

## Research Article

# Production of Biodiesel from *Jatropha curcas* by Using Homogenous Catalyst

Jaffar Hussain<sup>1\*</sup>, Zeenat M. Ali<sup>1</sup> and Syed Farman Ali Shah<sup>2</sup>

<sup>1</sup>Department of Chemical Engineering, MUET Jamshoro, Pakistan; <sup>2</sup>Register, University of Sufism and Modron Sciences Bhitsbah, Pakistan.

**Abstract** | Energy requirement, fuel prices, global warming, emission of green house gases and decrease the sources of fossil fuel are the major problems of these days. Due to increased population, urbanization and industrialization energy sources decrease gradually. Major portion of energy come from fossil fuel and to achieve the requirements of energy to find new source. Biodiesel is alternative renewable, biodegradable, non-toxic and eco-friendly of environment. *Jatropha curcas* is highly source to produce biodiesel which oil content up to 40 %. Normally trans-esterification process is used for biodiesel production. Main three types of catalyst were used for the production of biodiesel like as Heterogeneous, enzymes and homogenous. Process selection, catalyst, reaction time, Molar ratio are the main factor for biodiesel production. There are many nano catalyst used for biodiesel production with different yield 83.2 to 99. Pakistan 5% introduced blended biodiesel in 2015 and also increase 10% in 2025. Homogenous catalyst like as NaOH applied for the production of biodiesel from jatropha oil seed maximum recovery was 85%, reaction time 1 to 2 h at 65 °C temperature.

**Received** | February 07, 2022; **Accepted** | November 25, 2022; **Published** | February 09, 2023

**\*Correspondence** | Jaffar Hussain, Department of Chemical Engineering, MUET Jamshoro, Pakistan; **Email:** jafarkhosa72@yahoo.com

**Citation** | Hussain, J., Z.M. Ali and S.F.A. Shah. 2022. Production of biodiesel from *Jatropha curcas* by using homogenous catalyst. *Journal of Innovative Sciences*, 9(1): 18-23.

**DOI** | <https://dx.doi.org/10.17582/journal.jis/2023/9.1.18.23>

**Keywords** | Jatropha, Biodiesel, Blended, Catalysts, NaOH, Renewable



**Copyright:** 2023 by the authors. Licensee ResearchersLinks Ltd, England, UK.

This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (<https://creativecommons.org/licenses/by/4.0/>).

## 1. Introduction

The massive quantity of petroleum products lead to increase the global warming and green house gases emission in the world (Indu *et al.*, 2020). The majority of researcher were working on environmental sustainability and energy crisis to find out new sources (Haris *et al.*, 2022). Presently the reduction of fossil fuel and climate change the researchers are trying to find alternative sources of energy (Krishna *et al.*, 2020). Biodiesel is a combination of fatty acid methylester (Reddy *et al.*, 2016). It is renewable, biodegradable,

environmental eco-friendly and non-toxic (Ranjitha *et al.*, 2019). It is produce from edible oils seed, non-edible oil, animal fats, waste cooking oil and algae (Verma *et al.*, 2016). Source of fatty acid can produce biodiesel (Rummi Devi Saini, 2017). Homogenous, heterogeneous and enzymes catalysts are used for the production of biodiesel. Strong acid and strong base are used as a catalyst in homogenous catalysis. The major of homogenous catalyst are destructive nature, incapable of recycling, non-eco-friendly and generate huge amount of effluent (Baskar and Ravi, 2015). Heterogeneous catalyst easy to separate,

regenerate, re-used and production cost reduced. Slowdown the reaction rate when used enzymatic catalyst and production cost increase (Gurunathan and Ravi, 2015). Adriana *et al.* (2022) studies about the production of Biodiesel from *Jatropha* seed plant at room temperature by using Potassium ferrate obtained yield 98%. The selection of raw materials for the production of biodiesel is around 70-95% and production cost can be reducing 60 to 70% by using low cost materials (Azocar *et al.*, 2010).

*Jatropha curcas* is belong to Euphorbiaceae family many years ago used for medicine treatment. It is non edible feed stock having high oil content up to 40% and can grows everywhere like as sand, gravelly or saline soil. The production of seed can be achieved in 12 to 15 month after cultivation 2 or 3 times in a year. Now a days many researchers are working to produce biodiesel from *jatropa* seed to overcome on energy crisis for economical way. Therefore, it is expected in next few years 1 to 2 millions hectares *jatropha* plant planted in the world.

