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Modelling Of Picralima Nitida Extraction and Optimization of the Effect of Process Parameters Using Artificial Neural Network and Response Surface Methodology

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Abstract

This study explores the extraction of bioactive components from the deciduous tree Picralima nitida, which is utilized in pharmacology and traditional medicine. The components, including alkaloids, flavonoids, tannins, and saponins, were extracted using ethanol as the solvent under different conditions such as particle size, temperature, and extraction time. The goal was to optimize the extraction process to achieve the highest yield. The study revealed that extraction yield was directly proportional to both temperature and time, while it had an inverse relationship with particle size. Two optimization tools, artificial neural network (ANN) and response surface methodology (RSM), were employed to model and optimize the extraction process. RSM was used to develop a quadratic model for predicting extraction yield based on variations in particle size, temperature, and extraction time. ANN, on the other hand, utilized the Bayesian regularization learning algorithm with the hyperbolic tangent (Tanh) function for the hidden and output layers, proving to be the superior model for predicting extraction yield. The performance of both models was evaluated using R2 and RMSE values. ANN yielded an R2 value of 0.97708 and an RMSE value of 0.063578, while RSM resulted in an R2 value of 0.9296 and an RMSE value of 2.07. Despite RSM predicting a higher optimum yield of 42.87 at 90°C, 50 minutes, and 1mm for temperature, extraction time, and particle size, respectively, ANN provided a more accurate prediction of 40.5762 under the same conditions. Therefore, based on the predicted yields, ANN is recommended as the more effective tool for modelling and optimizing the extraction process.

Keywords: Picralima nitida, Artificial Neural Network, Response Surface Methodology, Soxhlet extraction, Bioactive components, Process optimization, Extraction yield, GC-MS analysis, Phytochemicals, Predictive modelling, Secondary metabolites, Traditional medicine, Process parameters. .

1. INTRODUCTION

For thousands of years, plant sources have been used to cure or alleviate illnesses. Phytochemicals are naturally occurring substances found in plants which provide health benefits (Manoharan et al., 2024). Substances found in medicinal plant containing the healing property of the plant are known as the active components. Plants constitute a source of novel chemical compounds which are of potential use in medicine and other applications. Plants contain many active compounds such as alkaloids, steroids, anthraquinones, tannins, terpenes, saponins, cyanogenic glycosides, volatile oils, fixed oils, resins, phenols and flavonoids which are deposited in their specific parts such as leaves, flowers, bark, seeds, fruits, root, etc (Usmani et al., 2025). These are known as secondary metabolites and may often be created by modified synthetic pathways from primary metabolite or share substrates of primary metabolite origin. The beneficial medicinal effects of plant materials typically result from the combination of these secondary products (El Allaoui et al., 2024).

Picralima nitida, has widely varied applications in Nigeria folk medicine. Its leaves, seed or stembark, have been used as treatment for various fevers, hypertension, jaundice, gastrointestinal disorders and for malaria. The seed, stem and roots have also been reported to be effective as a cough suppressant anodyne, as well as an aphrodisiac and hypoglycaemic agent in treatment of diabetes (Jean-Claude et al., 2025). *Picralima nitida* is used in traditional medicine for the treatment of diseases like malaria, typhoid fever, hypertension, anaemia, gastro-intestinal disorder, male sexual impotence, jaundice and dysmenorrhea. Previous pharmacological studies of this plant extract showed that this plant possesses sympathicotonic, antimalarial, antipsychotic and anaesthetic activities equivalent to that of cocaine (Ogbeide et al., 2025). It has been shown to possess antitrypanosomiasis, anti-inflammatory, antipyretic, antiplasmodial, antimicrobial as well as antidiarrheal properties (El Allaoui et al., 2024).

Researches on the phytochemical screening of *Picralima nitida* show that the plant contains flavonoids, terpenoids, saponins, oxalates, phenols, phytates, cyanogenic glycosides, polyphenols, cardiac glycosides, alkaloids, tannins, and fat and oil in the root, stem barks, fruits, leaves, mature and immature seeds (Kayembe et al., 2020). For isolation of biological components, extraction from plant is one of the more sustainable approaches (Hlatshwayo et al., 2025). Extraction, as the term is used pharmaceutically, involves the separation of medicinally active portions of plant or animal tissues from the inactive or inert components by using selective solvents in standard extraction procedures (Sun et al., 2025).

Southeastern Nigeria is endowed with a lot of vegetative natural resources used as food and medicine; *Picralima nitida* happens to be one of such plants. It is believed that the herbal preparations of this plant are more efficacious than conventional synthetic drugs but there is scepticism about its usage since there is no clear-cut dosage and thus making it a major constraint (Agu et al., 2025). In this study, the bioactive components extracted from *Picralima nitida* have been characterized successfully using GC-MS hence allowing pharmacists across the globe to know for certain the compounds present in the extracts and their corresponding proportions (Onwuegbuchulam et al., 2024a). The limitations of the current technology for extracting bioactive component from Picralima nitida include its inability to meet up to global demand of these bioactive compounds. Scaling up the work done in this study and improving on the method of extraction could solve this issue. The aim of the study was to propose a mathematical model to describe the extraction of bioactive constituents from *Picralima nitida* using empirical approach such as artificial neural network (ANN) and response surface methodology (RSM) in order to describe the variation of extraction yield with time and to evaluate the effect of extraction operating variables on the extract yield and the overall process rate; thereby increasing the extract yield.

