Research Article

Production of Biodiesel from Jatropha Oil in Pakistan: Current Trends and Challenges

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Abstract | Energy is a fundamental need for every sector of economic improvement in a country. Industrial, transportation and human population activates are increase the requirement of energy. In developing countries face increasing local demand for energy in rural areas, they also must deal with both economic and environmental pressure on agricultural lands in general. According to an estimate the energy demand may increase from 60.4 to 129 million tones of oil equivalent in the next 15 years in Pakistan. Fossil fuels are the major source of energy in the world. The consumption of fossil fuels like that natural gas, coal and petroleum base products are going to end, so to find alternative source of energy to meet the global energy demand. Renewable energy sources are good alternative for fossil fuels. Biodiesel is a most important alternative energy source in the world which is renewable, biodegradable, environmental friendly and non toxic. Biodiesel is produce from edible, non edible, animal fats and algae. Jatropha is a one of them non edible oil which production annual yield 200 thousand metric tones. Suitable to many site conditions in arid and semi-arid areas of the country. The 70 to 80% directly or indirectly Pakistani populations depend upon agriculture. Jatropha oil have density 909kg/m^3,viscosity 25.63CST,flash point 250 ^{o}C and acid value was 1.20 mgKoH/g.

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1. Introduction

Presently the Pakistan facing the shortage of energy. The demand in country going high day by day. The energy was essential for all socio-economic activities. The energy mandatory to run the industrial wheel, to lighten the domestic sector, to boost the educational sector and development in science and technology. Government of Pakistan is serious to produce diesel from alternate renewable sources for that purpose Pakistan state oil (PSO) and Alternative Energy Development Board (AEDB) are working together to produce biodiesel to develop the economy of the country (Mushtaq *et al*., 2017). Pakistan state oil is working on blending biodiesel. Government of Pakistan is working 15% blended biodiesel in

2025 to meet the requirement of petroleum product consumption (PSO, site). Biodiesel is produced by any source of fatty acid. Animal fats, algae, edible and non-edible oils and waste cooking oil are the main raw materials of biodiesel production (Verma *et al.*, 2016). More then 55% cost reduce by the selection of raw material for the production of product. Mostly edible oil is used but these are used for food purpose so waste cooking oil and non-edible oils are good source to produce biodiesel and having high amount of fatty acid upto 12% by weight (Javier *et al.*, 2019). Jatropha oil seed is most important for biodiesel production in term of sociological, economical and environmental implication (Wilson, 2010). 2.5 to 3.5 tones yields of jatropha seed in first 3 year it also gradually increase 12000 tones per hectare on six years or onwards. Jatropha oil is normally used in modified engine instead other vegetable oils in North amercia and Europe or other parts of the world (Ofori-Boateng and Lee, 2011). The jatropha name was derived from Greek words jatros mean doctor and trophe mena food which used for medicine purpose. Jatropha belong to Euphorbiaceae family. It is America native plants but is grow subtropical and tropical countries in the world like India, China, Pakistan, America, Africa and many more (Redday *et al.*, 2016). The production of jatropha will start after 3 to 4 months after cultivation up to 50 years. It is non edible oil seed which mostly having large amount of fatty acid to produce of biodiesel and small amount of water is used for the cultivation. It produce in saline and normally saline soil or in desert (Tuno *et al.*, 2016). The homogeneous catalysts were the acid or base expedite the esterification and transesterification reaction for biodiesel production. They prominent because of their selectivity, better catalytic activity and yield, and fast reaction rate (Vivek *et al.*, 2011). The alkali homogonous catalyst were hexoxide of sodium and Potassium. The sodium hydroxide more popular than potassium hydroxide because of its cost effectiveness, had high purity and solubility in methanol. Heterogeneous catalysts are noncorrosive, ecologically beneficial, and a green process. They may be recycled and reused several times, providing a more cost-effective method to biodiesel manufacturing (Jaffar *et al.*, 2022).

