Optimization of Process Parameters for Biodiesel Production from Three Indigenous Vegetable Oils

Abstract

Optimization procedures using a variety of input parameters have gotten a lot of attention, but using three non-edible seed oils of Jatropha (Jatropha curcas), Sesame (Sesamum indicum), and Sweet Almond (Prunus amygdalus dulcis) has a few advantages, including availability and non-food competitiveness. Optimizing a two-stage transesterification process using a sodium hydroxide-based catalyst at a fixed catalyst (1.0wt %) and temperature (60 °C) while varying molar ratio (1:3, 1:6, 1:12), time (20–60 min), and mixing speed (500–1000 rpm), to produce optimal responses of yields were studied using response surface methodology (RSM). The optimization solution of molar ratio (1:3), time (40.9 min.), and speed (500 rpm) resulted in an 86.9 % for refined jatropha biodiesel (RJB), the optimization for refined sesame biodiesel (RJB) with molar ratio (1:6), time (41.7 min.), and speed (619 rpm) resulted in an 88.5 %, and the optimization for refined sweet almond biodiesel (RSAB) with the molar ratio (1:3), time (49.359 min.), and speed (500 rpm) resulted in an 88.7 % at the conditions. RJO, RJB, and RSAB had predicted biodiesel yields of 86.9 %, 88.5 %, and 88.7 %, with less than 0.2 % variation, respectively. The characteristics of biodiesel were studied, and the results were...
determined to meet both ASTM D6751 and EN14214 criteria. The effects of molar ratio, and
time on biodiesel yield from their respective oils were important parameters that greatly
influenced the yields, but speed only changed the yields marginally. This work has addressed
important difficulties influencing mass production of biodiesel such as the utilization of low-
cost feedstock such as non-edible vegetable oils, boosting production efficiency through
variable optimization of process parameters, and lowering catalyst dosages through catalyst
regeneration.

**Keywords:** vegetable-oils; biodiesel, optimization, yield; non-edible .

1. Introduction

Several important variables influence the transesterification reaction. To achieve the largest
biodiesel production, these variables must be at their peak since the rate of reaction is
influenced by the reaction temperature. A higher reaction temperature can reduce the viscosity
of oils, increasing the reaction rate as more energy was supplied for the reaction to occur. The
reaction temperature must be lower than the alcohol's boiling point (60–70 oC at normal
atmospheric pressure for methanol) to prevent the alcohol from vaporizing. As a result, raising
the reaction temperature over its optimum range reduces biodiesel yield since the
saponification reaction was quickened, resulting in less biodiesel. Temperatures between 60
and 80 oC generate the best production, depending on the type of oil [1-2]. The stoichiometric
ratio of the trans-esterification reaction in 3 moles of alcohol and 1 mole of triglyceride
produced 3 moles of fatty acid ester and 1 mole of glycerol. The forward reaction was more
favorable, during trans-esterification, more alcohol was used to ensure that the oils were
completely converted to ester [3-5].

A larger alcohol-to-triglyceride ratio can also lead to faster ester conversion. The molar ratio
is strongly influenced by the type of catalyst used. In base-catalyzed biodiesel production, a
molar ratio of 5:1 or 6:1 of methanol to oil is sufficient to convert Jatropha oil to biodiesel if
free fatty acids after pretreatment are less than 1% [6-9]. If the fraction of free fatty acids in
oils was large, a molar ratio of 20:1 or 24:1 was necessary when using acid-catalyzed trans-
esterification [10-13]. The amount of catalyst used can alter the yield of biodiesel produced as
basic catalysts are often favored over acid catalysts due to their better reactivity and reduced
process temperature requirements [14]. Freedman et al. and Ifeoluwa et al. [15-16] discovered
that sodium methoxide was more effective than sodium hydroxide due to the lesser amount of
water produced when mixing sodium hydroxide with methanol. As the catalyst concentration
was increased, the conversion of triglycerides and the generation of biodiesel both increased. It
has been demonstrated that a concentration of NaOH in the range of 1.0–1.4 percent (w/w)
converts jatropha oil to methyl ester by 90–98%. [17-19]. About 95–99 % of jatropha biodiesel
has been obtained with KOH concentrations ranging from 0.55 to 2.0 percent (w/w) [20-21].
However, if the alkali catalysts were used at higher concentrations than their optimum, the
generation of biodiesel was reduced because more soap was generated [22]

