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Prosopis *julifera* oil: optimization and biodiesel production

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Graphical abstract

Figure 1 *Prosopis Julifera* Tree

Figure 2 Leaves and Pods (fruits) Tree

Figure 3 Pods (fruits) and Seeds

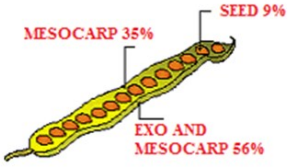

Figure 4 Inner part of a Pod

Abstract

More strict environmental rules and pollution from fossil fuels necessitate cleaner fuels like biodiesel. Production of diesel automobiles has decreased in recent years due to a serious issue with air pollution caused by increased emissions of toxic gases. The most encouraging fuel currently is Biodiesel. Transesterification of nonconsumable oil has drawn the consideration of numerous analysts since it is practical when contrasted and palatable oils in financial and natural worries. The high gooey nature of noneatable oils might prompt difficult issues in Diesel engines and that can be diminished by a two-stage Transesterification process. The dissolvable extraction technique is used to separate oil from *Prosopis Julifera* and a regular transesterification process is taken on to extricate *Prosopis Julifera* biodiesel utilizing basic impetus (NaOH). Lessening the corrosive worth and augmenting the Biodiesel yield is the primary goal of this work. The ongoing survey means to using a Response surface methodology (RSM) strategy utilizing Central Composite Design (CCD) for optimizing the variables that determine the yield of methyl esters, such as the oil-to-methanol molar ratio, the amount of catalyst employed, the reaction time, and the reaction temperature. In like manner, smoothing out is performed to get the most outrageous give in of *Prosopis Julifera* methyl ester. *Prosopis Julifera* methyl ester (PJME) fuel attributes were assessed, distinguished, and measured by ASTM standards. The examinations uncover that the properties of PJME nearly coordinate with the traditional Diesel fuel. Moreover, biodiesel emits fewer air pollutants.

Keywords: Prosopis Julifera; Transesterification; Ultrasonic Transesterification; Response surface methodology

1. Introduction

The two significant issues that we are confronting now daily are natural debasement and non-renewable energy source consumption and this requires the investigation towards a doable, ecofriendly, unusual fuel. Deficient presence of leftover fills, cost climb of unrefined petroleum and ecological debasement invigorated the pursuit towards palatable, non eatable vegetable oils, creature fats as improved substitute for petroleum derivatives (Vasudevan 2008). Biodiesel created from vegetable and creature feedstock are non-poisonous, sulfur free assists with lessening the extreme issues like climatic contamination, expansion in worldwide temperature and so forth (Balat 2011). Oil from vegetable feedstock, for example, palm, sunflower and so on were utilized to run diesel motors in times past. Scientists overall are investigating assortment of palatable and non eatable vegetable oils in various nations, under different climatic circumstances. Different examinations have been accounted for in the open writing for the reasonableness of green growth as biodiesel powers. Because of the hole among request and supply, utilization of oils consumed by people for biodiesel creation was restricted which cleared the presentation of non-palatable oils (Atabani 2013). This likewise assists with diminishing clash between food stuff and utilization of fuel. Methyl esters acquired from plant oils can be straightly used in the diesel motors while different energizes must be handled in order to get the properties like traditional fills. Mileages of significant motor parts, the testimony of carbon, injector stifling are impressively less in 20 to 25% biodiesel based motors (Dave and Bhandari 2013). Species, for example, *Prosopis Julifera, Acacia Nilotica* can be established in Badlands because of

the reliance of less water and practicality to fill in dry saline waste terrains (Rajeshwaran *et al* 2022; Raja *et al* 2022). *Prosopis Julifera* grows up richly in India and is by all accounts began around a long time back are called by various names, for example, Vilayati babul, Vilayati kikar and so on Non-consumable oils have a significant gooey content, which makes them more crude and causes problems with fuel atomization. Hence, by lowering the thickness, diesel engines may continue to run as usual while biofuel could be generated profitably (Dave and Bhandari (2013). The four modified techniques for change of biodiesel from plant oils are mixing, Pyrolysis, Transesterification and miniature emulsification. Among this large number of methods, high gooey oils were proficiently taken care of by Transesterification cycle and that too with and without utilizing impetuses (Rajeshwaran *et al.,* 2022; Shreeram *et al.,* 2022).