1.1 Methods used for biodiesel production

The biodiesel syntheses from animal fats and vegetable oil. The fats and oil are water nosolvable. They make the immiscible layer when added to water because of their hydrophobic nature. The oil and fats are composed of 3 moles of fatty acid and 1 mole of glycerides. That was why commonly known as triglycerides. The fatty acid composed of unsaturated double bonds and long carbon chain. The chain varies molecule to molecule. Esterification and Transestrification were popular methods for the production of biodiesel. The other reported method, pyrolysis (cracking) microemulsion and blending. The recommended feedstock's acid value > 2.0 mg/KOH for esterification reaction. The acid value of the product separated at the bottom was determined. The acid value less than 2±0.25 mg KOH/ g was used for the transesterification reaction. The jatropha oil put into beaker and oil was heated at 65 to 70 °C, after that preparied catalyst mixed with methanol for different ratio 1:10 (oil to methanol). The mixed mixture of catalyst and methanol put into jatropha oil beaker the chemical reaction was occurred that is called transesterification. In this reaction glyceride converted into methoyl ester, any type of methyl ester also called Biodiesel. The oil and catalyst mixture leave for settling for 2 to 6 hours, after that two layer was observe upper layer was biodiesel oil and bottom layer was glycerin. If biodiesel oil have impurities removed with water.Reserachers are working to blended biodiesel with salvent or diesel (Hussain *et al.*, 2023; Gurunathan and Ravi, 2015; May *et al.*, 2011; Ahanna *et al.*, 2014).

Biodiesel obtained from microalgae is a biotechnological method, yield is higher 10 to 20 time than vegetable oil. Saima *et al.* (2021) reported that co-precipitation method was used to preparied the catalyst used on vegitable oil to produce biodiesel. By using Homogenous (NaoH) catalyst was obtained 84% of biodiesel from Jatropha at 65 °C reaction temperature and 2 to 24 hours reaction time (Hussain *et al.*, 2023; Baskar *et al.*, 2018). Cu dopped zinc oxide heterogeneous catalyst was used to obtained 92% of biodiesel from jatropha seed (Jaffar *et al.*, 2022; Baskar and Aiswarya, 2015; Gurunathan and Ravi, 2015).

Sathiesh *et al.* (2022) investigated using heterogeneous nanocatalyst ($CuTiO^2$). The yield of biodiesel was 90.2% with these parameters 3% catalyst concentration, 60 °C reaction temperature, 3 hours reaction time and methanol to oil molar ration 20:1. Adriana *et al.* (2022) reporated that transestrifaction method was ued to produced biodiesel from Jatropha and soyabean oil. Potassium ferrate is a strong oxidizing agent widely used for enervionmental

application. at room temperature maximum yield was 98% of jatropha oil.

Saima *et al.* (2021) reported that co-precipitation method was used to prepared the catalyst used on vegitable oil to produce biodiesel. The researcher worked to explore and discover the various homogeneous and heterogeneous catalysts to get better yield. They evaluated the catalytic activity under optimum condition.

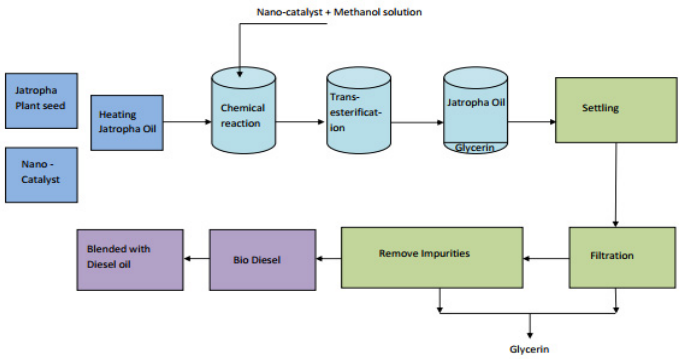

Figure 1: Production of Bio diesel from Jatropha Curcas.