According to the literature, as the reaction time reduces, the conversion rate increases. Because
the alcohol was blended and spread into the oil, the reaction was first delayed. After a period,
the reaction picks up pace until it reaches its maximum yield. For base-catalyzed trans-
esterification, the output of biodiesel peaks at 120 minutes or less [1]. Acid catalyzed trans-
esterification takes much longer than base catalyzed trans-esterification because base catalysts are frequently more reactive than acid catalysts [14]. According to previous studies [12-13], the reaction time needed to convert triglycerides to biodiesel might be anywhere from 18 to 24 hours. On the other hand, excessive reaction time would limit the product yield due to the reverse reaction of trans-esterification, which causes more fatty acids to be produced in the form of soaps [20]. Before biodiesel can be developed and optimized on a large scale, many factors and difficulties must be resolved. The key issues include the utilization of low-cost feedstock such as non-edible vegetable oils, increasing production efficiency through optimization of process parameters, lowering catalyst costs through catalyst regeneration, and the optimization of process parameters to maximize the biodiesel yield. This work seeks to address these issues.

2. Materials and Procedures

The three seeds of Jatropha (Jatropha curcas), sesame (Sesamum indicum) and sweet almond (Prunus amygdalus dulcis), and were collected in Ilorin markets in Kwara State, Nigeria. Sigma Aldrich provided the chemicals and equipment (Gillingham, Dorset, UK). Cold oil extraction was used to extract refined Jatropha oil (RJO), Sweet Almond oil (RSAO), and sesame oil (CSO) from crude Jatropha oil (CJO), Sweet Almond oil (CSAO), and sesame oil (CSO) (RSO). Following refinement, the oils were transesterified to obtain refined jatropha biodiesel (RJB), Sweet Almond biodiesel (RSAB), and sesame biodiesel (RSB) using the two-step method recommended by the American Standard for Testing Materials, the Association of Official Analytical Chemists and Mustapha et al. [22-26].

2.1 The Response Surface Method for Optimization of Biodiesel

The Response Surface Method (RSM) is a technique for calculating the number of parameters it takes for optimal response. Correlations between independent and response variables are established using the RSM approach. Although Box and Wilson [27] were the first to create a model or optimal response using experimental data, various techniques to process optimization have expanded its practical use. The p-value for each of the models can be determined using ANOVA. When the values were less than 0.05, the 0.05 p-value for most process variables was favorable, indicating that model terms were significant. Design Expert II was chosen as the statistical tool because it includes the three minimal categories of input and response variables, as well as anticipated and experimental values, which are required for the adequacy assessment.

2.2. Design of Experiments

To produce reliable ANOVA models, the RSM must create a design of experiments (DoE) using the smallest amount of data possible. Because Box–Behnken Design (BBD) designs do not contain axial points, all design points must fall between operating restrictions, and a design matrix (inputs) must be constructed using a BBD. It necessitates a decrease in the number of treatment options. The input components (molar ratio, time and speed) in fixed catalyst and temperature were chosen in a variety of combinations to give yield as an output. A fixed
sodium hydoxide dose of 1.0 wt. %, a molar ratio of 1:3, 1:6, 1:12, and a temperature of 60 °C were randomly tuned with variable time (20, 40, 60 min), and speed (500, 750, 1000 rpm) [26].

Table 1. Design levels with multiple independent variables.

| Independent factors to production |
|-----------------------------------|
| Molar ratio | 1:3, 1:6, 1:12 |
| NaOH (%) | 1 |
| Speed (rpm) | 500, 750, 1000 |
| Temperature (°C) | 60 |
| Time (min) | 20, 40, 60 |