Because of the quick reaction at less expense Reaction surface strategy (RSM) is seen to be a suitable procedure to improve different elements influencing the normal result. The primary objective of the response surface method is to position the reply response, which can be conceived of as a kind of outermost layer, with respect to various boundaries in the investigation space (Berchmans *et al* 2008; Melvin Jose *et al* 2011). The unmistakable boundaries in RSM depended on focal composite plan (CCD) to squeeze into entire second-request polynomial portrayal which gives an adequate representation of the larger part endless reaction surfaces (Kannan *et al* 2011; Shreeram *et al.,* (2022). RSM is a useful strategy for the assessment of composite cycles utilizing less number of trial runs. Enhancement of Biodiesel creation utilizing RSM strategy was advanced by numerous specialists (Gopinathan 2009).

The tiny cerium oxide particles and neem oil biofuel are used to make a new kind of fuel. They tested four different fuel mixes to see which one worked best. The best mix, called BCeE, had 90% biodiesel, a little bit of cerium oxide particles, and some ethanol. This mix performed better because it helps with burning and makes the fuel spray better. They checked things like how efficient the engine was and how much pollution it made. The BCeE mix was the winner, making the engine work better and polluting less. So, mixing biodiesel with these additives could make our energy cleaner and more efficient (Allasi 2023).

In this paper, RSM was utilized to improve and to concentrate on the most extreme biodiesel transformation of *Prosopis Julifera*. The current work centers around the oil extraction and Biodiesel creation from *Prosopis Julifera* alongside RSM improvement to track down boundaries that yield more noteworthy yield of methyl esters. The writing audits from different scientists somewhat recently don't have a lot of explanation in regards to getting of non consumable vegetable oil from the cases (seed) of non palatable *Prosopis Julifera*. Additionally, boundaries advancement of proficient *Prosopis Julifera* species was as of recently not portrayed exhaustively.

2. Materials and methods

2.1. Material

This family Leguminosae shares a location with the class *Prosopis Julifera* (PJ) (Fabaceae), sub-family Mimosoideae. The tree structure and its size change among the species. Most prominent and least level can be reach by *Prosopis Julifera* tree 23m and 12m independently (Dave and Bhandari 2013; Rajeshwaran *et al.,* 2022). *Prosopis Julifera* hardwoods have porous, dispersed growth. The needles on the tree contrast in quantity as well as size. *Prosopis Julifera* tree is shown in the **Figure 1**. It very well may be accessible in specific branches or may be missing. The size of the gifts changes tremendously, 3.5-25mm long and 0.9-10 mm wide. The blooms are little which are thickly collected on tube formed, spike-like inflorescences (Dave and Bhandari 2013). The preponderance of the 4.7–7mm length, straw-yellow flowers are. The plant blooms for all intents and purposes any season apart from the rankling summer to mid spinning season. *Prosopis Julifera* units are perfectly symmetrical and straight. The units are 6-20mm wide, 3.5-12mm thick, and 6.5-35 cm in length. **Figure 2** depicts the leaves and units of *Prosopis Julifera*. After the cases have fully developed, they will be thick and pale yellow in colour. Between 17.5 and 27.5 natural elements each bouquet, cases will be delivered per inflorescence. Up to 7.5 mm in length, seeds weigh between 0.3 and 0.4g (27,000–35, 000 seeds/kilogram) (Rajeshwaran *et al.,* 2022). **Figures 3 and 4** shows the dried units and inside bits of a case exclusively.

Figure 1. *Prosopis Julifera* tree

Figure 2. Leaves and Pods (fruits) tree

2.2. Methods of transesterification process

In the transesterification of vegetable oil part, the carbonyl carbon molecule (ester: - $RCOOR_1$) is going through nucleophilic dealt with by drawing nearer electrophile of alcohol (alkoxide: - R2O-). These blends give tetrahedral momentary, which on extra strategy gives ($RCOOR_2$). The overall energies of the reactant and thing choose the

allocation of the center agreement species. The part of transesterification is shown in **Figure 5**.

Figure 3. Pods (fruits) and seeds

Figure 4. Inner part of a Pod

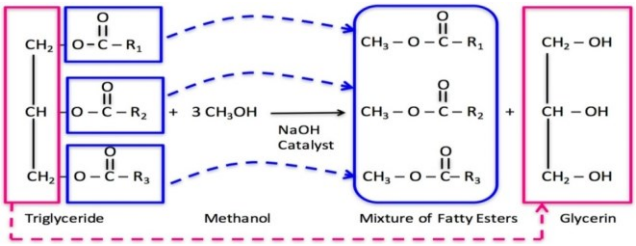

Figure 5. Mechanism of transesterification process

Strong acids and bases both have a removing a molecule from either the alcohol will have an effect on the process and creating major solid spaces for it. Strong acids affect the process by adding a proton to the carbonyl assembling and creating serious solid locations for it (Ramadhas *et al* 2005). These outlined particles have a great deal of favoritism towards each other and in this manner unite with each other and structures biodiesel and glycerin. The glycerin formed can be killed by water washing to get pure biodiesel.

