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Research Article

Biodiesel

African Oil Bean Seed Oil Biodiesel Optimization Production via the Technique of Response Surface Methodology-Genetic Algorithm (RSM-GA) and RSM

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This article focuses on optimized production of biodiesel from African Oil Bean Seed Oil, an indigenous African tropical tree of the leguminosea family, using response surface methodology (RSM) and response surface methodology-genetic algorithm (RSM-GA). Transeterification method was adopted using sodium hydroxide (NaOH) catalyst and methanol (alcohol). The extracted oil was pre-treated due to its high free fatty acid FFA contentFrom the research findings, the physiochemical properties of AOBSO are within ASTM ranges. The process parameters investigated were agitation speed, methanol/oil molar ratio, reaction time, reaction temperature, and catalyst concentration. RSM and RSM-GA gave nearly identical optimal results, with RSM-GA producing the better yield. Agitation speed of 225 rpm, methanol/oil molar ratio of 6.2:1, reaction time of 60 minutes, reaction temperature of 60oC and catalyst concentration of 0.775%wt were therefore the optimal parameters for RSM-GA.

The yield of methyl esters (FAAE) under these optimal process parameters was 99.75%.

Keywords: biodiesel, transesterification, fatty acid alkyl esters (FAAE), optimization

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1. Introduction

According to American Standard for Testing and Materials (ASTM), biodiesel is a fuel that consists of mono-alkyl esters of long chain fatty acids which are obtained from either animal fats or vegetable oils. Biodiesel can conveniently satisfy the technical requirements of petroleum diesel because of its strong molecular similarities to petroleum-based diesel[1]. Biodiesel can be created by catalytic cracking, transesterification, pyrolysis, and micro-emulsification with alcohols, according to [2], [3], [4], [5]. Biodiesel is a methyl ester, or FAME, made from vegetable oil or animal fat sources [6]. Transesterification is the most crucial of these processes for creating a fuel that is both safer for the environment and cleaner [7].

African oil bean tree, a member of the Leguminosea family (*Pentaclethra macrophylla*), is indigenous to tropical Africa. It is well-known in Nigeria, where it goes by a number of names (Apara in Yoruba for both the seed and the fermented product, Ugba (Igbo) being the most well-known). Among consumers, it is a favourite condiment and meat substitute [8]. The eastern and southern regions of Nigeria are home to the tree. It is a highly branched, reaching a height of roughly 21 metres and a girth of up to 6 metres, generating a canopy like a crown. It produces flowers around March and April, and the mature, woody, brown pods burst open with an explosive mechanism, scattering the seeds as they curl up. The seeds are roughly 6 cm long and 3 cm wide, dorso-ventrally flattened, firm, and brown in colour [9]. About 47.90% of the seed is made up of oil [10].

2. Materials and Method

(a) Production Process of Biodiesel

The processing of biodiesel can be done using a variety of methods, including direct use and blending, micro-emulsification, thermal cracking (pyrolysis), and transesterification (alkoholysis), which is the most often used method.

Transesterification (Alcoholysis)

In a three phase reversible reaction, triglyceride is converted to glycerin and fatty acid alkyl ester (FAAE), using alcohol and a catalyst. This process is known as tranesterification We refer to this FAAE as biodiesel.

The general transesterification reaction is depicted in Figure 1, and the sequent of converting triglycerides to FAAE and glycerin is shown in Figure 2. The alcohol/oil have a stoichiometric molar ratio of 3:1. However, because the process is a reversible reaction, depending on the production parameters (such as catalyst amount, temperature and type), extra alcohol is required for optimum FAAE synthesis.

Triglyceride + ROH ⇄Diglyceride + $RCOOR_1$

Diglyceride + ROH ⇄Monoglyceride + $RCOOR_2$

Monoglyceride + ROH ⇄Glycerine + $RCOOR_3$

R refers to alkyl group of the alcohol.

Figure 1: Schematics of the general reaction of creating biodiesel. R1, R2 and R3 depict fatty acids

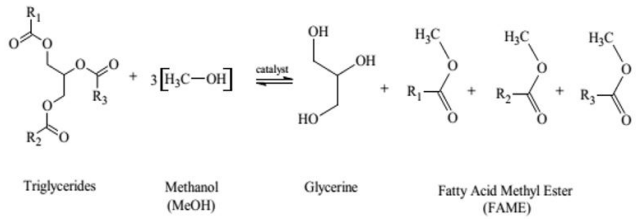


Figure 2: Sequential order of converting triglyceride into fatty acid alkyl ester (FAAE)

Preparing the Raw Oil and Pre-treatment before Transterification

The seeds were sourced from local vendors. Analytical grade chemicals which include methanol, n-hexane, sodium hydroxide (NaOH), HCL chloroform, acetic acid, sulpuric acid, etc were used in the processing of the AOBS oil. Also, a viscometer, magnetic hot plate, conical flask, separating funnel, distillation column, refractometer, gas chromatography mass spectrometer and Fourier transform infra-red spectroscopy were some the equipment used. The seeds were sun-dried and sorted. They were grated in an industrial blender after being sun-dried. Every grated sample was passed through a 500 µm laboratory sieve. 75g of the sieved material were measured into a semi-permeable material and inserted into the thimble of a 250ml sohxlet extractor. A 500 ml circular flask with a flat bottom was filled with 250 ml of n-hexane. The flat bottom flask containing the n-hexane, and an attached condenser was connected to the extraction thimble of the Sohxlet. The extraction thimble holds the sample in a semi-permeable membrane.