Although the extraction, characterization and antimicrobial activity of the bioactive components of *Picralima nitida* have been carried out by several researchers (Adepiti et al., 2025; Alaebo et al., 2025; Ololade et al., 2023; Onwuegbuchulam et al., 2024b), limited studies have explored fully modelling and optimizing the extraction process using empirical approaches such as artificial neural network (ANN) in order to describe the variation of extract yield with time or to evaluate the effect of extraction operating variables on the extract yield and the overall process rate; thereby increasing the extract yield. Hence, this work presents a novel approach to improving the approach of the extraction process of *Picralima nitida*.

2. MATERIALS AND METHODS

2.1. MATERIALS AND REAGENTS USED

The materials used include the *Picralima nitida* blended sample, Lubricants, Ethanol, Distilled water. The Soxhlet apparatus was used for the extraction in this study.

2.1.1. Feed Preparation

The freshly purchased *Picralima nitida* fruits were purchased locally, after which the *Picralima nitida* fruits were thoroughly washed with tap water and the peels and fruits were cut into transverse section to expose the seeds, rinds and pulp. It was then dried naturally with the aid of the sun in order to prevent the destruction of any of the bioactive component. After which, they were ground using a grounding mill. The ground samples were then carried to the civil engineering soil laboratory at the University of Benin to be sieved to different sizes using the corresponding and appropriate mesh sizes of 1mm, 3mm and 5mm.
After sieving, they were packaged in different colour of packs for easy identification. This involved a continuous process of extraction. Here each of the weighted sample of the various particle size of *Picralima nitida* samples were placed inside a thimble that was made from thick filter paper. This was then loaded into the main chamber of the Soxhlet extractor, and the Soxhlet extractor placed onto a flask containing the extraction solvent in each of the desired runs. Next, the ethanol (solvent) was heated to reflux so that the solvent vapour traveled up a distillation arm, and flooded into the chamber housing the thimble housing the sample under consideration.

2.1.2. Experimental of the Soxhlet Apparatus

Soxhlet extraction which is the main area of focus was first proposed by Franz von Soxhlet in the year 1879. In Soxhlet extraction, the heat is supplied through a mantle into the round bottom flask containing the extracting solvent. Above this flask is the extraction apparatus being held by a retort stand.
The solute to be extracted is held by a thimble which seats in the apparatus**.** The condenser is placed above the extracting apparatus with cooling water into the lower inlet and leaving through upper outlet.
The mantle is adjusted to ensure the solvent boils rapidly. The condensed solvent falls into the thimble from the distillation path slowly extracting the solute substance present there. When the extraction chamber is filled, the solvent siphons back into the flask as reflux. The process is then allowed to continue for as long as necessary.

2.1.3. Description of the Experimental setup

The experimental set up comprises of a Condenser unit at the extreme top of the set up. The condenser unit is effective for the control of heat flow through the glassware during the extraction process which is usually a hot extraction process. The Extractor is the area where the extraction process is carried out and its houses the thimble and siphon which is the sample holder. The Distillation flask is the glassware that houses the solvent for the extraction process. For the sake of this kind of extraction process an oil bath heat source was used to heat up the solvent to temperature above 100 Celsius due heat lost to the environment in order to meet up with the technical experimental temperature requirements.

2.2. METHODS

20g of dried, ground Picralima nitida sample was measured using a weighing balance, placed into a small transparent sample sack, and positioned in the extractor section of the Soxhlet apparatus. For the first run, 200ml of ethanol (the extracting solvent) was measured into the distillation flask. The Soxhlet apparatus was assembled as shown in Figure 1, with the condenser connected to a water outlet at the top and a water inlet at the bottom. This mechanism facilitates cooling, making condensation within the condenser possible. The heating mantle was set to a temperature of 90°C for 90 minutes for the initial run. After heating for a duration, the extracting solvent (C_2H_5OH) begins to evaporate upon reaching its boiling point of 78.37°C. The solvent vapor travels up the distillation arm and meets the cold water circulating in the condenser, which condenses the vapor back into a liquid that drops into the extractor to extract the Picralima nitida sample. The extractor containing the Picralima nitida sample is slowly filled with the warm ethanol solvent, allowing the desired bioactive components from the plant to dissolve into the solvent.

When the Soxhlet chamber (extractor) is almost full, it is automatically emptied by the siphon side arm, with the solvent running back down into the distillation flask. After 50 minutes, the process is stopped. The ethanol in the extractor is poured back into the distillation flask, and any residual solvent in the Picralima nitida sample is manually pressed into the distillation flask. The next step involves evaporating the ethanol from the extracted Picralima nitida components. The mixture containing the ethanol and the plant extract is heated at 78°C. As the ethanol starts to escape as vapor and condense back into the extractor, caution is taken to prevent reflux, which would return the removed ethanol back into the mixture. To avoid this, the process is stopped just before the reflux level is reached, and the recovered liquid ethanol is removed and poured into a separate container. This process is repeated until the ethanol in the mixture is almost completely removed, leaving only the Picralima nitida extract. The extract is collected from the distillation flask, stored in a container, and weighed to determine the mass of the extract. Additionally, the ethanol evaporated and recovered from the extract is weighed to determine the final volume of ethanol after the extraction process. This method was repeated for all subsequent runs, keeping the 20g sample mass constant while varying the process parameters.