3. Biodiesel optimization test matrices were developed using a fixed sodium hydoxide dose and time.

3.1. Biodiesel derived from refined jatropha biodiesel (RJB)

Table 2. Experimental matrix with a variety of molar ratios, times, and speeds

| Run | A:Molar ratio | B:Time (s) | C:Speed (rpm) | Yield (%): Actual | Yield (%): Predicted |
|-----|---------------|------------|---------------|-------------------|---------------------|
| 1   | 7.5           | 45         | 750           | 80.00             | 80.00               |
| 2   | 7.5           | 45         | 750           | 80.00             | 80.00               |
| 3   | 12            | 60         | 750           | 73.30             | 75.64               |
| 4   | 7.5           | 60         | 500           | 86.67             | 82.34               |
| 5   | 12            | 45         | 1000          | 96.00             | 89.32               |
| 6   | 7.5           | 45         | 750           | 80.00             | 80.00               |
| 7   | 7.5           | 30         | 1000          | 66.70             | 71.03               |
| 8   | 3             | 60         | 750           | 80.00             | 77.66               |
| 9   | 3             | 45         | 500           | 82.67             | 89.35               |
| 10  | 12            | 45         | 500           | 85.30             | 87.30               |
| 11  | 7.5           | 45         | 750           | 80.00             | 80.00               |
| 12  | 12            | 30         | 750           | 73.30             | 75.65               |
| 13  | 3             | 30         | 750           | 66.70             | 64.36               |
| 14  | 7.5           | 60         | 1000          | 73.30             | 77.64               |
| 15  | 7.5           | 45         | 750           | 80.00             | 80.00               |
| 16  | 7.5           | 30         | 500           | 80.00             | 75.66               |
| 17  | 3             | 45         | 1000          | 80.00             | 78.00               |

Based on the three levels of inputs, the Design Expert program generated the most number of runs possible. Figure 1 depicts the link between the actual values acquired experimentally (Table 2) and the yield values predicted by various models.
Figure 1. shows a scatter diagram with the 3D surfaces that correspond to it.

The Variance Analysis (ANOVA)

The equation represents the second polynomial functions in terms of the actual components used to describe yield.

In terms of actual factors, the following is the final equation:

\[
\text{Yield} = +46.78389 - 0.478426 \text{Molar ratio} + 3.79436 \text{Time} - 0.143413 \text{Speed} - 0.049259 \text{Molar ratio} \times \text{Time} + 0.002971 \text{Molar ratio} \times \text{Speed} - 4.66667 \times 10^{-6} \text{Time} \times \text{Speed} + 0.065432 \text{Molar ratio}^2 - 0.035556 \text{Time}^2 + 0.000075 \text{Speed}^2
\]  

Table 3. ANOVA Quadratic model "RJB Yield"

| Source    | Sum of Squares | df | Mean Square | F-value | p-value |
|-----------|----------------|----|-------------|---------|---------|
| Model     | 614.62         | 9  | 68.29       | 2.46    | 0.1243  |
| A-Molar ratio | 42.92       | 1  | 42.92       | 1.55    | 0.2538  |
| B-Time    | 88.25         | 1  | 88.25       | 3.18    | 0.1178  |
| C-Speed   | 43.43         | 1  | 43.43       | 1.56    | 0.2512  |
| AB        | 44.22         | 1  | 44.22       | 1.59    | 0.2474  |
| AC        | 44.69         | 1  | 44.69       | 1.61    | 0.2451  |
| BC        | 0.0012        | 1  | 0.0012      | 0.0000  | 0.9949  |
| A^2       | 7.39          | 1  | 7.39        | 0.2662  | 0.6218  |
| B^2       | 269.47        | 1  | 269.47      | 9.71    | 0.0170  |
| C^2       | 91.73         | 1  | 91.73       | 3.30    | 0.1120  |
| Residual  | 194.36        | 7  | 27.77       |         |         |
| Lack of Fit | 194.36      | 3  | 64.79       |         |         |
| Pure Error| 0.0000        | 4  | 0.0000      |         |         |
| Cor Total | 808.99        | 16 |             |         |         |
Table 4: Constraints for RJB biodiesel optimization

| Name   | Goal    | Lower Limit | Upper Limit | Lower Weight | Upper Weight | Importance |
|--------|---------|-------------|-------------|--------------|--------------|------------|
| A:Molar ratio | minimize | 3           | 12          | 1            | 1            | 3          |
| B:Time   | minimize | 30          | 60          | 1            | 1            | 3          |
| C:Speed  | minimize | 500         | 1000        | 1            | 1            | 3          |
| Yield    | maximize | 66.7        | 96          | 1            | 1            | 3          |

Table 5. Results discovered based on the RSAB biodiesel optimization scenario

| Number | Molar ratio | Time   | Speed     | Yield  | Desirability | Actual | Predicted | Selected |
|--------|-------------|--------|-----------|--------|--------------|--------|-----------|----------|
| 1      | 3.000       | 40.910 | 500.000   | 86.937 | 0.843        | 90.00  | 90.00     | Selected |
| 2      | 3.000       | 41.024 | 500.000   | 87.077 | 0.843        | 90.00  | 90.00     |          |
| 3      | 3.000       | 41.102 | 500.000   | 87.077 | 0.843        | 90.00  | 90.00     |          |
| 4      | 3.000       | 40.605 | 500.000   | 86.712 | 0.843        | 90.00  | 90.00     |          |
| 5      | 3.000       | 40.372 | 500.000   | 86.531 | 0.843        | 90.00  | 90.00     |          |