1.2 Biodiesel production in Pakistan

Pakistan is an agricultural country which population more than 80% depend upon on directly or indirectly to this field. The land of Pakistan is good for every crop and having best canal system in the world. To meet the energy demand government of Pakistan, get step to produce biodiesel form edible and non edible seed plants so started their cultivation normally in 2003, for this purpose started cultivation in 2005 only for 2 acors after that provide sector take part and grow nurseries for jatropha oil seed and in 2006, 10000 saplings were provided to nursery at least their growth 50000 in 2008 specially in Sindh and Punjab and 20000 Jatropha plants cultivated by PSO in 2008. Now all over the country researcher and university work inprogress to produce biodiesel from biomass material. It is a great achievement for Pakistan to meet the energy demand and find source to overcome on pevorty. Pakistan can produce biofuel 0.17 barrel ton per day in 2016 and In 2019, biofuels production for Pakistan was 0.09 thousand barrels per day its quantity increase day by day.

1.3 Jatropha oil physical properties

These samples were tested in PCSIR fuel department lab Karachi. Acid components are measure the acid valve in oil, this was carried out with standard ASTM D664 by titration method. High Flash point make biodiesel safer for storage, handling and transportation. Internal property any fluid to resistance in flow. Results of samples were given in Table 1, Some different oil samples used as a reference to compare the properties which also shown in Table 2. The Jatroha oil have high amount of free fetty acid 14 to 20%, density and flash point at 15 °C is 932 kg/m^3 242, respectively and gross Clarific vales 37.01 Mj/kg. The viscosity of jatropha oil is 51CSt at 30 °C.

Table 1: Properties of jatropha oil and diesel oil sample.

Name of sample	Acid value mg KoH/gm	Density Kg/ ^{3}m	Viscosity Cst	Flash point °C
Jatropha oil	1.20	909 @ 25c	25.63	250
Diesel	0.064	800 @25C	1.563	52

Conclusions and Recommendations

Energy requirements increase day by day due to increase population, industrialization and urbanization. Pakistan energy demand increase 11% in 2030 and three time in 2050. The coal, petroleum products and natural gas ar major sources of energy is the form of fossil fuels which are going to end

Table 2: Properties of Biodiesel (Joon, 2011).

Property	Unit	Palm oil	Wco	Jatropha	Soybean	Diesel fuel	ASTM D6751/02	DIN EN14214
Calorific value	Mj/kg	33.5	32.9	39.2	33.5	42	--	--
Flash point	C^0	164	180	135	178	68	130	120
Pour point	C^0	12	- 5	2	- 7	- 20	- 15 to 10	- 15 to 10
Cloud point	C^0	13	1	--	1	4	--	--
Cetane num	--	62	57.2	61	45	49	48 to 60	49
Viscosity	Mm^2/s	5.7	4.5	2.37	4.5	2.60	1.9 to 6	3.5 to 5
Density	Kg/m^3	880	884	880	885	850	870 to 890	875 to 900
Carbon residue	Wt%	--	0.3	0.20	--	0.17	--	0.3
Sulfur	Ppm	--	--	--	--	500	50	50

therefore it is important to find new renewable alternate source of energy. Biofuel is a renewable alternate source of energy in the world. Biodiesel is the form of biofuel which obtained from any source of fatty acid. Jatropha is a non edible oil seed source which produce of bioiesel. It is renewable, non-toxic and ecofriendly of environment. Jatropha seed also can be cultivated saline and normal saline soil which used small amount of water. Jatropha oil have density 909kg/m^3, viscosity 25.63CST, flash point 250 °C and acid value was 1.20 mgKoH/g.

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Novelty Statement

To find new source to overcome the energy crisis.

Author's Contribution

All authors contributed equally in this manuscript.

Conflict of interest

The authors have declared no conflict of interest.