A heating mantle was used to heat the Soxhlet extraction setup while water flow was permitted at the condenser's outer jacket. The process wa stopped when all of the oil had been extracted from the sample. The defatted sample in the semi-permeable membrane was discarded, while the oil and n-hexane mixture in the flat bottom flask were separated by distillation. The n-hexane distills over, leaving the oil in the flask, .

The oil percentage yield was calculated as thus:

$$\%\ yield = \frac{\text{weight of the oil extracted}}{\text{weight of the sample used}}\ x\ 100 \qquad 1$$

Oil Yield of African Oil Bean Seed (AOBS)

Table 1 shows African Oil Bean Seed (AOBS) oil yield [11]. Using n-haxane; the AOBS oil percentage oil yield was 47.97%, and is comparable to some eatable oil yields like almond seed oil (47%). It was also comparatively greater than the yields recorded for other non-edible seed oils, such as *mangifera indica* (30.7%) [12]. Food security will be enhanced by AOBS's comparative excellent oil yield, which also de-emphasize reliance on eatable oils as fuel for the production of biodiesel.

Table 1: Oil yield of African oil bean seed using n-hexane

Seed Type	Yield of oil (%)
African oil bean seed (AOBS)	47.97

The extracted oil was characterized to determine its pyhsical propertie; these include specific gravity, melting point, flash point, moisture content, saponification value, iodine value, peroxide value, free fatty acid value, calorific value, and sulphur content [13], [14], [15]. Because of the extracted oil's high free fatty acid (FFA) content—above 1% for the feedstock-a pre-treatment operation was carried out on it. In order to prepare the oil sample for the transesterification reaction, methanol and concentrated sulfuric acid were used as a catalyst. This was accomplished by filling a viscometer to the "2d" mark and pushing it up into the opposite side of the tube. [16] reported that the stopwatch was reset when the oil was refilled into the original tube.

To drive off any moisture present, the oil sample was first heated for ten minutes at 110°C on a heating mantle. In a water bath, the sample was cooled to 60°C. The oil sample was weighed into a 500 ml three-necked round-bottomed flask, and then methanol (60 percent by weight of the oil) and concentrated sulfuric acid (7% by weight of the oil) [17] were added. Water circulated at the reflux condenser's outer jacket after it was placed into the flask's middle arm. One of the side arms was used to put a thermometer into the sample inside the flask. The entire apparatus was set up on a magnetic heating mantle and heated for 120 minutes at 60 degrees Celsius with 450 rpm of agitation. After that, the mixture was put into a 150 ml separating funnel, where it eventually divided into three layers: methanol at the top, pre-treated oil in the middle, and water at the bottom. The water was removed first, then the oil, and finally the methanol, in order to thoroughly separate the components of the combination. After adding hot, distilled water to the oil and shaking it, it was let to stand. To cleanse the esterified oil, this was done. After some time, the water (below) and oil (above) layers were visible. The separating funnel's water was tapped out. After the pre-treated oil had been carefully dried in an oven set to 1050C until all of the remaining water had evaporated, it was put into a beaker. The pre-treated oil was then prepared for the transesterification procedure.

(b) Development of Models and Optimization

Researches have employed response surface methodology (RSM) to investigate the parameters for optimizing the production of biodiesel from eatable and non-eatable oils [18]. Response Surface Methodology is a trusted mathematical computational tool used in modelling, optimisation, and design of experiments (DoE) [19], [20]. The primary advantage is in its ability to decrease the quantity of experiments required to study the effect of various variables and their combined impacts on the outcome. Increasing a process' efficiency requires first optimizing its operating process variables [19]. Since RSM can only locate local optima, its optimization algorithm, adopts a local optimization approach.

Response surface methodology (RSM) of Design Expert version 6 was used to generate experimental design matrix for biodiesel production and model development.

(c) Experimental Design and Model Development by RSM

In this research, the experiment was designed and the reaction conditions were optimized using Design Expert software (version 6).