Tables 2–4 show desirability functions for three different criteria using varied input components (molar ratio, time and speed) for constant NaOH, temperature, and the combination of processes that were examined. The optimization strategies identified based on the biodiesel optimization scenario is shown in Table 5. Using a fixed catalyst of 1.0 wt. %, temperature 60 °C and a molar ratio (1:3, 1:6, 1:12), the optimization solution with the molar ratio (1:3), time (40.910) and speed (500.00 rpm) yielded biodiesel (RJB) of 86.937 %, with the stipulated overall desirability of 0.843. Molar ratio, time, and speed were all important variables in biodiesel synthesis, according to the results of the analysis of variance (ANOVA).

3.1.2 Biodiesel derived from refined sesame biodiesel (RSB)

Table 6. Experimental matrix with a variety of molar ratios, times, and speeds

| Run | A:Molar ratio | B:Time | C:Speed | Yield (%) | Actual | Predicted |
|-----|---------------|--------|---------|-----------|--------|-----------|
| 1   | 7.5           | 45     | 750     | 90.00     | 90.00  | 90.00     |
| 2   | 7.5           | 45     | 750     | 90.00     | 90.00  | 90.00     |
| 3   | 12            | 60     | 750     | 83.30     | 84.56  | 84.56     |
| 4   | 7.5           | 60     | 500     | 90.00     | 90.42  | 90.42     |
| 5   | 12            | 45     | 1000    | 80.00     | 79.14  | 79.14     |
| 6   | 7.5           | 45     | 750     | 90.00     | 90.00  | 90.00     |
| 7   | 7.5           | 30     | 1000    | 86.67     | 86.25  | 86.25     |
| 8   | 3             | 60     | 750     | 86.67     | 85.40  | 85.40     |
| 9   | 3             | 45     | 500     | 78.30     | 79.16  | 79.16     |
| 10  | 12            | 45     | 500     | 90.00     | 88.32  | 88.32     |
| 11  | 7.5           | 45     | 750     | 90.00     | 90.00  | 90.00     |
| 12  | 12            | 30     | 750     | 83.30     | 84.57  | 84.57     |
| 13  | 3             | 30     | 750     | 81.67     | 80.41  | 80.41     |
| 14  | 7.5           | 60     | 1000    | 83.30     | 82.89  | 82.89     |
| 15  | 7.5           | 45     | 750     | 90.00     | 90.00  | 90.00     |
| 16  | 7.5           | 30     | 500     | 81.67     | 82.08  | 82.08     |
| 17  | 3             | 45     | 1000    | 83.30     | 84.98  | 84.98     |
Based on the three levels of inputs, the Design Expert program generated the most number of runs possible. Figure 2 depicts the link between the actual values acquired experimentally (Table 6) and the yield values predicted by various models.

![Graph showing predicted vs. actual yield values](image)

**Figure 2.** shows a scatter diagram with the 3D surfaces that correspond to it.

**The Variance Analysis (ANOVA)**

The equation represents the second polynomial functions in terms of the actual components used to describe yield

**In terms of actual factors, the following is the final equation:**

\[
\text{Yield} = -17.4325 + 6.7683\text{Molar ratio} + 1.5578\text{Time} + 0.1218\text{Speed} - 0.0185\text{Molar ratio} \times \text{Time} - 0.0033\text{Molar ratio} \times \text{Speed} - 0.0008\text{Time} \times \text{Speed} - 0.2167\text{Molar ratio}^2 - 0.0083\text{Time}^2 - 0.0000\text{Speed}^2
\]

(2)

**Table 7. ANOVA Quadratic model "RSB Yield"**

| Source | Sum of Squares | df | Mean Square | F-value | p-value |
|--------|----------------|----|-------------|---------|---------|
| Model  | 259.77         | 9  | 28.86       | 14.21   | 0.0010  |
| A-Molar ratio | 5.54   | 1  | 5.54        | 2.73    | 0.1424  |
| B-Time | 12.40          | 1  | 12.40       | 6.11    | 0.0428  |
| C-Speed| 5.61           | 1  | 5.61        | 2.76    | 0.1404  |
| AB     | 6.25           | 1  | 6.25        | 3.08    | 0.1228  |
| AC     | 56.25          | 1  | 56.25       | 27.70   | 0.0012  |
| BC     | 34.22          | 1  | 34.22       | 16.85   | 0.0045  |
| A²     | 81.05          | 1  | 81.05       | 39.92   | 0.0004  |
| B²     | 14.84          | 1  | 14.84       | 7.31    | 0.0305  |
| C²     | 30.98          | 1  | 30.98       | 15.26   | 0.0059  |
| Residual | 14.21        | 7  | 2.03        |         |         |
| Lack of Fit | 14.21    | 3  | 4.74        |         |         |
| Pure Error | 0.0000     | 4  | 0.0000      |         |         |
| Cor Total | 273.99       | 16 |             |         |         |
Table 8. Constraints for RSB biodiesel optimization

