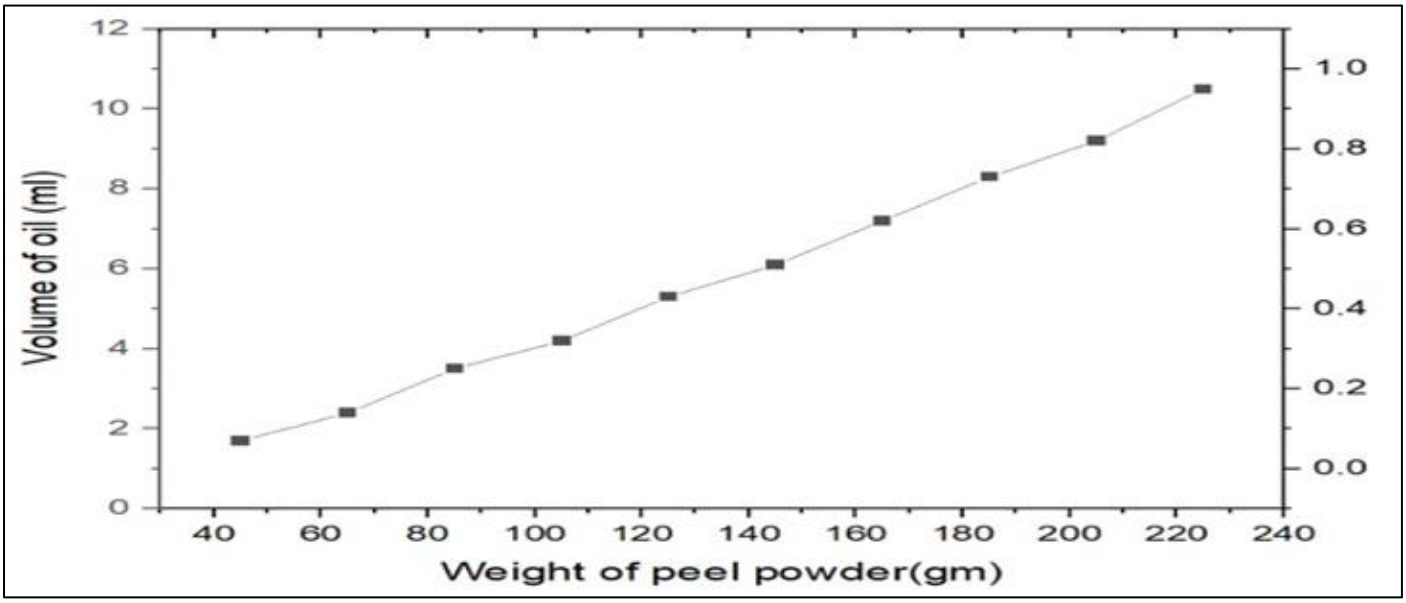

Fig 8 Weight of Peel powder (gm)

Table 3 Amount of oil extracted with varying amount of solvent and orange peels at 60 Degree Celsius

Amount of solvent (methanol) ml	Weight of peel powder (gm)	Volume of oil (ml)
25	45	2.0
50	65	2.9
75	85	3.8
100	105	4.6
125	125	5.5
150	145	6.7
175	165	7.8
200	185	8.6
225	205	9.4
250	225	10.8

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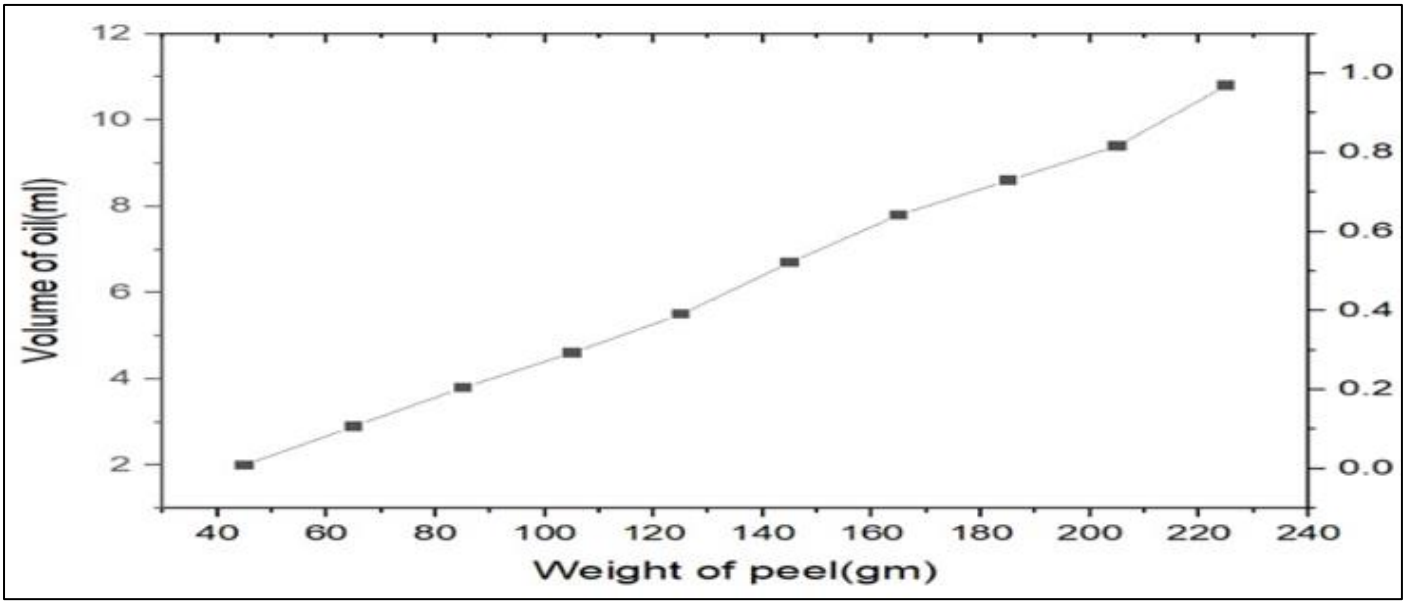