2.3. Apparatus

The mechanical assembly utilised for transesterification includes a reacting beaker with such a extractor, a water shower with a predictable temperature, and high level rpm. The motorised stirrer rpm is mechanically controlled, and throughout the transesterification procedures, constant fomentation rates of 600 rpm were maintained. The schematic design of the biodiesel plant can be seen in **Figure 6**.

2.4. Pretreatment and transesterification

2.4.1. Pretreatment

Before transesterification, oil should first undergo acid esterification, which is followed by fundamental transesterification. It is crucial to have a free unsaturated fatty acid throughout the crucial pretreatment step fat of 5mgKOH/gm so in the ever-evolving pretreatment step 1mgKOH/gm free unsaturated fat worth will be gotten (Melvin Jose *et al* 2011). 100 gram of *Prosopis Julifera* oil alongside 1% v/v of H_2SO_4 were blended completely and kept in a water shower for some particular time and temperature. As there was the slow improvement in the proportion of methanol and oil molar proportion, time taken for response, then the corrosive worth dropped from 44 to 39 mgKOH/gm (3:1, 0.5 hrs) and in the last stage the corrosive worth totally decreased to 18.5 mgKOH/gm (3:1,2 hrs). The streamlined boundaries picked for getting the decrement in the corrosive worth from 44 mgKOH/gm to 8.6 mgKOH/gm, were seen to be 120 minutes time for response, and 9:2 v/v methanol (liquor/oil) molar proportion. The final result acquired from corrosive transesterification process was productively utilized for base transesterification process. A progression of examinations following the above strategy was continued utilizing different grouping of reactants and items, extent of impetus, time taken for response and temperature. From the outcomes induced, the most ideal circumstances for corrosive decrease were noted down (Gopinathan 2009).

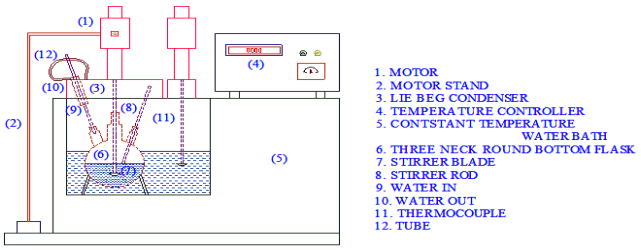

Figure 6. Schematic diagram of Biodiesel production plant

2.4.2. Transesterification

From the start, the impetus (NaOH) was condensed with methanol by overwhelming blending of these two in a Biofuel reactor. After this, the combination was added with plain non consumable *Prosopis Julifera* oil and mixed strongly for an hour time span and ± 60˚C under an enveloping environmental tension. Final product of complete transesterification process brought about 2 different fluid stages to be specific *Prosopis Julifera* methyl ester and crude glycerine. Time taken for partition of fluid stages went from 120 min to 180 min. Of these two stages crude glycerine settled at the base and methyl ester at the top following 8 to 10 hours. By a 2 stage washing process, the methyl ester was washed. The washing game plan was made by joining as one 26.0 % the ratio of 1 mg of tannic acid and 1 gm of non-edible oil per liter of distilled water Atabani (2013). After clear methyl ester was obtained, this was then added to *Prosopis Julifera* methyl ester (PJME) and mixed thoroughly. The complete amount of biodiesel removed utilizing NaOH impetus was 81% which was less thick in nature like customary diesel fuel. The methyl esters got was mixed in various extents and tried in like manner rail diesel motor. **Figure 7** portrays the design of biodiesel creation process.