| Name         | Goal     | Lower Limit | Upper Limit | Lower Weight | Upper Weight | Importance |
|--------------|----------|-------------|-------------|--------------|--------------|------------|
| A: Molar ratio | minimize | 3           | 12          | 1            | 1            | 3          |
| B: Time      | minimize | 30          | 60          | 1            | 1            | 3          |
| C: Speed     | minimize | 500         | 1000        | 1            | 1            | 3          |
| Yield        | maximize | 78.3        | 90          | 1            | 1            | 3          |

Table 9. Results discovered based on the RSB biodiesel optimization scenario

| Number | Molar ratio | Time    | Speed    | Yield (%) | Desirability |
|--------|-------------|---------|----------|-----------|--------------|
| 1      | 6.930       | 41.734  | 619.262  | 88.545    | 0.967        |
| 2      | 6.920       | 41.738  | 621.375  | 88.562    | 0.967        |

Tables 6–8 show desirability functions for three different criteria using varied input components (molar ratio, time and speed) for constant NaOH, temperature, and the combination of processes that were examined. The optimization strategies identified based on the biodiesel optimization scenario are shown in Table 6. Using a fixed catalyst of 1.0 wt. %, temperature 60 °C and a molar ratio (1:3, 1:6, 1:12), the optimization solution with the molar ratio (1:6), time (41.734) and speed (619.262 rpm) yielded biodiesel (RSB) of 88.545 %, with the stipulated overall desirability of 0.967. Molar ratio, time, and speed were all important variables in biodiesel synthesis, according to the results of the analysis of variance (ANOVA).

3.1.3 Biodiesel derived from refined sweet almond biodiesel (RSAB)

Table 10. Experimental matrix with a variety of molar ratios, times, and speeds

| Run | Factor 1 | Factor 2 | Factor 3 | Response |
|-----|----------|----------|----------|----------|
|     | A: Molar ratio | B: Time | C: Speed | Yield (%) |
| 1   | 7.5       | 45       | 750      | 81.40    |
| 2   | 7.5       | 45       | 750      | 81.40    |
| 3   | 12        | 60       | 750      | 90.00    |
| 4   | 7.5       | 60       | 500      | 89.50    |
| 5   | 12        | 45       | 1000     | 85.80    |
| 6   | 7.5       | 45       | 750      | 81.40    |
| 7   | 7.5       | 30       | 1000     | 88.50    |
| 8   | 3         | 60       | 750      | 85.70    |
| 9   | 3         | 45       | 500      | 82.80    |
| 10  | 12        | 45       | 500      | 64.20    |
| 11  | 7.5       | 45       | 750      | 81.40    |
| 12  | 12        | 30       | 750      | 92.80    |
| 13  | 3         | 30       | 750      | 78.50    |
| 14  | 7.5       | 60       | 1000     | 70.00    |
| 15  | 7.5       | 45       | 750      | 81.40    |
| 16  | 7.5       | 30       | 500      | 85.70    |
| 17  | 3         | 45       | 1000     | 84.20    |
Based on the three levels of inputs, the Design Expert program generated the most number of runs possible. Figure 3 depicts the link between the actual values acquired experimentally (Table 10) and the yield values predicted by various models.