Copper zinc oxide to use for biodiesel yield obtained was 97.7% (Sandhya *et al.*, 2018). biodiesel yield, up to 73% in the first cycle and 64% in the second one by using CaO-ZnO catalyst having size average size of 2  $\mu\text{m}$  (Javier *et al.*, 2019). There are many nano catalyst used for biodiesel production with different yield 83.2 to 99 on different condition like that reaction time, molal ratio, feed stock and catalyst used (Mandana *et al.*, 2014). maximum biodiesel yield of 97.71% by using CZO nanocomposite on these factor 12% (w/w) nanocatalyst concentration, 1:8 (v/v) O/M ratio, 55°C temperature and 50 min of reaction time (Gurunathn and Ravi, 2015). 1.5 Zn/Mg- $\gamma\text{Al}_2\text{O}_3$

used for castor oil to produce 99% yield (Marisa *et al.*, 2020). ZnO/TiO<sub>2</sub> is a best conversion of biodiesel of soya bean oil (Mbala-Mukenga, 2012).

The different equipments are used to characterization of the catalysts some of them are Fourier-transform infrared spectroscopy, atomic force microscope, Scanning electron microscope, EDS, UV, ZETA POTENTIAL, X-Ray diffraction and Nuclear magnetic resonance spectroscopy.

### 1.1 Composition of *Jatropha* oil

The composition of *Jatropha* oil was determined by gas chromatography which shows that composition of acid presented in oil sample. These acid values were representing in Table 1.

## 2. Materials and Methods

If the fatty acid value is more than 2 the estrification process was used for the production of biodiesel, in this reaction sulfuric acid react with methanol which converted free fatty acid to ester. A common method was used for the production of biodiesel from *Jatropha curcas* called transestrification, it is also called three steps method. The transesterification reaction was carried out with ratio v/v methanol-to-oil ratio, In transestrification reaction the triglyceride react with methanol, from this reaction to produce the triglyceride which converted to monoglycerides when further reaction with methanol. After that monoglycerides react with methanol to produce methyl ester and by product glycerine. Any material having ester is called Biodiesel. In the transestrification process these factors effecting on the production of biodiesel from *Jatropha curcas* were catalyst concentration (g),

**Table 1: Raw materials for production of biodiesel.**

| Edible oil                                                                                                                                 | Nonedible oil                                                                                   | Animal fats                                                                       | Waste and algae             |
|--------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------|-----------------------------|
| Palm, peanut, rice bran, soybean, canola, coconut, palm, olive, grape seed, rapeseed, sorghum, safflower, barley, groundnut and many more. | <i>Jatropha</i> , karajae, neem, jojoba, linseed, tobacco seed oil, mahua, pongamia, sea mango, | Tallow, yellow grease, chicken fat and by product of the refining vegetable oils. | Waste cooking oil and algae |

**Table 2: Production of oil from different seed.**

| S # | Plants seed name | Oil % in seed | Yield of oil tons/ha/year | Seed yield ton/ year x 10 <sup>6</sup> | Reference                |
|-----|------------------|---------------|---------------------------|----------------------------------------|--------------------------|
| 1   | Linseed          | 35 to 40      | 0.5 to 1.0                | 0.15                                   | May <i>et al.</i> , 2011 |
| 2   | Mahua            | 35 to 40      | 1.0 to 4.0                | 0.20                                   |                          |
| 3   | caster           | 45 to 50      | 0.5 to 1.0                | 0.25                                   |                          |
| 4   | <i>Jatropha</i>  | 50 to 60      | 2.0 to 3.0                | 0.2                                    |                          |
| 5   | Karanja          | 30 to 40      | 2.0 to 4.0                | 0.06                                   |                          |

**Table 3: Fatty acid formation of jatropha curcas oil.**

| Fatty acid       | Composition wt% |
|------------------|-----------------|
| Palmitic         | 14.1 to 15.3    |
| Stearic          | 3.9 to 9.8      |
| Eicosenic        | 0.160           |
| Behinic          | 0.183           |
| Polmitolic       | 0.499           |
| Arachidic        | 0.3             |
| Oleic            | 41.39           |
| Linoleic         | 37.95           |
| Gamma. Linolenic | 0.307           |
| Myristic         | 0.1             |