Let

Mass of beaker = Ml (g)

Mass of beaker + oil = M2 (g)

Mass of oil = M2 -Ml = M3 (g)

Mass of sample (ground bitter kola seeds) = M (g)

$$\frac{mass of oil}{mass of sample} \times \frac{100}{1} = \text{Percentage Yield (\%)}$$

The values of volume of solvent, weight of sample and extracting time were used according to the experimental design in *Table 1* and a total of 11 experimental runs were recorded.

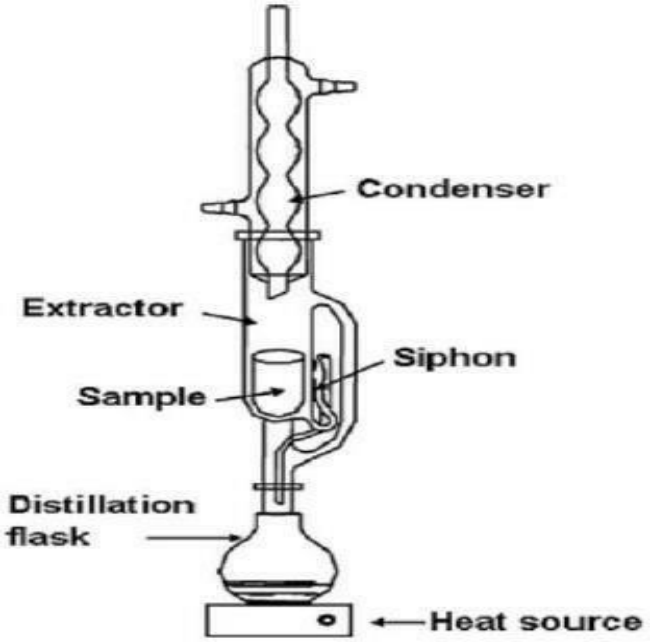

Figure 1: Soxhlet Apparatus Kit

Table 1: Experimental Design of Variables.

Independent Variables	**Symbols**	**Coded and actual levels**		
		H	Aug	L
		-	0	+
Extraction time (mins)	X_1	10	30	50

Particle size (mm) X_2	1	3	5
Temperature (℃) X_3	78	84	90

3. RESULTS AND DISCUSSION

Presentation of Results

The experimental results obtained during the period of observation are presented in Table 2 and further analysed using statistical graphs as shown.

Table 2: Three variable full factorial design for Picralima nitida *Extraction*

Run No.	Actual values of factors			Coded values of factors			Yield	
	Particle Size (mm)	Temp (°C)	Time (min.)	Particle Size (mm)	Temp (°C)	Time (min.)	Exp (%)	Pred (%)
	X_1	X_2	X_3	X_{1S}	X_2	X_3	Y_1	Y_1
1	1	84	50	-1	0	1	25.68	32.56
2	1	90	30	-1	1	0	24.27	27.44
3	1	78	30	-1	-1	0	21.03	17.00
4	1	78	50	-1	-1	1	22.27	25.75
5	1	78	10	-1	-1	-1	9.36	8.53
6	1	90	50	-1	1	1	48.78	42.87
7	1	84	10	-1	0	-1	11.43	8.67
8	3	90	50	1	1	1	39.08	36.96
9	3	90	30	1	1	0	20.45	22.34
10	3	78	50	-1	-1	1	27.69	22.89
11	3	84	10	0	0	-1	4.57	5.91
12	3	84	50	0	0	1	30.96	28.18
13	3	84	30	0	0	0	16.71	16.90
14	3	78	30	-1	-1	0	13.72	14.95
15	3	90	10	1	1	-1	5.82	8.02
16	3	78	10	-1	-1	-1	4.45	7.30
17	5	90	10	1	1	-1	4.26	2.25
18	5	90	50	1	1	1	26.79	29.55

19	5	84	30	0	0	0	14.29	11.84
20	5	78	10	-1	-1	-1	2.47	4.58
21	5	84	10	0	0	-1	4.56	1.67
22	5	84	50	0	0	1	19.81	22.3

3.1 MODELLING OF THE YIELD (*Picralima nitida* YIELD)

3.1.1. Determination of suitable model

Several models such as: linear, cubic, quadratic, modified, 2FI, that are present in the response surface are tested for, to determine which best relates the variables with the desired response; it is seen on Table 3 that the quadratic model was significant with a p-value lower than 0.0001 and a large f-value of 32.05. The quadratic model also had a lack of fit with a non-significant f value of 0.097, a p-value of 0.9986 and the predictive R-Squared" of 0.9279 is in reasonable agreement with the adjusted R-Squared" of 0.9395. This makes the quadratic model the most suitable model to clearly define the relationship between the variables and response

Table 3: model summary statistics

S/N	Sources	Std. Dev.	R^2	Adjusted R^2	Predicted R^2	PRESS	
1.	Linear	4.67	0.8749	0.8540	0.7983	633.32	
2.	2FI	3.99	0.9237	0.8932	0.8006	626.01	
3.	**Quadratic**	**4.29**	**0.9296**	**0.8768**	**0.7260**	**860.31**	**Suggested**
4.	Cubic	3.11	0.9846	0.9353	0.6307	1159.53	Aliased

3.1.2. Analysis of variance-ANOVA

Based on the data in *Table 3*, the identified response model that relates the extraction yield to the process variables in terms of coded factors is shown in *Equation 1*:

$$Y_{1(extract\ yield)} = +16.90 + 3.70X_1 - 4.32X_2 + 11.13X_3 - 1.52X_1X_2 + 3.34X_1X_3 - 0.82X_2X_3 + 1.75{X_1}^2 - 0.75{X_2}^2 + 0.14{X_3}^2$$

