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Comprehensive study of Jatropha (Jatropha curcas) Biodiesel production and its prospectus in Pakistan

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Abstract: This research work describes the characteristic of Jatropha biodiesel. The attempt was made to discover the Jatropha existence and cultivation in Pakistan. The characteristic of Jatropha oil and Jatropha biodiesel was determined and compared to petroleum diesel. The Jatropha oil yield was found 36.17% with free fatty acid concentration 12.2 weight(wt) %, saponification value was 195.5. The free fatty acid percentage was reduced by two step estrification reaction resulting the acid value was stood 0.774 mg KOH / gm. The Kinematic viscosity at 40^0C of Jatropha biodiesel were 4.54 mm^2/sec, flash point 170^0C, pour point - 3^0C and, sulfur 0.0092 wt%.. The distillation recovery of Jatropha biodiesel was 96%, cetane number 48^0 C and water content 0.05 %. It was concluded that due to small sulfur content, low kinematic viscosity and high cetane number the Jatropha biodiesel was best substitute of petroleum diesel can be used as individual or in blended form. Also Jatropha plant can easily administrated specially in sindh, Pakistan.

Keywords: Biodiesel, characteristic, saponification, Jatropha

1. INTRODUCTION

The Pakistan Government keenly interest to introduce the blended petroleum on national level in order to meet the increasing demand of country. According to energy book published by Hydrocarbon Development Institute of Pakistan Islamabad, Ministry of Petroleum and Natural Resources that country imports 401545.51 Barrels per day to meet the demand. If it would switch to biodiesel than 10% imports would be cutoff. The government of Pakistan wish to introduce 5% by volume the biodiesel blended petroleum diesel in 2015 and gradually increase up to 10% in 2025 (Awan, and Khan, 2014).. This proposal was forwarded to Alternative Energy Development Board for execution. The matter is under the review stage. The Government is encourging and promoting the economical procodure for biodeseal production. The various edible and non edible seeds are the main sources of biodeiseal production. Among all the non-edible feed stock the Jatropha curcas commonly known as Jatropha has been acknowledged as the most suitable source for biodiesel production. It is an oil seed bearing plant. Due to its versatility as hardy nature, short growth period, adaptability in wide range made it most popular among all the non edible feed stock. It can be grown up easily in Coastal areas, hot deserts, wetlands, waterlogged, moderate humid, hilly plane and poor nutrient soils areas (Kazmi, *et al.,* 2003). (Rao, *et al.,* 2000) (Kumar, *et al.,* 2003) (Pakistan energy yearbook 2013), In nutrient rich soil the Jatropha gave high oil yield that is why the high biodiesel conversion happened and can be easily minimized the energy crisis. In short the Jatropha cultivated everywhere even on gravely, sandy, acidic, alkaline soils and, degraded land.In that connection various national and multinational companies are establishing the Jatropha nurseries in different parts of country **(Table 1)**. Other uses of Jatropha plantation is embellishment. It planted in recreation Park and gardens, road sides and beautification of railway tracks (Samniang, *et al.,* 2014).. Its various heights and shape were maintained by trimming and pruning to make the delightful appearance (Pranab, 2011). The purpose of this study was to conduct the feasibility survey in order to promote the Jatropha biodiesel in Pakistan. In this connection the research was conducted with survey relevant to existence of Jatropha plant in Pakistan, population, survival condition, climatically active and pest attacks. The next step was the recovery of oil yield and uses of press cake. The third step was the conversion of Jatropha oil in Jatropha biodiesel. The last was the determination of physcio-chemical properties of Jatropha biodiesel.

Table 1: The details of Jatropha nursery in Pakistan (ref. 2)

Company	Jatropha Nursery
Pakistan State Oil Company Ltd Karachi & Arid Zone Research Institute	22 acre at Pipri Karachi
Al-Wardah Agro Industries Farm	Behawalpur & Cholistan 01 acre each
One Gas(Pvt.) Ltd Lahore	50 acre at Karachi
National University of S&T	85 acre near Karachi
Contract with CIDA	2 acre in Bahawalpur

2. ORIGIN OF JATROPHA

The Pakistan existed at longitude 61° -760 east and latitude from 230 to 370 north with 79.61 million hectares. Pakistan is agriculture country and soil of Pakistan was very fertile and topographically varies region to region. The existence of Jatropha in Pakistan

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was surveyed through the physical visits and information collected through personal inter questionnaire.

The Jatropha is the common name Jatropha caurcas is the binomial name belonging to spurge family. The Jatropha plant consists of flower, fruit and latex. The latex is dirty white fluid used as protective coating for wound healing. The leaves are non Anti-flammetory. Both are useful in the medicine and drugs preparation. The fruit comprises of seeds and fruit hulls or skin. The fruit are of green color and is hard and non fleshy. Inside the fruit there were purple color seeds. The seeds are collected for processing and inside the seeds there were the white color Kernels. The Kernels are the oil bearing bodies utilized for Biodiesel Production. The skin of fruit buried in soil to improve its nutritional value.