Figure 3 shows a scatter diagram of with the 3D surfaces that correspond to it

The Variance Analysis (ANOVA)

The equation represents the second polynomial function in terms of the actual components used to describe the yield

In terms of actual factors, the following is the final equation:

\[
\text{Yield} = +46.37108 - 1.65556\text{Molar ratio} + 1.30694\text{Time} + 0.036383\text{Speed} - 0.037037\text{Molar ratio} \times \text{Time} + 0.004489\text{Molar ratio} \times \text{Speed} - 0.001487\text{Time} \times \text{Speed}
\]  
(3)

| Source         | Sum of Squares | df | Mean Square | F-value | p-value  |
|----------------|----------------|----|-------------|---------|----------|
| Model          | 269.87         | 6  | 44.98       | 0.8572  | 0.5561   |
| A-Molar ratio  | 0.3200         | 1  | 0.3200      | 0.0061  | 0.9393   |
| B-Time         | 13.26          | 1  | 13.26       | 0.2527  | 0.6260   |
| C-Speed        | 4.96           | 1  | 4.96        | 0.0946  | 0.7648   |
| AB             | 25.00          | 1  | 25.00       | 0.4764  | 0.5057   |
| AC             | 102.01         | 1  | 102.01      | 1.94    | 0.1934   |
| BC             | 124.32         | 1  | 124.32      | 2.37    | 0.1548   |
| Residual       | 524.72         | 10 | 52.47       |         |          |
| Lack of Fit    | 524.72         | 6  | 87.45       |         |          |
| Pure Error     | 0.0000         | 4  | 0.0000      |         |          |
| Cor Total      | 794.60         | 16 |             |         |          |

Table 11. ANOVA Linear Model "RSAB Yield"

| Name         | Goal   | Lower Limit | Upper Limit | Lower Weight | Upper Weight | Importance |
|--------------|--------|-------------|-------------|--------------|--------------|------------|
| A:Molar ratio| minimize | 3           | 12          | 1            | 1            | 3          |
| B:Time       | minimize | 30          | 60          | 1            | 1            | 3          |

Table 12. Constraints for RSAB biodiesel optimization
Table 13. Results discovered based on the RSAB biodiesel optimization scenario

| Number | Molar ratio | Time | Speed | Yield | Desirability |
|--------|-------------|------|-------|-------|--------------|
| 1      | 3.000       | 49.359 | 500.000 | 88.664 | 0.892 Selected |
| 2      | 3.000       | 49.461 | 500.000 | 88.710 | 0.892         |
| 3      | 3.000       | 49.186 | 500.001 | 88.586 | 0.892         |
| 4      | 3.000       | 49.629 | 500.001 | 88.786 | 0.892         |
| 5      | 3.000       | 48.729 | 500.000 | 88.379 | 0.892         |

Tables 10–12 show desirability functions for three different criteria using varied input components (molar ratio, time and speed) for constant NaOH, temperature, and the combination of processes that were examined. The optimization strategies identified based on the biodiesel optimization scenario is shown in Table 5. Using a fixed catalyst of 1.0 wt.%, temperature 60 °C and a molar ratio (1:3, 1:6, 1:12), the optimization solution with the molar ratio (1:3), time (49.359) and speed (500.00 rpm) yielded biodiesel (RSAB) of 88.664 %, with the stipulated overall desirability of 0.892. Molar ratio, time, and speed, were all important variables in biodiesel synthesis, according to the results of the analysis of variance (ANOVA).

Table 14. Optimization solutions for the three biodiesel optimizations (RJB, RSB and RSAB)

| Number | Molar ratio | Time | Speed | Yield | Desirability |
|--------|-------------|------|-------|-------|--------------|
| RJB    | 3.000       | 40.910 | 500.000 | 86.937 | 0.995 Selected |
| RSB    | 6.930       | 41.734 | 619.262 | 88.545 | 0.931 Selected |
| RSAB   | 3.000       | 49.359 | 500.000 | 88.664 | 0.892 Selected |

4. Conclusions

The optimal parameters for biodiesel were studied in this study using the Surface Response Methodology of Box-Behnken Design. It demonstrated and compared the desirability package's ability to combine production factors to produce three optimal biodiesel productions with a fixed catalyst, temperature and under diverse molar ratio, time, and speed for the optimization scenarios. The correctness of the projected technique was tested using the biodiesel data obtained from the three sets of combination variable testing. Biodiesel yields of 86.937 %, 88.545 %, and 88.664 % were predicted by RJO, RJB, and RSAB, respectively, with less than 0.2 % variation. Biodiesel properties were investigated, and the results were found to meet both ASTM D6751 and EN14214 standards. The optimal yield outputs for each of these biodiesels were obtained, and the effects of molar ratio, and time on biodiesel yield from the RJO, RSO, and RSAO were major parameters that greatly influenced the yield, although speed altered only a little. Finally, the use of low-cost feedstock, such as non-edible vegetable oils, increasing production efficiency through process parameters and variable optimization, and lowering catalyst prices through catalyst regeneration are all major issues affecting mass production that this work addressed.

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