Equation 1

The identified response model that relates the extraction yield to the process variables in terms of actual factors is shown in *Equation 2*.

$$Y_{1(extract\ yield)} = +332.45383 - 7.99503X_1 + 10.24394X_2 - 1.74099X_3 - 0.12703X_1X_2 + 0.027822X_1X_3 - 0.020409X_2X_3 + 0.048557{X_1}^2 - 0.18664{X_2}^2 + 0.000362447{X_3}^2$$

Equation 2

Where:
Y_1 represents the extraction yield in %,
X_1 represents temperature in ^oC,
X_2 represents particle size in mm, and,
X_3 represents time in minutes

Equation 2 showing extraction yield in terms of actual factors can be used to predict the response for a given level specified in the original units of each factor. However, it should not be used to determine the relative impact of each factor because the coefficients are scaled to accommodate the units of each factor and the intercept is not at the centre of the design space. $X_1, X_2, X_3, X_1X_3, X_2X_3$, terms play an important role in increasing the extraction yield of *Picralima nitida* whereas $X_1X_2, {X_1}^2, {X_2}^2, {X_3}^2$, had a negative effect on the reaction that decreased the extraction yield.
The analysis of variance for the quadratic model is given in *Table 4* and table 5:

[1]
Table 4: ANOVA for response surface quadratic model

S/N	Source	Sum of squares	Df	Mean Square	F-value	p-value Prob>F	
1	**Model**	2918.59	9	324.29	17.61	< 0.0001	significant
2	A-temp	171.81	1	171.81	9.33	0.0100	
3	B-particle size	217.33	1	217.33	11.80	0.0049	
4	C-time	1889.50	1	1889.50	102.60	<0.0001	
5	AB	12.62	1	12.62	0.69	0.4240	
6	AC	81.97	1	81.97	4.45	0.0566	
7	BC	4.90	1	4.90	0.27	0.6153	
8	A^2	13.56	1	13.56	0.74	0.4077	
9	B^2	2.64	1	2.64	0.14	0.7118	
10	C^2	0.086	1	0.086	0.004674	0.9466	
11	Residual	220.99	12	18.42			
12	Cor Total	3139.58	21				

In Table 4, the Model F-value of 17.61 implies the model is significant. There is only a 0.01% chance that a "Model F-Value" this large could occur due to noise. Values of "Prob > F" less than 0.0500 indicate model terms are significant. In this case A, B, C are significant model terms.

Table 5: Summary of fit quadratic model

S/N	Parameter	Value
1	Standard deviation	4.29
2	Mean	18.11
3	Coefficient of variation (%)	6.07
4	PRESS	60.31
5	R^2	0.9296
6	Adjusted R^2	0.9068

7	Predicted R^2	0.8960
8	Adeq. Precision	14.241

The R^2 (Coefficient of determination) value of 0.9296 which is close to 1 indicates a high level of precision between experimental (actual) and predicted values. The Pred R^2 of 0.8960 is in reasonable agreement with the Adj R^2 of 0.9068. The adjusted R^2 which is also close to 1 indicates the high significance of the model. A relatively small value for the coefficient of variation (CV), (6.07%) indicates a high reproducibility for the model. Adequate Precision measures the signal to noise ratio. A ratio greater than 4 is desirable. The ratio of 14.241 indicates an adequate signal. Therefore, this model can be used to navigate the design space.

3.2.3 Modelling Using Artificial Neural Network (ANN)

A two-layer feed forward network with sigmoid hidden neurons and linear output neurons, implemented in MATLAB version R2014a, was used to model the extraction yield under a combination of the three process parameters (particle size, temperature, and time) for *Picralima nitida*. Three training algorithms; Levenberg-Marquardt, Bayesian Regularization and Scaled Conjugate Gradient were used. The ANN model achieved an R^2 score of 0.9778 as shown in Figure 2.