2.4.3. Fuel Properties of Methyl esters of Prosopis Julifera oil

Table 1 summarises the fuel qualities of PJ oil biodiesel production in compliance with the Bio - diesel ASTM requirements. The majority of the PJME characteristics are in line with what the EN 14214 standards and ASTM standard D6752-02 both prescribe. Full consumption is facilitated by the biodiesel's oxygen content. The calorific value of 39 MJ/kg of PJME was lower than that of diesel because biodiesel contains oxygen. The cetane number (CN) 47-51 was seen as possibly more critical than the customary diesel fuel and this is assessed using Start Quality analyzer Contraption by the standard test system ASTM - D613. Moreover, 4.9 mm^2/sec consistencies seemed to be somewhat more obvious than diesel. This suggests that there should be a small engine alteration made because biodiesel has amazing initial qualities. In particular, thickness of 893 Kg/m^3 was more important as fuel. The ASTM D6751-02 set a restriction for the 4°C cloud point and 124°C flash point saw.

2.4.4. Optimization of transesterification process

To differentiate between the effects of the various collaboration elements on the variation in unsaturated fat methyl esters, central composite design (CCD) was utilized. The reaction temperature (°C), reaction time (min), and the methanol/oil molar extent (v/v) were regarded independent variables, while the degree of biodiesel modification was deemed the dependent variable (Berchmans *et al* 2008). The constraints of the cycle factors impacting the methyl ester change are displayed in Table 2.

Table 1. Properties of Biodiesel produced from non-edible feedstocks

Properties	Test Procedure	Biodiesel-standard ASTM D6751-02	DIN EN 14214	Diesel	Diesel *Prosopis Julifera* oil-Biodiesel(PJME)
Density,Kg/m^3	ASTM D4052	875-900	860–900	847	893
Viscosity at 40°C(mm^2/sec)	ASTM D445	1.9–6.0	3.5–5.0	2.85	4.9
Calorific value(MJ/kg)	ASTM D240			43.4	39
Cetane number	D613	47 min	51 min	46	49
Flash point(°C)	ASTM D4052	>130	>120	68	120
Cloud point (°C)	ASTM D2500	-3 to 12	--	--	4
Acid value (mg KOH/g of oil)	ASTM D4052	>0.8	>0.50	0.35	2.7
Saponification value (mg KOH/g of oil)	--	--	--	--	92
Iodine value (I_2g100/g of oil)	--	--	--	--	87

Table 2. Process parameters level for the optimization of transesterification process

Factors	Process Parameters	Lower level (-1)	Middle level (0)	Upper level (+1)	Std. Dev.
A	Methanol/oil (v/v)	1:3	1:6	1:9	2.33
B	NaOH (w/v)	0.25	0.8383	1.5	0.47
C	Extraction temperature (°C)	55°C	62.5°C	70°C	5.81
D	Extraction time (min)	30	75	120	34.86

It was assessed how ward parameters affected the viability of the biodiesel change. The evaluation of the relationship between the connection parameters methanol/oil molar extent (factor A) (v/v), proportion of (factor B) NaOH (w/v), (factor c) reaction temperature (°C), and reaction time (factor D) (min) in relation to methyl ester yield (%) (Y) was conducted using the following scenario.