There were 32 experiments in the two-level, five factor fractional factorial design [21] used in this paper. For the optimization study, independent parameters such as methanol/oil molar ratio, reaction temperature,, reaction time, catalyst concentration, and agitation speed were chosen. The methyl ester yields from the transesterification of oil bean oil was selected as the response. To forecast a good assessment of errors, eight replications of the centre points were employed, and the trials were carried out in a randomized order [22]. Tables 1 and 2 present the analysis of the real and coded levels of each factor and design matrix, respectively. Codes −1 (lowest), 0 (middle), +1 highest), −α, and +α were used to represent the coded values. Alpha is a distance that can be within or without the range from the middle point, with a maximum value of 2n/4, where n is the number of variables. As a result, alpha is set to 0.5. It is important to note that the software investigates significant words using the notion of coded values; thus, the equation in coded values is employed to examine how the variables affect the response [23]. Equation (2) represents the empirical equation as follows:

$$Y = \beta_0 + \sum_{i=1}^{5} \beta_i X_i + \sum_{i=1}^{5} \beta_{ii} X^2{}_i + \sum_{i=1}^{5} \sum_{j=i+1}^{5} \beta_{ij} X_i X_j \quad (2)$$

The studies conducted to investigate the impacts of production parameters on the application of homogenous base catalyst for the transesterification reaction of the feedstock were used to determine the values for each factor.

Table 2: Investigated boundaries of each factor in real and coded form.

Factor	Units	Low level	High level	-α	+α	0 level
Methanol, (A)	Mol/mol	4(-1)	8(+1)	2(-2)	10(+2)	6
Catalyst conc. (B)	Wt%	0.50(-1)	1.00(+1)	0.25(-2)	1.25(+2)	0.75
Agitation speed (C)	Rpm	300(-1)	400(+1)	250(-2)	450(+2)	350
Temperature, (D)	°C	55(-1)	65(+1)	50(-2)	70(+2)	60
Reaction time (E)	Minutes	45(-1)	75(+1)	30(-2)	90(+2)	60

Design of Experiment Matrix/response for NaOH catalyzed optimization transesterification studies is shown in table 3.

Responses of Design Matrix for Optimization Study

Table 3: Responses of design of experiment matrix for the AOBSO transesterification

Run order	Methanol/ Oil molar ratioX1		Catalyst conc. (wt%) X2		Tempe-rature (oC)X3		Time (Mints) X4		Agitation Speed (Rpm) X5		Bio diesel Yield Y (%)
	Coded	Real	Coded	Real	Coded	Real	Coded	Real	Coded	Real	
1	-1	4	-1	0.5	-1	55	-1	45	+1	300	59.00
2	+1	8	-1	0.5	-1	55	-1	45	-1	200	69.30
3	-1	4	+1	1	-1	55	-1	45	-1	200	67.00
4	+1	8	+1	1	-1	55	-1	45	+1	300	74.70
5	-1	4	-1	0.5	+1	65	-1	45	-1	200	55.90
6	+1	8	-1	0.5	+1	65	-1	45	+1	300	72.00
7	-1	4	+1	1	+1	65	-1	45	+1	300	67.00
8	+1	8	+1	1	+1	65	-1	45	-1	200	78.70
9	-1	4	-1	0.5	-1	55	+1	75	-1	200	60.00
10	+1	8	-1	0.5	-1	55	+1	75	+1	300	79.60
11	-1	4	+1	1	-1	55	+1	75	+1	300	72.20
12	+1	8	+1	1	-1	55	+1	75	-1	200	77.00
13	-1	4	-1	0.5	+1	65	+1	75	+1	300	67.20
14	+1	8	-1	0.5	+1	65	+1	75	-1	200	73.60
15	-1	4	+1	1	+1	65	+1	75	-1	200	65.20
16	+1	8	+1	1	+1	65	+1	75	+1	300	99.00
17	-2	2	0	0.75	0	60	0	60	0	250	26.00
18	+2	10	0	0.75	0	60	0	60	0	250	53.00
19	0	6	-2	0.25	0	60	0	60	0	250	74.70
20	0	6	+2	1.25	0	60	0	60	0	250	90.90
21	0	6	0	0.75	-2	50	0	60	0	250	85.70
22	0	6	0	0.75	+2	70	0	60	0	250	90.90
23	0	6	0	0.75	0	60	-2	30	0	250	79.60
24	0	6	0	0.75	0	60	+2	90	0	250	92.10
25	0	6	0	0.75	0	60	0	60	-2	150	80.70
26	0	6	0	0.75	0	60	0	60	+2	350	92.00
27	0	6	0	0.75	0	60	0	60	0	250	99.00
28	0	6	0	0.75	0	60	0	60	0	250	99.00
29	0	6	0	0.75	0	60	0	60	0	250	98.50
30	0	6	0	0.75	0	60	0	60	0	250	98.60
31	0	6	0	0.75	0	60	0	60	0	250	97.90
32	0	6	0	0.75	0	60	0	60	0	250	98.50

(d) Optimization of transesterification process

The ideal combination of the five process variables under investigation was found using RSM and GA optimization methods in order to maximise the biodiesel yield [24].