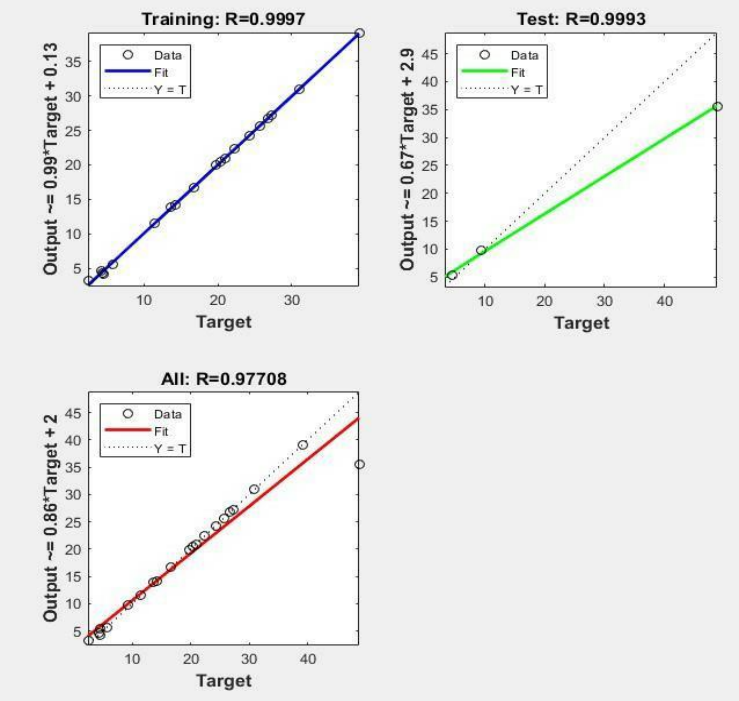

Figure 2: R^2 plots value for ANN architecture

3.2. COMPARISON OF RSM AND ANN PERFORMANCE

In order to get the best model that accurately optimizes the effect of time, particle size and temperature on the extraction yield of *Picralima nitida,* the R^2 and the RMSE values of both models were evaluated, and the results showed that both optimization models gave accurate predictions because of the high magnitude of their R^2 values. However, ANN gave a higher RMSE value as compared to RSM, thus ANN was a better modelling tool. Furthermore, data fittings of actual against predicted extraction yield for both models of RSM and ANN were plotted as shown in Figure 3 and the plots proved that ANN gave a better fit for modelling of the predicted against actual extraction yields.

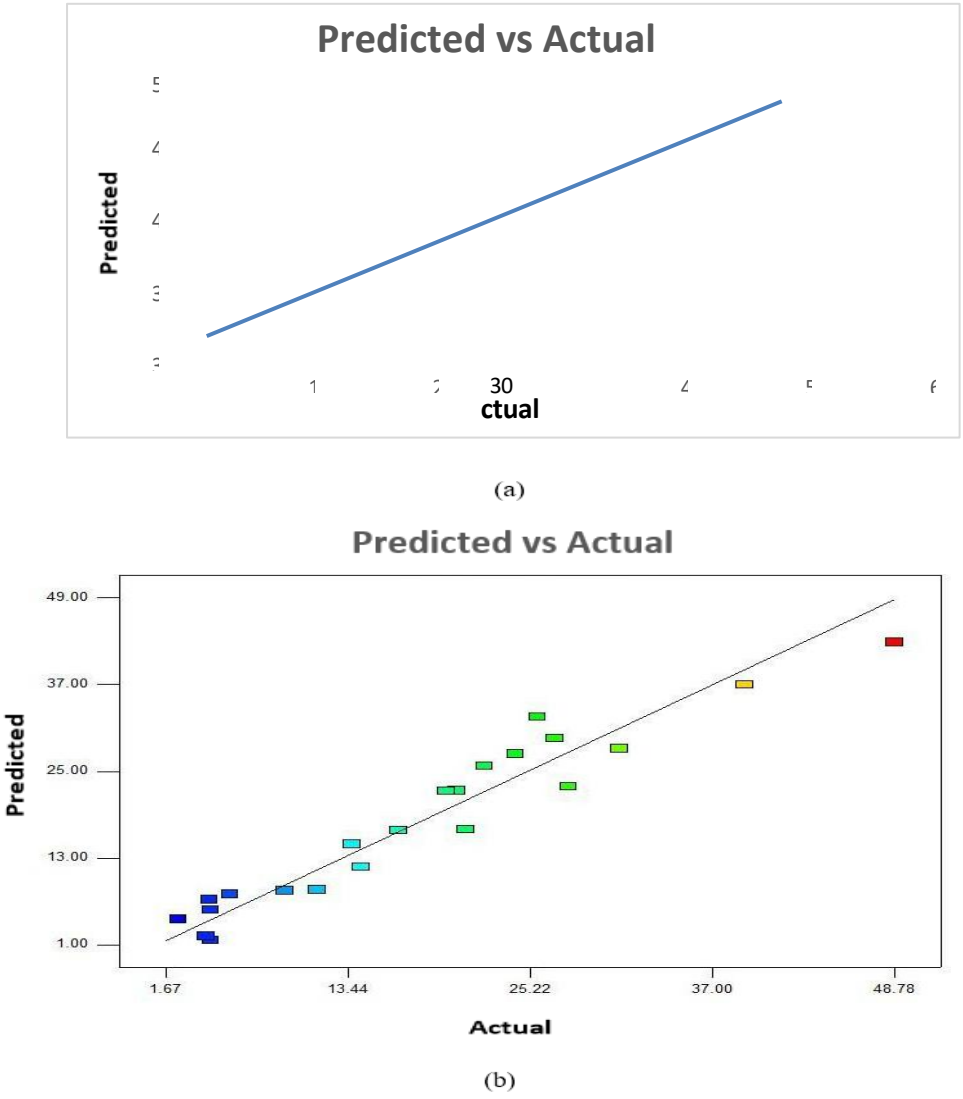

Figure 3: Parity plot of predicted vs actual extract yield for (a) RSM, and (b) ANN

3.3. EFFECTS OF PROCESS VARIABLES ON THE YIELD OF EXTRACTION

Analysis was carried out on two process parameters while keeping one constant, to describe their combined effects on the yield of the plant extract; they are represented in form of surface plots. Figure 4 (a) shows the effect of temperature and particle size on the extract yield while keeping time constant at 30mins. Optimum yield of 32.51% is obtained at a temperature of 89.91°c and particle size of 1mm. At a fixed particle size of 1mm, there is an increase in the yield of extraction from 78°c to 90°c, while at a constant temperature of 78 °c, there is a significant decrease in the extract yield increasing the particle size from 1-5mm. Figure 4(b) shows the effect of temperature and time on the extract yield while keeping time constant at 30mins. Optimum yield of 36.81% is obtained at a temperature of 89.98°c and an extraction time of 49.85minutes. At a fixed temperature of 78°c, there is an increase in the yield of extraction from 10 to 50minutes, while at a constant time of 10minutes, there is a slight increase in the extract yield increasing the temperature from 78°c to 90°c. Figure 4 (c) shows the effect of particle size and time on the extraction yield while keeping temperature constant at 84°c. Optimum yield of 32.51% is obtained at a temperature of 49.96 and particle

size of 1.02mm. At a fixed temperature of 84°c, there is an increase in the yield of extraction from 10 to 50minutes, while at a constant temperature of 78 °c, there is a significant decrease in the extract yield increasing the particle size from 1-5mm.