Fig 9 Weight of peel (gm)

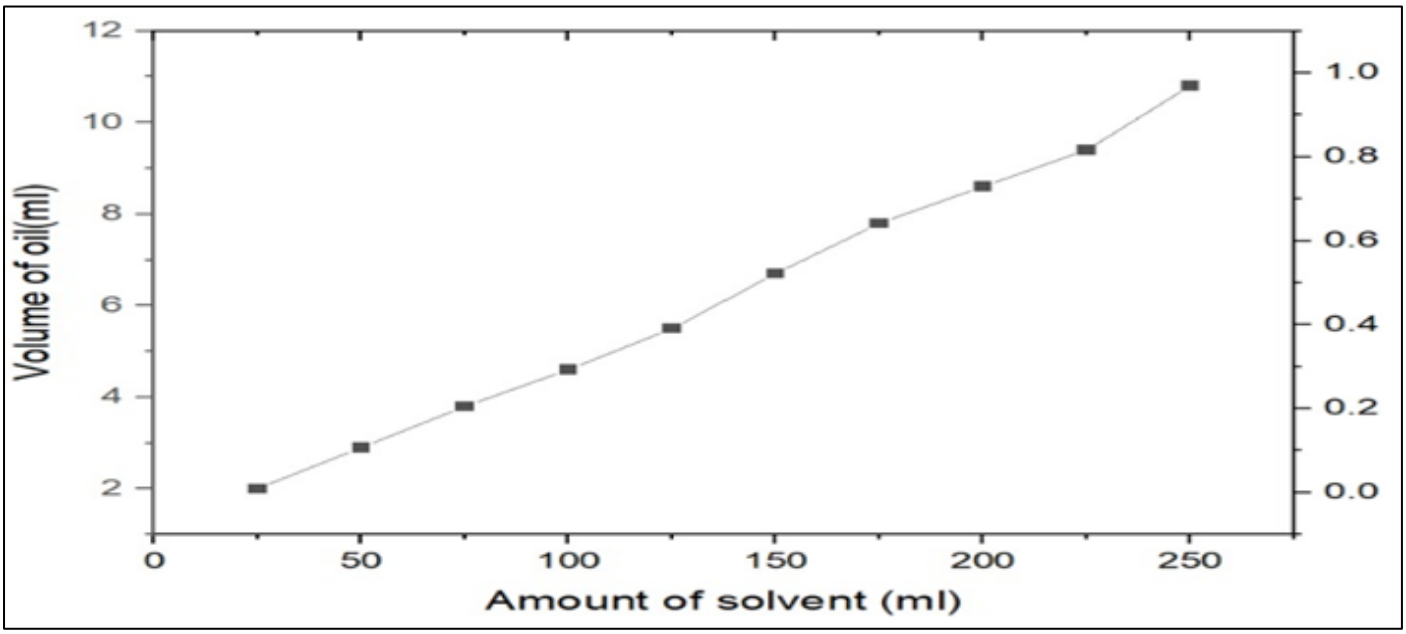

Fig 10 Amount of Solvent (ml)

X. CONCLUSION

It can be concluded that date seeds powder can be used to extract essential oil from it. The percentage extraction of essential oil increases on increasing the temperature of the reaction mixture. On increasing the solvent amount the percentage of oil extracted also increases. The waste seeds can be used can be used to extract oil. It is a process which helps to convert waste to oil which is used is a novel technique of converting waste to energy. The date oil synthesized is used to make biodiesel which is produced via transesterification process in a batch reactor.

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