The response (yield) was set to the maximum for RSM optimization, and the process variables were set within the ranges under investigation [25]. The best settings that produced the highest yield were found using the GA [24].

The GA's primary characteristics are listed in Table 3.3. Experiments were conducted to validate the optimal values calculated by each approach, and the average values achieved were compared with the estimated values [26].

Design Expert version 6.0 (Stat-Ease Inc., Minneapolis, MN, USA) was utilized for RSM optimization.

Table 4: GA optimization parameters [24]

Genetic algorithm	Property	RSM
	Population	20
	Selection	Stochastic uniform
	Crossover	1/intermediate
	Creation function	Uniform
	Generation	15-50
	Mutation rate	0.01/uniform

(e) Extracted Oil Characterization

Physicochemical Properties of AOBS Oil

Table 5 reveals the physiochemical characteristics of the raw African oil bean seed oil. The acid number of 2.86 mgKOH/g, is moderate, and free fatty acid value of 1.43%. The number implies that the raw oil should undergo pre-treatment prior to transesterification. The FFA value was able to drop below 1% thanks to the pre-treatment [27]. The oil cannot be utilized directly as biofuel due to its high viscosity and density, which will make it impossible for internal combustion engines to atomize. The raw and pre-treated oil's somewhat low pour point indicates that it will not harden at room temperature and can therefore be kept in storage for an extended period of time. Free radicals were the cause of the raw oil's elevated peroxide level. Following pre-treatment, the raw oil's peroxide level decreased. The pre-treated oil has better oxidation stability than the raw one, which is advantageous for the biodiesel generation process. This can be the consequence of the technique employed to extract the oil as well as a decrease in peroxide level. Base oil is created through solvent refining and contain some naturally occurring sulphur compounds. While hydro treated base oils require additional fortification with antioxidants to ensure thermal and oxidation stability, the AOBS base oil retains its inherent capacity to prevent oxidation.

Table 5: Physicochemical properties of AOBSO

S/N	Physicochemical properties	Raw AOBSO	Pre-treated AOBSO
1	Specific gravity	0.938	0.918
2	Acid value (mgKOHg)	2.86	0.54
3	Free fatty acid (FFA) (%)	1.43	0.27
4	Spanofication value (mgKOH/g)	187.05	90.23
5	Iodine value (gI2/100g)	36.49	36.49
6	Kinematic viscosity at 40oC (mm2/s)	35.65	28.31
7	Peroxide value (meq/kg)	1.2	0.06
8	Flash point (oC)	329	305
9	Cloud point (oC)	14.50	20.60
10	Pour point (oC)	13	10
11	Moisture content (%)	10	7
12	Refractive index	1.47	1.46
13	Oxidation stability 11oC (Hour)	3	6
14	Molecular weight	901.06	901.06
15	Calorific value (MJ/g)	34.68	34.72

3. Results and Discussion

(a) Effects of Process Parameters on Biodiesel Yield

Table 6: Optimal conditions and validation by RSM and RSM-GA

Bio diesel/ Tool	Methanol/oil molar ratio	Catalyst conc. (%wt)	Temp. (oC)	Reaction time (Mins)	Agitation speed (rpm)	Predicted Yield (%)	Actual Yield (%)	% Error
RSM-GA	6.2	0.775	60.5	60	255	99.88	99.75	0.13
RSM	6.58	0.81	61.5	46.4	246	98.87	98.54	0.33

From table 3, the process parameters considered in the optimization production are catalyst concentration, methanol/oil molar ratio, temperature, agitation speed and time [28]. Tables 4.3a to 4.3e show the effect of each process parameter to the biodiesel yield.

Table 7: Effect of methanol/oil ratio; Reaction conditions: catalyst concentration: 1.25 %wt, time: 60 minutes, temperature: 60 oC, speed: 250rpm. [29]

Runs	Methanol/Oil Ratio	Volume of Methanol (ml)	Volume of Biodiesel (ml)	Yield (%)
1	2:1	6.14	17.50	35.00
2	4:1	12.37	38.00	76.00
3	6:1	19.82	48.00	96.00
4	8:1	25.07	42.50	85.00
5	10:1	30.70	21.50	43.00
6	12:1	34.64	10.00	20.00

Table 8: Effect of catalyst concentration on yield of biodiesel. Reaction conditions: methanol/oil molar ratio: 6:1, time: 60 minutes, temperature: 60 oC, speed: 250rpm

Runs	Catalyst conc.(% wt of Oil)	Wt of Catalyst (g)	Volume of Biodiesel (ml)	Yield (%)
1	0.25		41.50	83.00
2	0.50		44.00	88.00
3	0.75		45.50	91.00
4	1.0		46.50	93.00
5	1.25		47.50	95.00
6	1.5		43.00	86.00