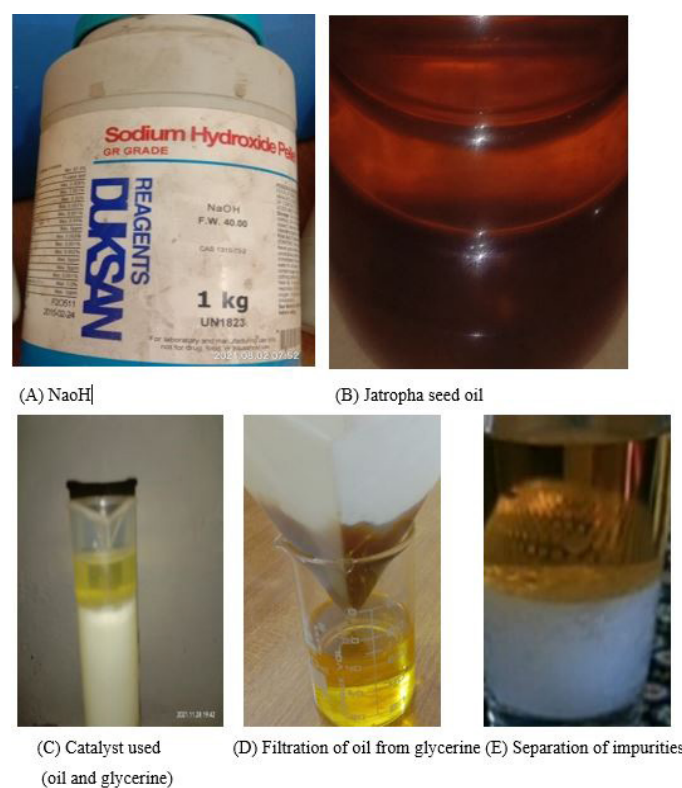
Mureed *et al.*, 2016.



**Figure 1: Jatropha seed plant.**

reaction temperature, oil to methanol molar ratio, reaction time, mixing rpm, pH and composition of fatty acid in oil raw material. Oil was obtained from jatropha seed plant and purchased from Kh herbals which deal all kind of essential oil, herbal extracted and cold press oil from Lahore. The extracted oil have some dark brown colour. In this experiment NaoH used as a catalysts. NaoH was manufactured by duksan company and purchased from Khan associate Lahore. Methanol is used with oil in different molar ratio on specific reaction time. Three (3) gm NaoH used as a catalyst with 10ml of methanol in 100 ml jatropha oil

at 65 °C temperature, agitate it for reaction time was 1 to 2 hr for better result and leave for settle down of oil and glycerine, in previous research the reaction time consider from 45 minutes to 24 hr at different temperature 25 to 65 °C. Magnetic stir was used for proper mixing at 500 rpm for some time mixed it for good reaction and leave it for 4 to 5 hours to settle down. Two layers was obtained upper layer is biodiesel and lower glycerine, filtrate it with the help of filter paper. Remove glycerine and some other properties distilled water was used in when oil and water layer were formed oil separated from water easily. In this experiment 84% oil was obtained previous research have a result 90 to 98%, process performed at different temperature and methanol to oil ratio with reaction time.