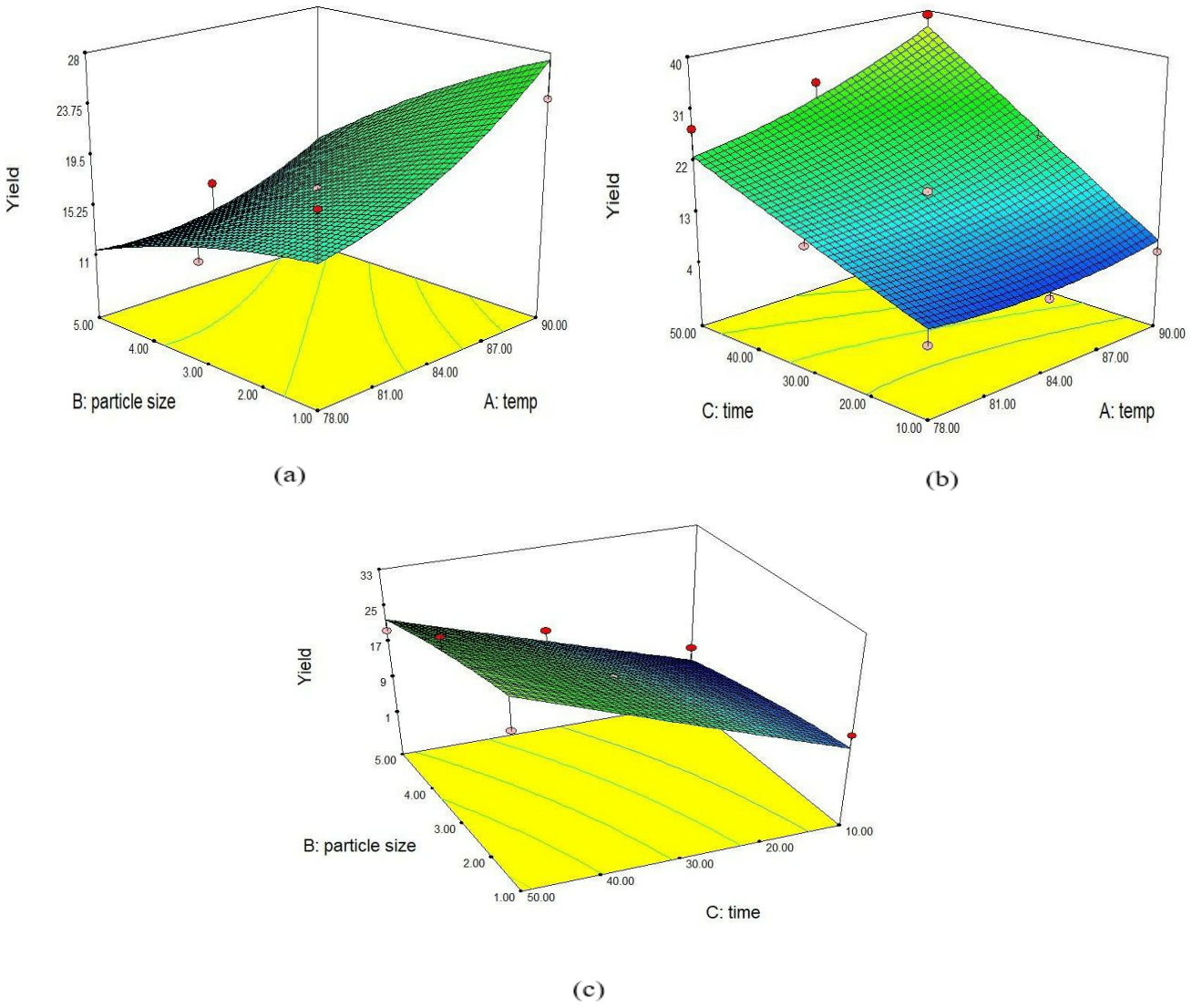

Figure 4: 3D response surface plot for the effect of: (a) temperature and particle size, (b) temperature and time, and; (c) time and particle size, on extraction yield

3.4. PHYTOCHEMICAL CHARACTERIZATION OF *PICRALIMA NITIDA* EXTRACT

The GCMS chromatogram of the *Picralima nitida* extract (Figure 5) exhibited a complex profile, displaying 29 distinct peaks that correspond to a diverse array of bioactive secondary metabolites. Identification of these compounds was achieved by comparing their retention times and mass spectra with those in the NIST library, as summarized in Table 6. Fatty acids and their derivatives constitute the predominant components of the extract. The most abundant constituents are Dodecanoic acid, 1,2,3-propanetriyl ester (Peaks 27 and 28), accounting for a cumulative area of 42.97%, and 9,12-Octadecadienoic acid (Z, Z)- (Linoleic acid, Peak 7) at 20.88%. The presence of Linoleic acid is notable, as it serves as a precursor to arachidonic acid and

prostaglandins, which are essential for anti-inflammatory responses (Berkowitz et al., 2026). The identification of n-Hexadecanoic acid (4.30%) and Octadecanoic acid (6.11%) is consistent with the established chemical profile of medicinal deciduous trees and supports the antimicrobial potential of the extract. Additionally, the detection of nitrogenous compounds and derivatives such as Etorphine at a retention time of 31.659 minutes offers a chemical rationale for the traditional application of *P. nitida* in pain management and other pharmacological contexts (Riley, 2025). The high resolution of peaks observed in the chromatogram (Figure X) confirms that the optimized extraction parameters (90°C, 50 minutes, 1 mm), as determined by the artificial neural network (ANN) and response surface methodology (RSM) models, were effective in recovering a broad range of heat-stable bioactive compounds without substantial thermal degradation.