Table 9: Effect of temperature on yield of biodiesel. Reaction conditions: methanol/oil molar ratio: 6:1, catalyst conc.: 1 %wt, time: 60 minutes, speed: 250rpm [30]

Runs	Temperature (oC)	Volume of Biodiesel (ml)	Yield (%)
1	25	15.50	31.00
2	45	36.00	72.00
3	50	41.00	82.00
4	55	45.50	91.00
5	60	47.00	94.00
6	65	47.00	94.00

Table 10: Effect of reaction time on yield of biodiesel. Reaction conditions: methanol/oil molar ratio: 6:1, catalyst conc.: 1 %wt, temperature: 60 oC, speed: 250rpm

Runs	Time (hrs)	Volume of Biodiesel (ml)	Yield (%)
1	15	34.50	69.00
2	30	37.50	75.00
3	45	43.00	86.00
4	60	46.00	92.00
5	75	46.00	92.00
6	90	46.00	92.00

Table 11: Effect of agitation speed on yield of biodiesel. Reaction conditions: methanol/oil molar ratio: 6:1, catalyst conc.: 1 %wt, temperature: 60 oC, reaction time: 60 minutes [30]

Runs	Speed (rpm)	Volume of Biodiesel (ml)	Yield (%)
1	150	44.00	88.00
2	200	46.50	93.00
3	250	48.00	96.00
4	300	49.00	98.00
5	350	49.00	95.00

(b) Plots Showing Effects of Process Parameters on Biodiesel Yield

Figures 3 to 7 show the corresponding plots of process parameters on biodiesel yield.

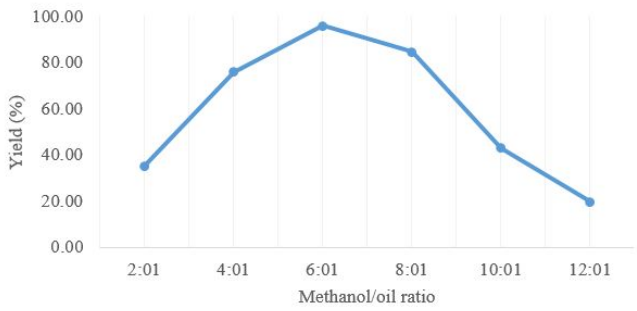


Figure 3: Plot of biodiesel yield (%) vs. methanol/oil ratio for AOBSO sample

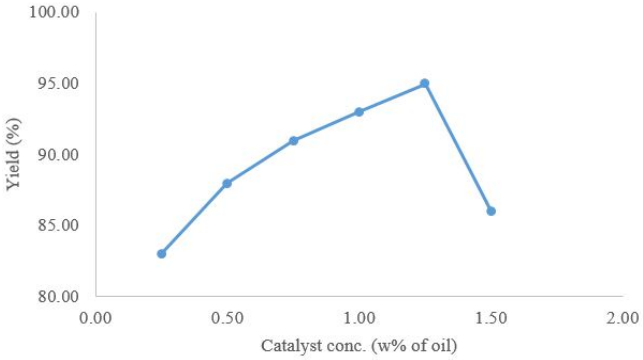


Figure 4: Plot of biodiesel yield (%) vs. catalyst conc. (W% of oil) ratio for AOBS sample