**Figure 2: Production of Biodiesel from Jatropha oil.**

**Table 4: Production of Jatropha Oil by using different catalyst.**

| S. # | Type of catalyst                                 | Methanol /oil molar ratio | Reaction temp (°C) | Reaction time (Min) | Catalyst loading | Yield % | Reference                     | Reference by                |
|------|--------------------------------------------------|---------------------------|--------------------|---------------------|------------------|---------|-------------------------------|-----------------------------|
| 1    | KOH                                              | 6:1                       | 50                 | 120                 | 1.0% w/w         | 97      | Berchman <i>et al.</i> , 2010 | Ching <i>et al.</i> , 2011; |
| 2    | KNO <sub>3</sub> /AL <sub>2</sub> O <sub>3</sub> | 12:1                      | 70                 | 360                 | 6 wt%            | 87      | Vyas <i>et al.</i> , 2009     | Shuit <i>et al.</i> , 2009  |
| 3    | H <sub>2</sub> SO <sub>4</sub>                   | 6:1                       | 60                 | 60                  | 15% wt           | 99.8    | Shuit <i>et al.</i> , 2009    |                             |
| 4    | NaoH                                             | 9:1                       | 45                 | 30                  | 0.8 %w/w         | 96      | Tapanes <i>et al.</i> , 2008  |                             |
| 5    | NaoH                                             | 24:1                      | 250                | 28                  | 0.8% w/w         | 90.5    | Tang <i>et al.</i> , 2007     |                             |
| 6    | Cao                                              | 9:1                       | 70                 | 150                 | 15% wt           | 93      | Zhu <i>et al.</i> , 2006      |                             |
| 7    | NaoH                                             | 5.6:1                     | 60                 | 90                  | 1.0%w/w          | 98      | Chitra <i>et al.</i> , 2005   |                             |

### 2.1 Homogenous catalysts

The different homogenous catalysts with their catalytic activity shown in table with Biodiesel yield%. The factors effecting on the production of biodiesel from *Jatropha curcas* were catalyst concentration (g), reaction temperature, oil to methanol molar ratio, reaction time, mixing rpm, pH and composition of fatty acid in oil raw material.

### 2.2 Properties of jatropha oil

The most desired properties of the materials, products and industrial process are sustainability, eco-friendly and industrial ecology. The main properties of Biodiesel from *Jatropha* oil represent in Table 2.

**Table 5: Biodiesel from *Jatropha* seed properties.**

| Property        | Unit               | <i>Jatropha</i> |
|-----------------|--------------------|-----------------|
| Calorific value | Mj/kg              | 39.2            |
| Flash point     | °C                 | 135             |
| Pour point      | °C                 | 2               |
| Cloud point     | °C                 | --              |
| Cetane num      | --                 | 61              |
| Viscosity       | Mm <sup>2</sup> /s | 2.37            |
| Density         | Kg/m <sup>3</sup>  | 880             |
| Carbon residue  | Wt%                | 0.20            |
| Sulfur          | Ppm                | --              |
| Water           | %                  | 0.025           |

## Conclusions and Recommendation

Energy requirement, fuel prices, global warming, emission of greenhouse gases and decrease the sources of fossil fuel are the major problems of these days. There are many sources in the world to overcome the crisis of energy, *Jatropha* seed plant is one of them to produce energy. *Jatropha* oil was purchased from Kh herbals and used for purification, for this purpose transesterification method was used to separate glycerine from oil, in this purpose NaOH used as catalyst. Homogenous catalyst like as NaOH applied for the production of biodiesel from *jatropha* oil seed maximum recovery was 85%, reaction time 1 to 2 hr at 65 °C temperature. Government must support the researchers to find new sources of energy for their requirement.

## Novelty Statement

To find Local energy Sources to meet the country demand. Biodiesel blended with diesel to decrease

the price of petroleum products. Biofuels are environmental sustainable.

## Author's Contribution

All authors contributed equally.

## Conflict of interest

The authors have declared no conflict of interest.