Table 6: Identified bioactive compounds present in extract

Peak Number	Compound name	Retention time	Peak area
1	Tetradecanoic acid	11.365	0.58
2	Hexadecanoic acid, methyl ester Pentadecanoic acid, 14 methyl-, methyl ester.	13.115	0.45
3	n-Hexadecanoic acid Tridecanoic acid	13.850	0.20
4	9,12-Octadecadienoic acid, methyl ester, (E,E)- 9,15-Octadecadienoic acid, methyl ester, (Z,Z)- 9,12-Octadecadienoic acid (Z,Z)-, methyl ester	15.408	0.20
5	trans-13-Octadecenoic acid, methyl ester 9-Octadecenoic acid, methyl ester, (E)- 8-Octadecenoic acid, methyl ester	15.487	1.04
6	Methyl stearate Heptadecanoic acid, 16 methyl-, methyl ester	15.840	0.48
7	9,12-Octadecadienoic acid (Z,Z)- cis-13-Octadecenoic acid	16.389	20.88
8	Octadecanoic acid	16.674	6.11
9	9,12-Octadecadienoic acid (Z,Z)- 9,17-Octadecadienal, (Z)-	16.989	3.24
10	9,12-Octadecadienoic acid (Z,Z)- Linoelaidic acid 9,17-Octadecadienal, (Z)-	17.341	0.80
11	Methyl 9,12 heptadecadienoate 9,12-Octadecadienoic acid (Z,Z)- 3,4-Octadiene, 7-methyl-	17.564	2.33
12	E-11-Hexadecenal cis-9-Hexadecenal 9-Tetradecenal, (Z)-	18.366	0.42
13	9,12-Octadecadienoic acid (Z,Z)- Linoelaidic acid 9,12-Octadecadienoic acid (Z,Z)-	20.342	0.50
14	9,17-Octadecadienal, (Z)- 9,12-Octadecadienoic acid (Z,Z)- Linoelaidic acid	20.733	0.10
15	9,12-Octadecadienoic acid (Z,Z)- Linoelaidic acid 9,17-Octadecadienal, (Z)-	21.038	1.08
16	9,12-Octadecadienoic acid (Z,Z)- Linoelaidic acid	21.412	0.20
17	9,12-Octadecadienoic acid (Z,Z)- Linoelaidic acid 9-Octadecenoic acid (Z)-, 2,3-dihydroxypropyl ester	21.767	0.59
18	9,12-Octadecadienoic acid (Z,Z)- 9,17-Octadecadienal, (Z)- Z,Z-10,12-Hexadecadien-1-ol acetat	21.969	0.14
19	2-Butynamide, N-methyl- (Z)-1,3-Dimethoxypropan-2 yl docos-13-enoate Oxonin, 4,5,6,7-tetrahydro-, (Z,Z)	24.036	0.10
20	9,17-Octadecadienal, (Z)- 9,12-Octadecadienal Propyleneglycol	24.440	2.89

	monoleate		
21	9-Octadecenoic acid (Z)-, 2 hydroxy-1 (hydroxymethyl)ethyl ester 9,12-Octadecadienoic acid (Z,Z)-9-Octadecenoic acid (Z)-, 2,3-dihy droxypropyl ester	24.800	1.03
22	3,8 Dioxatricyclo[5.1.0.0(2,4)]oct ane, 4-ethenyl-(Z)-1,3-Dimethoxypropan-2 yl octad 229766 1000412-79 5 16 ec-11-enoate 2-Butynamide, N-methyl-	25.422	0.87
23	2-Butynamide, N-methyl- 3,8- Dioxatricyclo[5.1.0.0(2,4)]oct ane, 4-ethenyl- 1,22-Docosanediol	25.796	0.71
24	n-Tridecan-1-ol Methyl 2- hydroxydodecanoate 2-Decanol	26.078	0.46
25	Carbonic acid, propargyl 2,2,2-trichloroethyl ester [1,2,4]Triazolo[1,5 a]pyrimidin-5(4H)-one, 7 amino-4-methyl- Fumaric acid, 4-heptyl tridecyl ester	27.003	1.29
26	Fumaric acid, 3-hexyl tridecyl ester Cyclohexane, 1,1'-(2-propyl 1,3-propanediyl)bis- Thiourea, 2-cyano-1,3 dihexyl-	27.207	0.41
27	Dodecanoic acid, 1,2,3-propanetriy l ester	30.341	22.41
28	Dodecanoic acid, 1,2,3-Propanetriy l ester	30.726	20.56
29	Acetamide, N-(4,6,7,8 tetrahydro-3,13-dimethoxy-4 oxoheptaleno(1,2 f)(1,3)benzodioxol-6-yl)-, (S)- Heptanamide, 2-methyl-N-[1 (1,2,3,4,4a,9,10,10a octahydro-1,4a-dimethyl-7 isopropylphenanthren-1 yl)methyl]- Etorphine	31.659	5.80