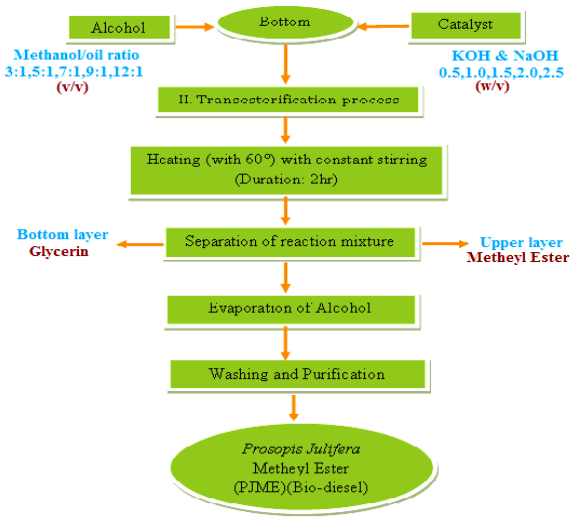

Figure 7. Layout of Transesterification Process

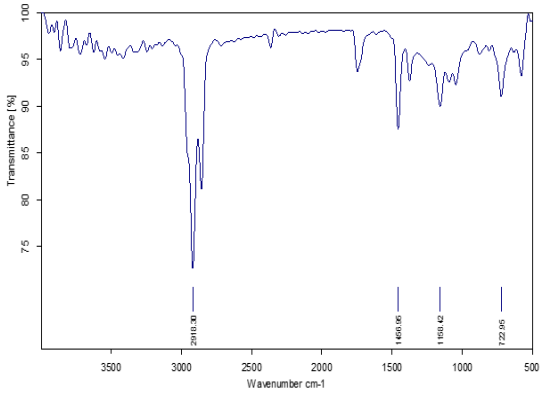

Figure 8. FTIR spectrum of *Prosopis Julifera* methyl ester fuel

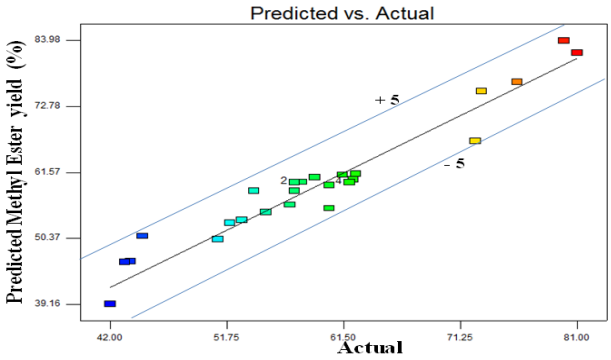

Figure 9. Predicted and Actual Methyl Ester Yield (%)

$$Y = +60.24 + 6.99A + 1.55B + 0.5C$$
$$+9.25D - 0.99\,AB - 0.633\,AC\ 3.11\,AD$$
$$+0.49\,BC - 1.67\,BD - 2.97\,CD$$

To assess the impact of process factors on acid value in the initial stage of transesterification, central composite design (CCD) was used. The applicability and significance of the model were evaluated using analysis of variance (ANOVA) based on the alkaline value (response). The levels of the process parameters for improving the transesterification process are shown in Table 3. Create expert the experimental results were statistically analysed using 7.1.5 trial software.

Table 3. Experimental design with process data and the response for transesterification process model

Std	Run	Methanol/ (v/v)	NaOH (w/v)	Temperature deg C	Time (min)	Yield of Methyl Ester (%)
1	1	-1	-1	-1	-1	42
2	2	+1	-1	-1	-1	51
3	3	-1	+1	-1	-1	43.7
4	4	9	+1	-1	-1	53
9	5	-1	-1	-1	+1	59.1
10	6	+1	-1	-1	+1	79.9
11	7	-1	+1	-1	+1	61.4
12	8	+1	1	-1	+1	81
21	9	0	0	-1	0	60.3
17	10	-1	0	0	0	52
18	11	+1	0	0	0	72.5
19	12	0	-1	0	0	57.4
20	13	0	+1	0	0	62.5
23	14	0	0	0	-1	44.7
24	15	0	0	0	+1	77.2
25	16	0	0	0	0	62
26	17	0	0	0	0	62
27	18	0	0	0	0	62
28	19	0	0	0	0	62
29	20	0	0	0	0	62
30	21	0	0	0	0	62
5	22	-1	-1	+1	-1	43.2
6	23	+1	-1	+1	-1	55
7	24	-1	+1	+1	-1	60.3
8	25	+1	+1	+1	-1	58
13	26	-1	-1	+1	+1	57
14	27	+1	-1	+1	+1	76
15	28	-1	+1	+1	+1	54
16	29	+1	+1	+1	+1	73
22	30	0	0	+1	0	62.3

2.4.5. Fourier transform infrared analyser (FTIR)

Fourier Transform Infrared Spectroscopy (FTIR) spectra was executed utilizing a FTIR - Shimadzu 8500 spectrophotometer in wave degree of 4100 - 510 cm^{-1} with a target of 2 cm^{-1}. The biodiesel conveyed from PJME was broke down utilizing FTIR spectrophotometer. **Figure 8** area the spectrographic picture of diesel, PJME autonomously. From the **Figures 8** plainly the band organized at around 2901-3000 cm^{-1} is ascribed to the C-H connecting of the two fold responsibilities of the C-H group which outline the olefins; the get-togethers organized at 2919 to 2857 cm^{-1} are related with CH vibrations of the methylene parties and to extending and decreasing vibrations of the methyl pack. Figures display how water seethe adapts IR between 4100 cm^{-1} & 3600 cm^{-1} & between 2100 cm^{-1} & 1100 cm^{-1}. Assuming the tops for water seethe relate with different peaks, for example, - Magnanimous and - NH group tops between 4100 cm^{-1} and 3550 cm^{-1} or C=O and - CH_2-pack tops between 2100 cm^{-1}

and 1100 cm^{-1}, the smoke zeniths can influence while isolating infrared spectra.