References

Adriana, N., Gutierrez, L., Violeta, Y., and Mario, A., 2022. Green and fast biodiesel production at room temoerature using soybean and *Jatropha curcas* L. oils catalyzed by potassium ferrate. *Jounal of Cleaner Production*. 372: 2022. https://doi.org/10.1016/j.jclepro.2022.133739

Ahana, S., Asmita, B., Peter, K., and Sushil, L., 2014. A case study on *Jatropha curcas* for biodiesel production in Nepal.

Baskar, G., and Aiswarya, R., 2015. Process optimization and kinetics of biodiesel production from neem oil using copper doped zinc oxide heterogeneous nanocatalyst. *Bioresource Technology*, 190: 4. https://doi.org/10.1016/j.biortech.2015.04.101

Baskar, G.I., Selvakumari, A.E., 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

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

Hussain, J., Ali, Z.M. and Shah, S.F.A., 2023. Production of biodiesel from Jatropha curcas by using homogenous catalyst. *Journal of Innovative Sciences*, 9(1): 18-23. https://doi.org/10.17582/journal.jis/2023/9.1.18.23

Jaffar, H., Zeenat, M.A., Khan, M.Q., Naila, K., and Shah, S.F.M.A., 2022. Production of biodiesel from *Jatropha curcas* by using heterogenous dopped zinc oxide. 3(2): 155-164. https://doi.org/10.52700/jn.v3i2.78

Javier, T.A., Juan, J.T., Diego, F.A., Cristian, O.I., Nelio A.O., and Cecilia, L.P., 2019. One-step synthesis of CaO-ZnO efficient catalyst for biodiesel production. *International Journal of Chemical Engineering*, 2019: 7. https://doi.org/10.1155/2019/1806017

Joon, C.J., Damayani, A.K., Yeong, W.B, and Taufiq, Y.Y., 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

May, Y.K., Tinia, T.M., and Mohd, G., 2011. A review of biodiesel production from *Jatropha curcas* L. oil. *Renewable and Sustainable Energy Reviews*. 15: 2240–2251. https://doi.org/10.1016/j.rser.2011.02.013

Mushtaq,A.,Hammad,A.J.,Shazia,S.,Muhammad, Z., Muhammad, A.A., and Kifayat, U., 2017. Prospects for the production of biodiesel in Pakistan. *Biofuels Status and Perspective*.

Ofori, B.C., and Lee, K.T., 2011. Feasibility of Jatropha oil for biodiesel economic analysis world. *Renewable Energy Congress Sweden*.

Reddy, A., Hamdan S.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

Saima, N., Kalsoom, K., Munawar, I., Hanadi, B., Numrah, N., Umme, H.S.F., Jan, N.G., Yassine, S.H., Muhammad, I.K., and Arif, N., 2021. Eco-benign approach to produce biodiesel from neem oil using heterogeneous nano-catalysts and process optimization. *Environmental*

Technology and Innovation, 22. https://doi.org/10.1016/j.eti.2021.101430

Sathiesh, K.N., Paranthaman, P., Gopal, P.M., Huu, T.V., Lan, H.N., and Sadib, B.K., 2022. Enhancing the production yield of Jatropha and pongamia oil based biodiesel by introducing nanocatalyst. *Journal of Nanomaterials*. 2022: 6723296. https://doi.org/10.1155/2022/6723296

Sharma, M.S., and Puneet, V., 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

Tuno, M.M., Rsomo, S.R., Ali, Z.M., and Chand, K., 2016. Investigation of jatropha biodiesel production on experimental scale. Technical Journal, University of Engineering and Technology (UET) Taxila, Pakistan. 21 No. II. https://psopk.com/en/product-and-services/alternate

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

Vivek, P., Rafael, L., Aziz, F., Haibo, Z., Mohamed, B., Jean-Marie, B., 2011. Magnetically recoverable nanocatalysts. *Chem. Rev.*, 111: 3036–3075. https://doi.org/10.1021/cr100230z

Wilson, P., 2010. Biodiesel production from Jatropha curcas: A review. Sci. Res. Esays. 5(14): 1796-1808. http://www.academicjournals.org/SRE ISSN 1992-2218