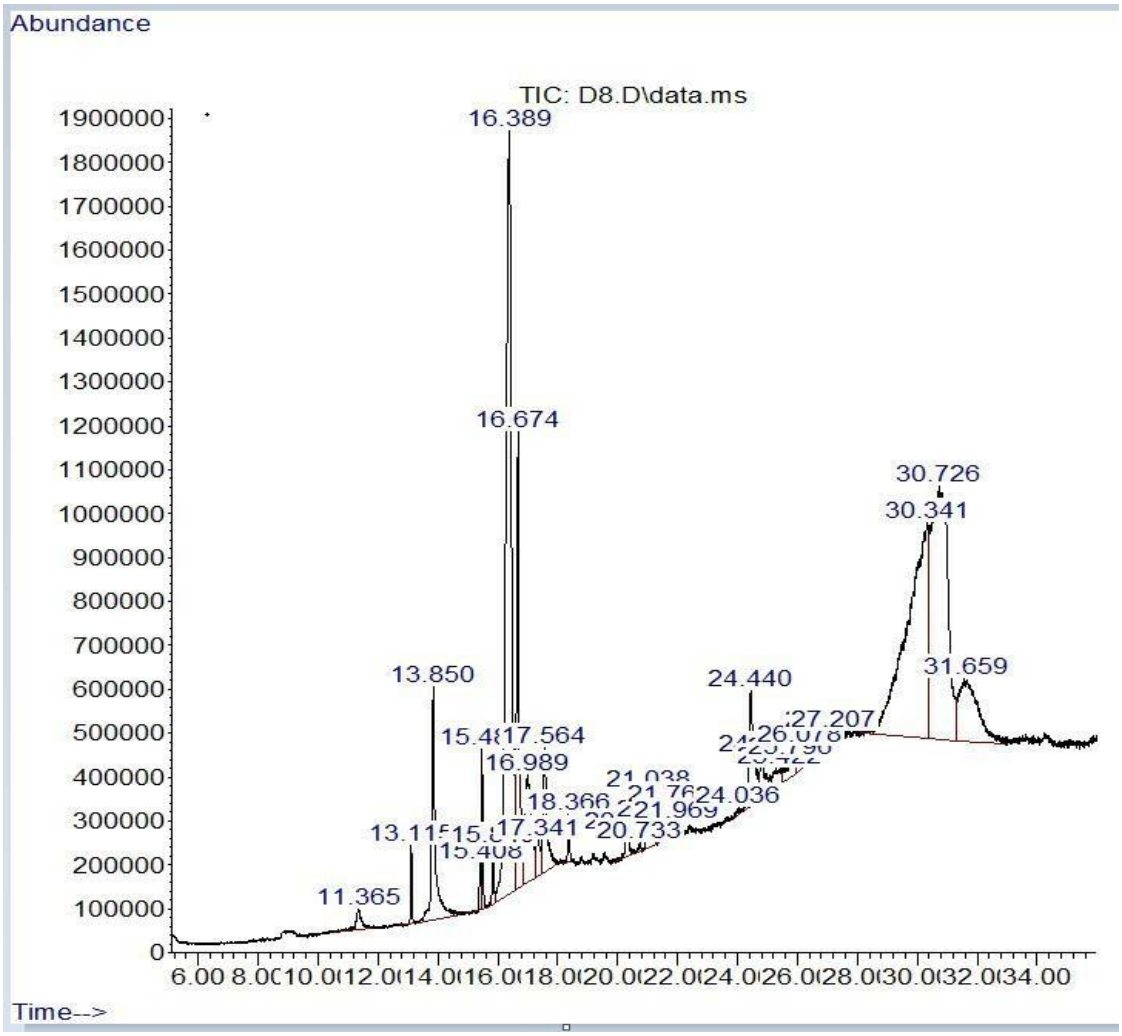

Figure 5: GC-MS Total Ion Chromatogram (TIC) of Picralima nitida *Extract showing major peaks of bioactive metabolites.*

4. CONCLUSION AND RECOMMENDATIONS

This study successfully modeled and optimized the extraction of bioactive components from *Picralima nitida* using a comparative approach between Response Surface Methodology and Artificial Neural Networks. The results established that extraction yield is significantly influenced by process parameters. Specifically, the yield showed a direct proportionality with temperature and time, while maintaining an inverse relationship with particle size. Although the quadratic model developed via RSM proved statistically significant, the ANN demonstrated superior predictive accuracy. By utilizing a Bayesian regularization algorithm with a hyperbolic tangent transfer function, the ANN achieved an R^2 value of 0.97708. Phytochemical characterization via GC-MS confirmed the presence of 29 bioactive compounds, most notably linoleic acid and dodecanoic acid esters. The identification of these constituents alongside specialized nitrogenous derivatives such as etorphine provides a robust chemical rationale for the traditional use of *P. nitida* in pain management and pharmacology. The high yield and quality of the extracts suggest that the Soxhlet extraction process, conducted under the optimized conditions identified in this work, is viable for industrial scale-up. Future research should build upon these findings by investigating additional variables such as solvent-to-solid ratio and solvent density to further enhance the efficiency and economic feasibility of *P. nitida* valorization.

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