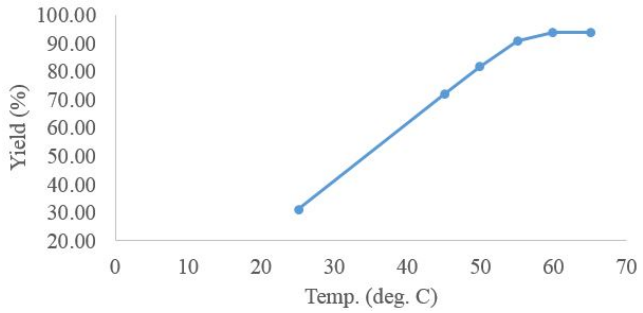


Figure 5: Plot of biodiesel yield (%) vs. temp. (deg. C) for AOBSO sample

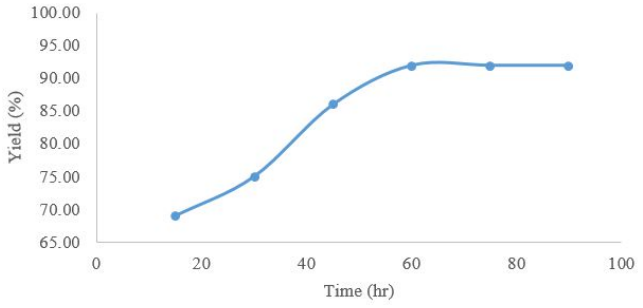


Figure 6: Plot of biodiesel yield (%) vs. time (hr) for AOBS sample

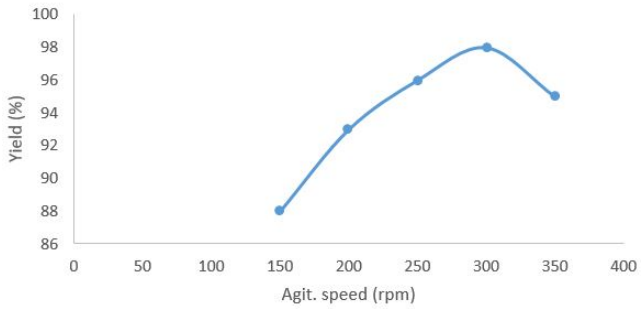


Figure 7: Plot of biodiesel yield (%) vs. agitation speed (rpm) for AOBSO sample

Surface Plots of Estimated Biodiesel Yield

The surface plots of the estimated biodiesel yield for the AOBS oil are shown in Figures 8 to 17. Figures 8 indicates the synergistic influence of the methanol/oil molar ratio and catalyst concentration on the yield of biodiesel. The graph demonstrates that the concentration of the catalyst and the molar ratio of the methanol/oil both raise the yield of methyl ester [31], [32]. A greater catalyst concentration and methanol/oil molar ratio, however, decreases the yield since the two component's quadratic terms become more prominent and have a negative impact. It was also found that the influence on the oil yield followed a similar trend.

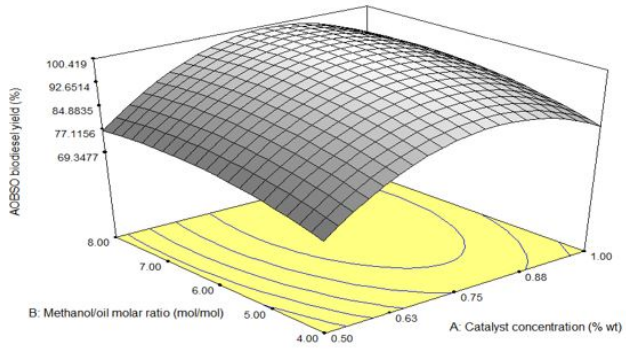


Figure 8: Interaction effect of catalyst concentration and methanol/oil molar ratio on AOBSO biodiesel yield

Figure 9 illustrates the substantial interaction between catalyst concentration and temperature on biodiesel yield for all catalysts employed. The graph shows that an increase in reaction temperature and catalyst concentration also results to a corresponding increase in the yield of biodiesel [21]. However, because methanol evaporates at a higher temperature, a drop in yield can be seen with higher catalyst concentrations and reaction temperatures.

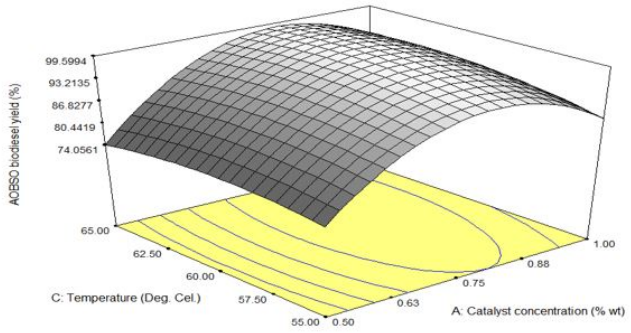


Figure 9: Interaction effect of catalyst conc. and temperature on AOBSO biodiesel yield

Figures 10 illustrates the interaction effect of catalyst concentration and time on biodiesel yield. According to the numbers, the yield of biodiesel improves with an increase in catalyst concentration and reaction duration. On the other hand, the saponification reaction might cause a yield drop at higher reaction times and catalyst concentrations.

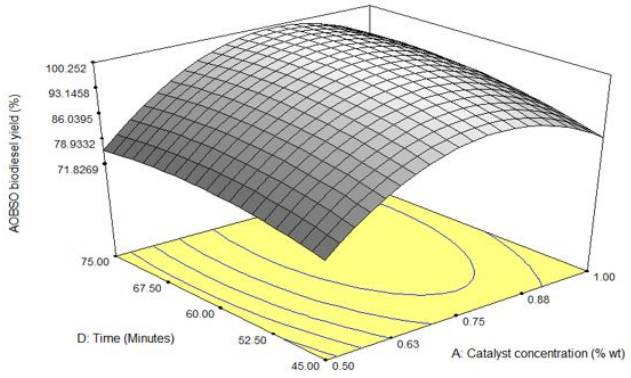


Figure 10: Effect of catalyst concentration and time on yield of biodiesel (AOBSOB)

The yield of biodiesel is significantly impacted by the interplay between catalyst concentration and agitation speed, as illustrated in Figure 11. The data indicates that the biodiesel production rose as the catalyst concentration and agitation speed increased [21], possibly as a consequence of adequate mixing.