## References

- Abdel-Galil, A., Balboul, M.R., and Sharif, A., 2015. Synthesis and characterization of Mn-doped ZnO diluted magnetic semiconductors. *Physical B*, 477: 20–28. <https://doi.org/10.1016/j.physb.2015.08.001>
- Adriana, N., Gutierrez, L., Violeta, Y., and Mario, A., 2022. Green and fast biodiesel production at room temperature using soybean and *Jatropha curcas* L. oils catalyzed by potassium ferrate. *Journal of Cleaner Production*, 372: 2022. <https://doi.org/10.1016/j.jclepro.2022.133739>
- Avinash, P., Anuj, C., Rafael, P., Sabrina, M., and Silvio, S., 2020. Advances in nanocatalysts mediated biodiesel production: A critical appraisal; Symmetry,
- Azocar, H., Alam, M.Z., Mirghani, M.E.S. 2010. Sludge palm oil as a renewable raw material for biodiesel production by two-step processes. *Bioresour. Technol.*, 101:7804–11.
- Baskar, G. and A. Ravi. 2015. Process optimization and kinetics of biodiesel production from neem oil using copper doped zinc oxide heterogeneous nanocatalyst. *Bioresource Technology*, 190: 424–428. <https://doi.org/10.1016/j.biortech.2015.04.101>
- Baskar, G.I., Aberna, E.S., and Aiswarya, R., 2018. Biodiesel production from castor oil using heterogeneous Ni doped ZnO nanocatalyst. *Bioresource Technology*, 250: 793–798. <https://doi.org/10.1016/j.biortech.2017.12.010>
- Kalavathy, G., and Backer, G., 2019. Synergism of clay with zinc oxide as nanocatalyst for production of biodiesel from marine *Ulva lactuca*. *Bioresource Technology*, 281: 234–238. <https://doi.org/10.1016/j.biortech.2019.02.101>
- Gurunathan, B. and Ravi, A., 2015. Biodiesel production from waste cooking oil using copper doped zinc oxide nanocomposite as heterogeneous catalyst. *Bioresource Technology*,

- 188: 124–127. <https://doi.org/10.1016/j.biortech.2015.01.012>
- Haris, M.K., Tanveer, I., Saima, Y., Muhammad, I., Muhammad, M.A., Ibham, V., Manzoore, E., Muhammad, S., Anas, A.R., and Kalam, M.A., 2022. Heterogeneous catalyzed biodiesel production using cosolvent: A mini review, *Sustainability*, 2022, 14. <https://doi.org/10.3390/su14095062>
- Indu, A., Varsha, S., Sidra, I., Esa, H., and Mika, S., 2020. Effect of different co-solvents on biodiesel production from various low-cost feedstocks using Sr-Al double oxides. *Renewable Energy*, 146: 2158–2169. <https://doi.org/10.1016/j.renene.2019.08.061>
- Indu, A., Varsha, S., Sidra, I., Esa, H., and Mika, S., 2020. Effect of different co-solvents on biodiesel production from various low-cost feedstocks using Sr, Al double oxides. *Renewable Energy*, 146(2020): 2158–2169. <https://doi.org/10.1016/j.renene.2019.08.061>
- Javier, T.A., Juan, J.J., Diego, F., Cristion, O.T., Nelio, A.O. and Cecilica, L.P. 2019. One step synthesis of Cao- zno efficient catalyst for Biodiesel production, Catalytic upgrading of biorenewable to value added product.
- Joon, C., Damayani, A.K., Yeong, W., Taufiq, H., 2011. Biodiesel production from jatropha oil by catalytic and non-catalytic approaches: An overview. *Bioresource Technology*, 102: 452–460. <https://doi.org/10.1016/j.biortech.2010.09.093>
- Krishnamurthy, K.N., Sridhara, S.N., Ananda, C.S., and Optimization, K., 2020. Kinetic study of biodiesel production from Hydnocarpus wightiana oil and dairy waste scum using snail shell CaO nano catalyst, *Renewable Energy*, 146: 280–296. <https://doi.org/10.1016/j.renene.2019.06.161>
- Kambiz, S., Hossein, E., Bizhan, H., and Nadia., 2020. AC/CuFe2O4@CaO as a novel nanocatalyst to produce biodiesel from chicken fat Esfandiari. *Renewable Energy*, 147: 25–34. <https://doi.org/10.1016/j.renene.2019.08.105>
- Krishna, M., Sridhara, and Ananda, K., 2020. Optimization and kinetic study of biodiesel production from Hydnocarpus wightiana oil and dairy waste scum using snail shell CaO nano catalyst. *Renewable Energy*, 146: 280–296. <https://doi.org/10.1016/j.renene.2019.06.161>
- Mandana, A., Farshad, Y., Elahe, M., Dezhi, H., Hamidueza, A. 2014. A review on conversion of biomass to biofuel by nanocatalyst. *Biofuel Res. J.*
- Marisa, B., Navas, José F., Ruggera, Ileana, D., and Mónica, L., 2020. A sustainable process for biodiesel production using Zn/Mg oxidic species as active, selective and reusable heterogeneous catalysts. *Bioresour. Bioprocess.*
- Mbala-Mukega, 2012. Biodiesel production over supported zinc oxide nano particales. *University of Johannesburg.*
- Mukesh, K., Mahendra, P., and Sharma. 2016. Selection of potential oils for biodiesel production. *Renewable and Sustainable Energy Reviews*, 56: 1129–1138. <https://doi.org/10.1016/j.rser.2015.12.032>
- Mureed, T. 2016. Compressive study of jatropha biodiesel production and its prospectus in Pakistan. *Sindh Uni. J. (science serries)* 48:(1)
- Niaz, S., Manzoor, T. and Pandith, A.H., 2015. Hydrogen storage: Materials, methods and perspectives. *Renewable and Sustainable Energy Reviews*, 50: 457–469. <https://doi.org/10.1016/j.rser.2015.05.011>
- Peng, Y.P., Amesho, K.T., Chen, C.E., Jhang, S.R., Chou, F.C. and Lin, Y.C., 2018. Optimization of biodiesel production from waste cooking oil using waste eggshell as a base catalyst under a microwave heating system. *Catalysts*, 8(2): 81. <https://doi.org/10.3390/catal8020081>
- Puneet, V., and Sharma, M.P., 2016. Review of process parameters for biodiesel production from different feedstocks. *Renewable and Sustainable Energy Reviews*, 62: 1063–1071. <https://doi.org/10.1016/j.rser.2016.04.054>
- Dhivagar, R., 2018. Biodiesel from lemon and lemon grass oil and its effect on engine performance and exhaust emission, *et al* 2018 IOP Conf. Ser. Mater. Sci. Eng., *IOP Conference Series: Materials Science and Engineering*, 330: 012103. <https://doi.org/10.1088/1757-899X/330/1/012103>
- Rajesh, M., and Shakkthivel, P., 2013. Biodiesel synthesis by TiO2–ZnO mixed oxide nanocatalyst catalyzed palm oil transesterification process. *Bioresource Technology*, 150: 55–59. <https://doi.org/10.1016/j.biortech.2013.09.087>
- Ranjitha, J., Madonna, S., and Vijayalakshmi. 2019. Biodiesel production using lipase immobilised functionalized magnetic nanocatalyst from oleaginous fungal lipid. *Cleaner Production*,

