Modeling and Optimization of Castor Oil Extraction using Mechanical Method for Biodiesel Production

[1]Muyiwa Abiodun OKUSANYA* &[2]Emmanuel Atto AJAV

[1]The Federal Polytechnic Ilaro, P.M.B. 50, Ilaro, Ogun State, Nigeria

[2]University of Ibadan, Ibadan, Oyo State, Nigeria

***Corresponding Author:** muyiwa.okusanya@federalpolyilaro.edu.ng (+2348037441901)

Extended Abstract

Introduction

Nigeria economy has been negatively impacted by the elimination of petroleum subsidies, rising energy costs, sporadic gasoline shortages, and overall inflation. The over reliance on fossil fuels as sources of energy has led to the disproportionate impact of petroleum fuel on the economy. This gives sufficient justifications for promoting energy sector reform. Hence, if biofuel is to be included in the energy mix, agriculture must be given priority.

All over the world, a wide range of feedstock types are utilized in the production of biodiesel; yet, it is imperative to investigate the potentials of biodiesel derived from diverse locally accessible resources. Despite the potentials the agricultural sector of Nigeria economy has in producing energy crops for biodiesel production, there remains a knowledge vacuum about the current state of the biodiesel business. Not enough research has been observed on the costs, availability, viability of various feed-stocks, environmental impact, engine performance analysis and as well as the ability of the nation's economy to produce, supply, and use biodiesel (Sokan-Adeaga and GREE, 2015). It is critical to close these information gaps in order to properly comprehend the potential of biodiesel in Nigeria and develop strategies and policies that would successfully stimulate its expansion (Chidiebere, 2023).

Objective

The efficiency of extraction depends on a number of variables. In order to maximize extraction of castor oil for production of biodiesel, this study attempts to develop a mathematical model for oil extraction through mechanical process.

Methodology

The Central Composite design (CCD) was used to design the experiment. The CCD consists of 20 experimental runs, including 8 factorial points, 6 axial points, and 6 center points. Experimental runs were randomized to minimize the effect of extraneous variables. The efficiency of oil extraction was predicted using a model based on response surface methodology (RSM).There are four independent variables as input variables for the experiment. The variables are temperature, speed, pressure and moisture content.

The ranges of input variables used are as given in the subsection below. The output variable is the oil extraction efficiency (Y) and is the percentage of oil extracted from castor seeds.

Input Variables (Predictors)

i. Temperature (X1): 40 - 60°C

ii. Speed of Expeller (X2): 20 - 40 rpm

iii. Pressure (X3): 10 - 30 MPa

1v. Moisture Content of Seed (X4): 5 - 15%

Output Variable (Response)

i. Oil Extraction Efficiency (Y): percentage of oil extracted from castor seeds

Results and Discussion

For moisture content of 13%, temperature of 40° C and pressure of 36 MPa, the oil extraction efficiency of 93.5 % was predicted. When experimental data was used to validate the model, the results demonstrated a high degree of agreement between the observed and predicted values. The developed model has observed parameters for pressure, temperature, speed and moisture content as 32 MPa, 42° C, 35.2 and 12% respectively. This resulted in an oil extraction efficiency of 88.6 %. Investigations on the physicochemical properties of the extracted oil were conducted. The extracted oil's qualities satisfied ASTM requirements.

Conclusions

Response surface method (RSM) was successfully used to model and optimize the mechanical extraction of castor oil for biodiesel production. The optimal conditions were found to be 42^0 C for temperature, 32 MPa for pressure, 36.5 rpm for speed and 12 % for moisture content, resulting in predicted oil extraction efficiency as 93.5 %.The study highlights the importance of considering the interactions between variables to achieve optimal oil extraction efficiency.By diversifying the sources of energy used for transportation and other applications, biodiesel can help reduce dependence on imported fossil fuels and enhance energy security for countries around the world. Also, biodiesel production can create new economic opportunities in Agriculture, manufacturing, and other sectors. It can help stimulate rural development by providing farmers with a new market for their crop.

Keywords

Castor oil, biodiesel, mechanical extraction, optimization, mathematical modeling, and response surface methodology.