From the compass, obviously the water rage present in the methyl ester. The extraordinary summit organized at 1750 cm^{-1} connects with the carbonyl moderate and is regular for esters. The get-togethers organized at 1455 - 1470 cm^{-1} were interfaces with the unpredictable loosening up of the C-H bond and the whimsical twisting of the valuable party. There is a standard of get-togethers some spot in the extent of 1000 and 1300 cm^{-1} that are connected with sporadic vibrations of the C (=O) - O and O C bonds; the drew in energy packs viewed as between 1160 - 1180 cm^{-1} are credited to the connecting of the methyl group O-CH_3 and to the fundamentally unpredictable misshapening of the C-C=O securities. The social affairs between 1200 - 1180 cm^{-1} related with the vibrations of the C-CH_2-O pack, the lopsided loosening up of C-O-C and C bond widening. The drew in energy top organized at 723 cm^{-1} associates with turns out of the plane of the C-O pack and the one organized at 1160 cm^{-1} is ascribed to the average sassy twisting of the C-H responsibility of olefins. Taking into account the above conversation, obviously PJME are sprinkled hydrocarbons and the presence of hydrocarbon pack C-H shows that it has a potential as a fuel for marine diesel motor.

3. Results and discussion

3.1. Analysis and evaluation of alkaline-esterification process parameters

Biodiesel was delivered by essential transesterification immediately after corrosive transesterification reduced the FFA value of the *Prosopis Julifera* oil. The evaluation of contrast was then completed in order to verify the model's validity. Table no. 4 contains the ANOVA table. Research was done on the evaluation of communication limitations for methyl ester yield (%) (Y) in relation to methanol/oil volume extent (v/v), extent of NaOH (w/v), response temperature (°C), and response duration (min).

Table 4. ANOVA result for methyl ester yield by transesterification method

Source	Sum of Squares	Df	Mean Square	Value	p-value Prob > F	
Model	2867.982	10	286.7982	20.11568	<0.0001	Significant
A-Methanol/oil (v/v)	862.0208	1	862.0208	60.46111	<0.0001	
B-NaOH	33.40525	1	33.40525	2.343004	0.1423	
C-Temperature	4.226698	1	4.226698	0.296456	0.5924	
D-Time	1518.303	1	1518.303	106.492	<0.0001	
AB	13.81237	1	13.81237	0.968783	0.3374	
AC	5.950516	1	5.950516	0.417362	0.5260	
AD	149.384	1	149.384	10.47762	0.0043	
BC	3.29608	1	3.29608	0.231183	0.6361	
BD	41.28586	1	41.28586	2.895741	0.1051	
CD	135.1723	1	135.1723	9.480824	0.0062	
Residual	270.8914	19	14.25744			
Lack of Fit	242.6781	14	17.33415	3.071978	0.1107	not significant
Pure Error	28.21333	5	5.642667			
Cor Total	3138.874	29				

Table 5. R-squared results for methyl ester yield

Factor	Optimum value	Factor	Optimum value
Std. Dev.	3.726169	R-Squared	0.915744
Mean	60.28333	Adj R-Squared	0.871399
C.V. %	6.181094	Pred R-Squared	0.679232
PRESS	1004.313	Adeq Precision	19.84067

The model employing the Reactive Surface Strategy with Central Composite Design (CCD) for the methyl ester yield has an F-value of 21.60 and a p-value of 0.0001, indicating that the model is enormous with a chance of 0.01% and the Model-F esteem occurred as a result of disturbance. In this RSM model, the volume extent of the mixture of methanol and oil (factor A) was the major settling factor in the biodiesel production, and the most important thing was to increase the yield. The significant F-value of 110.54 for factor A provided evidence for this. In addition to this, the yield of biodiesel was also significantly impacted by the limits of the proportion of biodegradable force and sodium hydroxide (factor B), but the yield of methyl ester was not significantly affected by temperature. The p-value of 0.3517, which was below 0.05, indicates that the two cycle variable, specifically the amount of methanol/oil volume extent (factor A) and the amount of sodium hydroxide (factor B), had a natural influence. R squared and adj R squared values discovered by RSM were separately 0.935744 and 0.885, as shown in Table 5. This table displays the typical conveyance of the data, which supports the ANOVA findings.