- 215: 245-258. <https://doi.org/10.1016/j.jclepro.2018.12.146>
- Reddy, A., Saleh, S.H.S., and Abdul, M., 2016. Biodiesel production from crude jatropha oil using a highly active heterogeneous nanocatalyst by optimizing transesterification reaction parameters. *Energy Fuels*, 30: 334–343. <https://doi.org/10.1021/acs.energyfuels.5b01899>.
- Rummi, D.S. 2017. Conversion of waste cooking oil to Biodiesel. *Int. J. Petrol. Sci. Technol.*, 11: 9–21.
- Shuit, S.H., Lee, K.T., Kamaruddin, A.H., and Yusup, S., 2009. Reactive extraction and in situ esterification of *Jatropha curcas* L. seeds for the production of biodiesel. *Fuel*, 2009. (Short communication). <https://doi.org/10.1016/j.fuel.2009.07.011>
- Sandhya, G. and Ravichandra, B. 2018. Adsorption studies of Cr and Cu metal ions from aqueous solution by synthesis Ag and Mg co-doped Tio<sub>2</sub> nanoparticles, *Separation science and technology*.
- Tunio, M.M., Samo, S.R., Ali, Z.M. and Chand, K., 2016. Comprehensive study of *Jatropha* (*Jatropha curcas*) Biodiesel production and its prospectus in Pakistan. *Sindh University Research Journal-SURJ (Science Series)*, 48(1).
- Verma, D., Nema, S., Shandilya, A.M. and Dash, S.K., 2016. Maximum power point tracking (MPPT) techniques: Recapitulation in solar photovoltaic systems. *Renewable and Sustainable Energy Reviews*, 54: 1018-1034. <https://doi.org/10.1016/j.rser.2015.10.068>
- Zahra, S. and Hosseini, S.A., 2019. Study and optimization of conditions of biodiesel production from edible oils using ZnO/BiFeO<sub>3</sub> nano magnetic catalyst. *Fuel*, 239: 1204–1212. <https://doi.org/10.1016/j.fuel.2018.11.125>