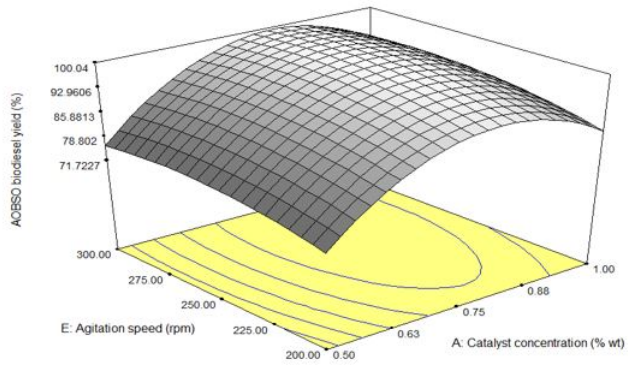


Figure 11: Interaction effect of catalyst concentration and agitation speed on AOBSO biodiesel yield

Figures 12 illustrates the interaction effect of reaction temperature and the methanol/oil molar ratio on biodiesel yield. According to the figures, reaction temperature and the methanol/oil molar ratio both boosted the amount of biodiesel yields [34]. The evaporation of methanol was found to cause a decrease in biodiesel output at higher reaction temperatures and methanol/oil molar ratios.

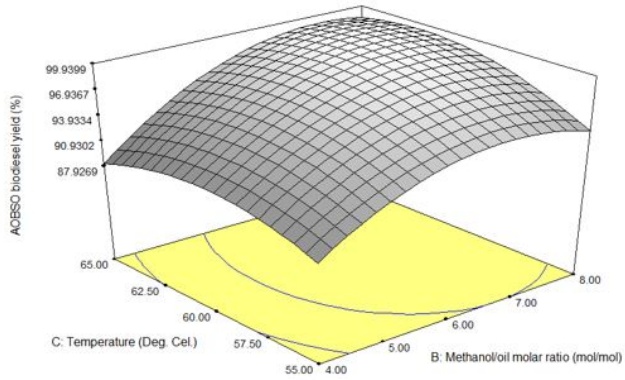


Figure 12: Interaction effect of methanol/oil molar ratio and temperature on AOBSO biodiesel yield

Figures 13 illustrates the interaction effect of reaction methanol/oil molar ratio and agitation speed on biodiesel yield [35]. The result indicates a positive significant effect of the interaction terms between agitation speed and methanol/oil molar ratio on response, with the biodiesel production increasing with agitation speed and the molar ratio of methanol/oil [36]. However, a reduction in the biodiesel yield can be seen at higher agitation speeds and methanol/oil molar ratios [37], because of a decrease in the effective collisions between the reactant molecules brought on by the increased speed.

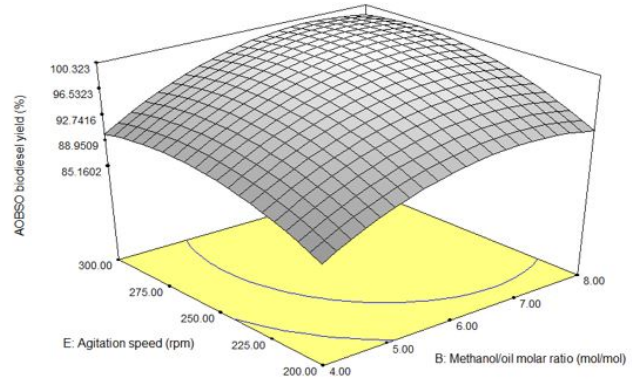


Figure 13: Interaction effect of methanol/oil molar ratio and agitation speed on AOBSO biodiesel yield

Figure 14 illustrates how temperature and time interact to affect the amount of biodiesel produced by AOBSO. The yield rose with time at lower temperatures—below 60oC Nevertheless, there was a decrease in yield over 60oC. This could be because the process is inhibited by the methanol evaporating.

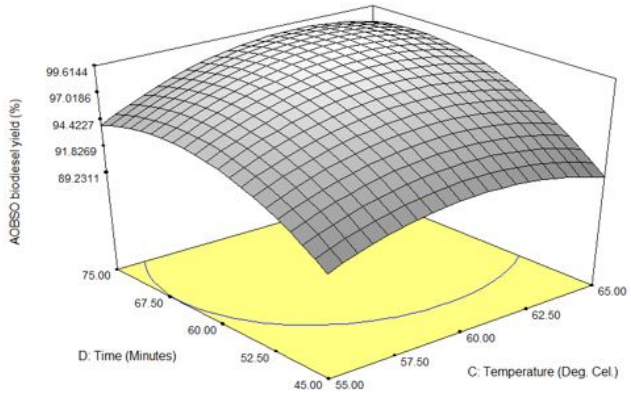


Figure 14: Interaction effect of temperature and time on AOBSO biodiesel yield

Figures 15 illustrates the combined impact of reaction temperature and agitation speed on FAME yield [38], [39] and [40]. The graph shows that, as reaction temperature and agitation speed increased, the biodiesel yield also increased. However, because of low effective collisions brought on by high agitation and methanol evaporation, there was a drop in biodiesel output at higher reaction temperatures and agitation speeds.