The extent of the methyl ester yield and the methanol/oil volume indicated a negative non-direct steep twist in the irritation outline. The graphic also shows that, when differentiating between distinct variables, factor A was the main collaboration constraint. **Figures 9, 10, and 11** show the residuals vs run, difficulty, and anticipated and certified methyl ester yield charts based on RSM. Cook's distance

versus Run number **Figure 12** was under 0.19, which was much below the 0.2 maximum. **Figure 9** Bother (Disturbance) graph shows a negative non-direct steep recurrent pattern for the methyl ester yield and methanol/oil volume extent. The design displayed the ester yield for the specific ingredients, which have been menthol/oil 7.51 (v/v), NaOH 0.89 (v/v), 60°C, and 60 (min). Similar to this, it was determined that when differentiated and various elements, (factor A) was the major cycle limit. The biodiesel yield was most limited when the methanol/oil volume extent was maintained at least 3:1(v/v) and the inputs of sodium hydroxide were also minimal. The trial recipe might indicate the yield level. The biodiesel yield was most limited when the methanol/oil volume extent was maintained at least 3:1(v/v) and the inputs of sodium hydroxide were also minimal. The yield level might be shown by the test recipe.

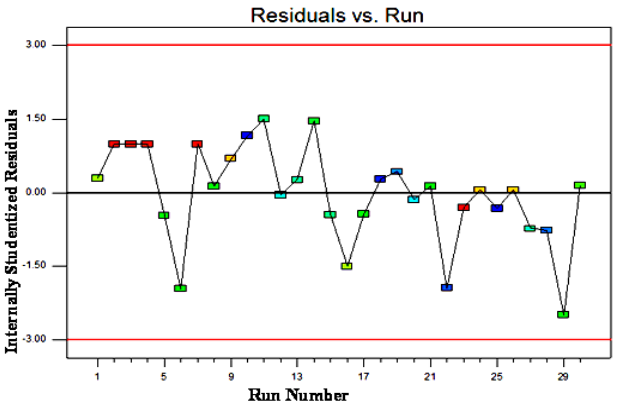

Figure 10. Residuals Vs Run

Yield Of Methyl Ester (Y) = - 16.15458 + 2.78394 X Methanol/oil + 3.76168 X NaOH + 0.8556 X Temperature + 0.67313 X Time - 0.51977 X Methanol/oil X NaOH-0.028478 X Methanol/oil X Temperature + 0.023820 X Methanol/oil X Time + 0.098240 X NaOH X Temperature - 0.060318 X NaOH X Time - 8.70369E - 004 X Temperature X Time.

4. Conclusion

By using various catalysts, methanol/oil molar ratios, reaction temperatures, and response times, optimization and the oil from *Prosopis Julifera* was used to produce biodiesel. The linked focuses have been satisfied by the current effort.

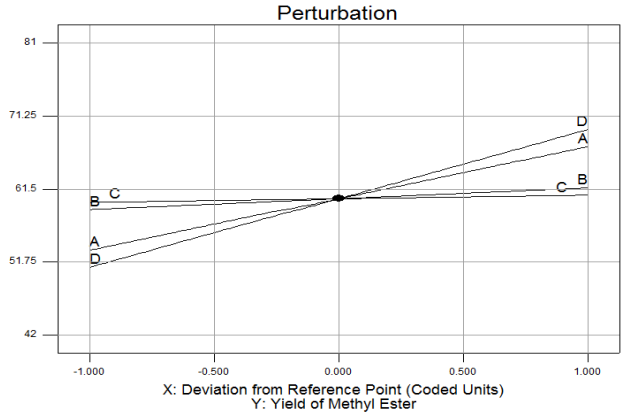

Figure 11. Perturbation chart and Actual Methyl Ester Yield (%)