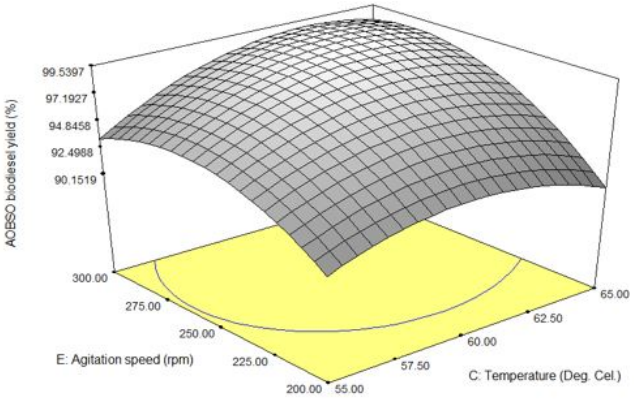
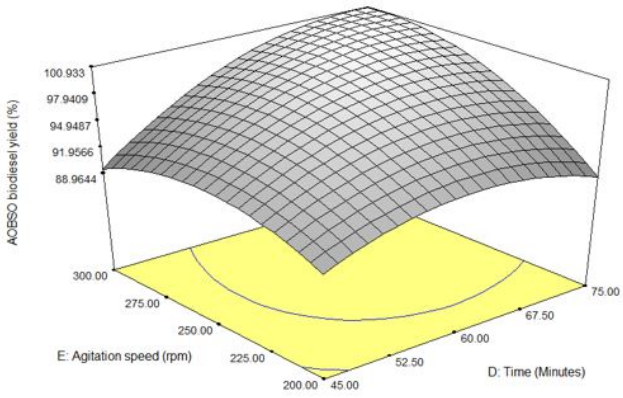


Figure 15: Synergistic effect of temperature and agitation speed on the yield of biodiesel (AOBSOB)



Figures 16: Interaction effect of time and agitation speed on biodiesel yield.

The graph shows that as response time and agitation speed grew, so did the biodiesel yield. The reversible transesterification reaction that results in the loss of esters, however, may be the cause of the decrease in biodiesel output at greater reaction times and agitation speeds [41].

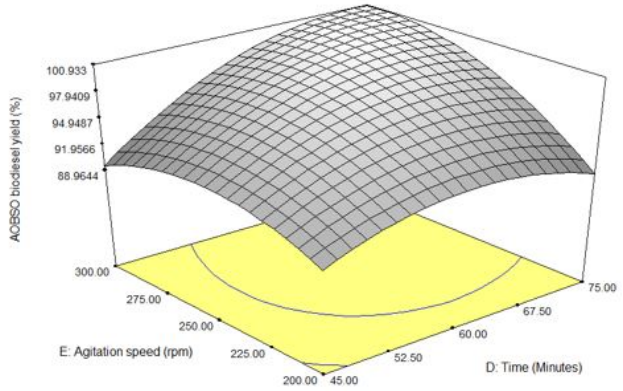


Figure 17: Synergistic effect of agitation speed and time on yield of AOBSO biodiesel

Table 12: AOBSOB properties compared with ASTM limits.

PROPERTY	UNITS	ASTMMETHODS	AOBSOB	ASTM LIMITS
Kinematics Viscosity	Cst	ASTM D-445	3.64	1.6-6.0
Flash Point	oC	ASTM D-93	147	≥130
Pour Point	oC	ASTM D-97	-1.0	+15 max
Density	kg/m3	ASTM D-1298	866	830-880
Cloud Point	oC	ASTM D-2500	6.5	-15 to 5
Acid Value	mgKOH/g	ASTM D-974	0.28	≤ 0.80
Low Heating Value	MJ/kg		38.7	≥ 35
Aniline Point	(oC)	ASTM D-4737	19.5	
Higher Heating Value	MJ/Kg		41	
Oxidative stability	Hour	ASTM D-6751/EN 14112	7.8	3 min
Cetane number		ASTM D-130	62.19	47 min

4. Conclusion

The reaction variables for the biodiesel generation from AOBS oil was optimized using response surface methodology and response surface methodology-genetic algorithm. Prominent variables to determine the response values were the effects of catalyst concentration, agitation speed, temperature, methanol/oil molar ratio, and reaction time on the amount of biodiesel yields. RSM-GA and RSM produced nearly identical optimal yields for the AOBSO FAME, with RSM-GA producing the best yield. The catalyst concentration of 0.775 %wt, the methanol/oil molar ratio of 6.2:1, the agitation speed of 255 rpm, and the reaction time of 60 minutes were therefore the optimal parameters for RSM-GA. The yield of methyl esters (biodiesel) obtained from these conditions was 99.75% for the AOBSOB FAAE.

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