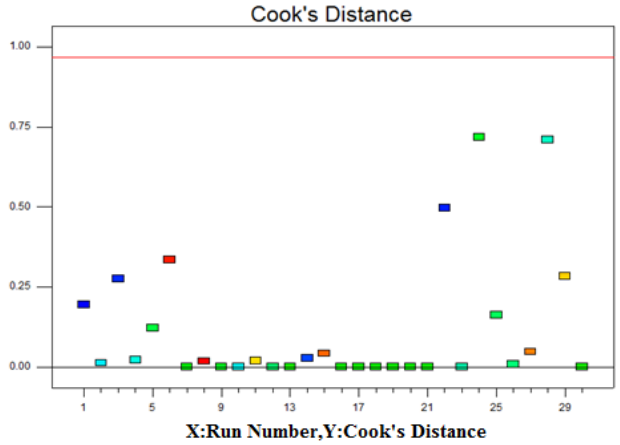

Figure 12. Cook's Distance Vs Run number

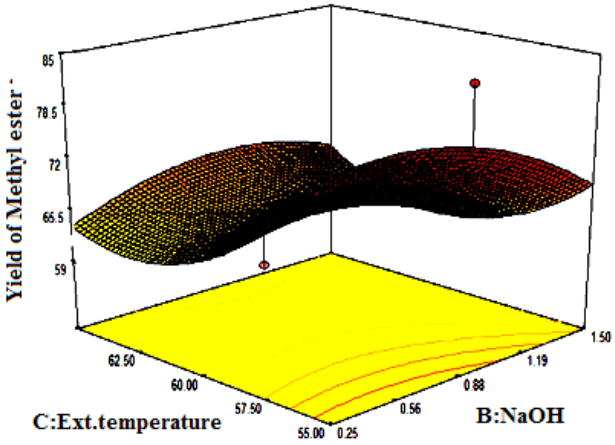

Figure 13. Response surface plot of PJME yield as a function of Reaction temperature and catalyst concentration

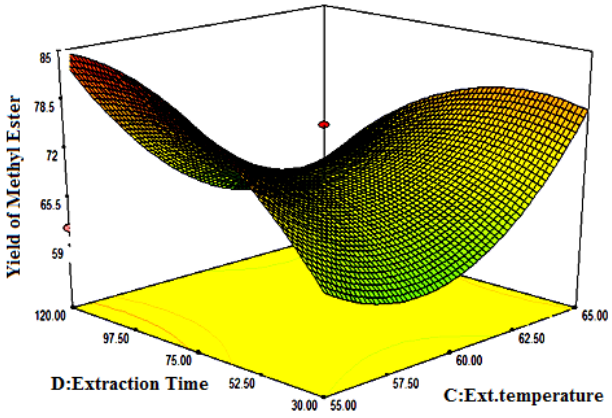

Figure 14. Response surface plot of PJME yield as a function of Reaction temperature and Extraction temperature

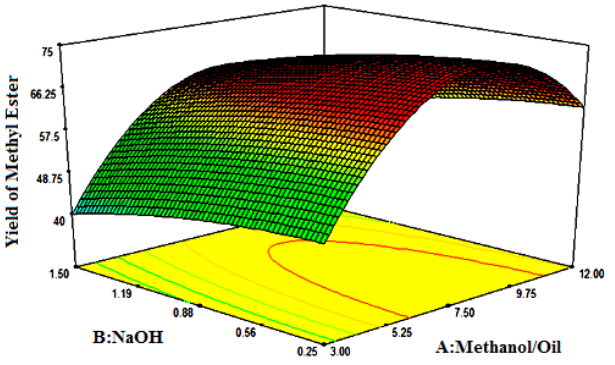

Figure 15. Response surface plot of PJME yield as a function of Methanol to oil ratio and catalyst concentration.

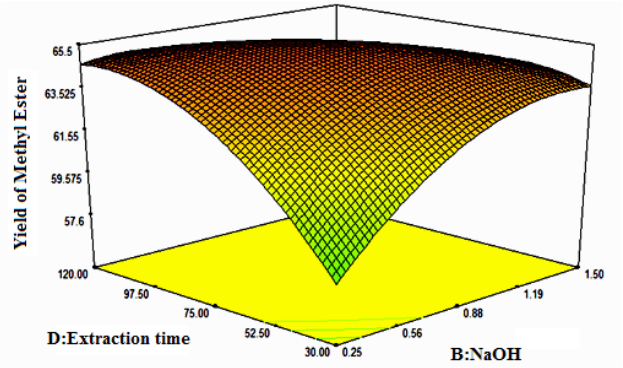

Figure 16. Response surface plot of PJME yield as a function of Extraction time and catalyst concentration.

Utilizing sodium hydroxide as a catalyst during transesterification, 81% of the *Prosopis Julifera* oil was transformed into biodiesel.

Using Response surface approach, the ideal conditions of 9:1 (v/v) methanol/oil ratio proportion, 1% (w/v) NaOH, at an extraction temperature of 55 (°C), and an extract period of 120 (min), yielded 82.28% of methyl ester yield (RSM).

The tested characteristics of *Prosopis Julifera* -based biodiesel, including cetane number, kinematic viscosity, calorific value, and acid values, as compared to traditional diesel fuel, are in excellent agreement with ASTM specifications.

This cycle output of biodiesel might be the most economical alternative fuel for diesel engines' direct injection.

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