3. JATROPHA OIL EXTRACTION AND BIODIESEL PRODUCTION

The Jatropha oil is obtaining by enzymatic extraction, solvent extraction and screw press method. In this research the screw press method was practiced because it gave high oil yield (Karaj, and Müller, 2011). (Sepidar *et al.,* 2009). The screw press oil expeller was specially designed by Mechanical Engineering Department QUEST Nawabshah. The Jatropha seeds were pretreated by means of washing, drying, hulls cracking and kernels collection (Tunio, *et al.,* 2014). The press cake was again and again screwed pressed in order to get maximum oil yield. The press cake was rich in phosphorous, nitrogen and potassium content (Keith 2000) so it was send directly to farmers as soil enhancer. The screw pressed Jatropha oil was collected in air tight, pre sterilized bottle for production of Jatropha biodiesel. **(Table 2)**

Table 2: The composition of Pakistani origin Jatropha oil (Ref 12-18)

Jatropha crude oil	Obtained value	Reported values
Density	0.919	0.921
K. Visosity# 40 °C (mm^2/sec)	35.75	44.3
Flash Point(^{0}C)	160	225.4
Cloud Point(^{0}C)	3	2
Pour Point(^{0}C)	0	4.76
Sulfur (wt. %)	0.011	0.012
FFA*(wt. %)	12.24	10.23
Sap.** value	195.5	196.4

K. Visosity#= Kinematic Viscosity FFA*= Free fatty acids
Sap.** = Saponification value

The collected Jatropha oil was analyzed without delay in order to discover its physiochemical properties. The analysis was carried out in PSO Lab Karachi. The comparative report of Jatropha oil grown up in various part of world dissipated in table 2. As the Jatropha is natural product hence its oil composition varied from regions to regions dependent on climatically, active component, geographical, and topographical conditions.

The tests results confirmed that Jatropha oil was complex esters of free fatty acids which was commonly known as triglycerides. The high free fatty acids content made it highly viscous oil and problematic during the conversion of Jatropha biodiesel and in the use of in combustion engines. The free fatty acids are the saturated and unsaturated in nature. The detail results comprehended that Palmitoleic Oleic and Gamma- Lionlenic acid and Alpha-Linolenic is the mono saturated acids. While the Palmitoleic and Oleic acids were saturated acids. The total free fatty acids include the Palmitic, Steric and Behinic acids. In fatty Jatropha biodiesel up to international standard. The Jatropha biodiesel acids the carbon content were ranged between C14 to C18. The free fatty acid can be removed and viscosity can be improved by estrification followed by tranestrification. There were the two step reaction. In first step the free fatty was removed while in second step the Jatropha oil converted to biodiesel using the methanol as catalyst (Lu, *et al.,* 2009). In this study the estrification and tranestrification was followed up in two steps in sense to lower down the free fatty acids content in Jatropha oil and prior to was prepared according to method. After preparation it was analyzed and characteristic and were compared with petroleum diesel available in service stations of Hyderabad Pakistan **(Table 3)**

Table 3: The comparison of petroleum diesel and Jatropha biodiesel

Properties	Standard ASTM	Petroleum diesel	Jatropha biodiesel
Color	D1500	3.5 max*	L2.0
Density 15 ° C (kg/L)	D-1298	---	0.8809
K***. Viscosity 40 ° C (mm^2 / SEC)	D-445	1.9 – 6.0	4.54
Sulfur (wt%)	D-4294	0.05 max*	0.0092
Flash point (° C)	D-93	130 min**	170
TAN# (mg KOH / gm)	D-664	0.80 max*	0.774
Pour point (° C)	D-97	-15 to16	+3
Distillation 90 % recovery	D-86	360 max*	340
Cetane number	D-976	47 min**	48
Cloud point	D-2500	-3 to -12	+3
Water (Vol%)	D-85		0.05

max*= Maximum K***. Viscosity= Kinematic viscosity
min**= Minimum TAN#=Total Acid Number

4. RESULTS AND DICUSSION

The research study revealed that Jatropha Biodiesel was the best substitute of Petroleum diesel in individual and blended form. According to research study the Jatropha can be easily cultivated in all types of soil and climates at low cultivation expenses (Sepidar *et al.,* 2009). The Jatropha Plant had high resist against the pets, herbs insects and rodents so affordable to formers and stack holders. The Jatropha oil composition and yield varies because of nutritional content of soil. However the Jatropha oil recovery was stood around 36.7-38%. The Jatropha oil recovery was calculated by taken 15 Jatropha seeds samples from different regions of Pakistan. The seeds samples were in 10kg packing and screw press thrice to recover all Jatropha oil and make the Jatropha oil free cake. The press cake, fruits hulls and seeds shell were used as soil enhancer.

Through analysis of the Jatropha oil was found rich in fatty acids. To two-step pretreatment process reduced the acid value and free fatty acid content. The reported value by different researchers was 10.23% (Berchmans, and Hirata, 2008), however the Pakistani oriented Jatropha contain the 12.24%. It was bit higher which consequently affect the quality of Jatropha biodiesel. The density and saponification value and sulphur content was comparable. The difference arises in flash, cloud and pour points which were needed to be improved. Firstly the attempted was made to channelized the free fatty acids content so all the corresponding values came up to standard. The next step was conversion of Jatropha oil to Jatropha biodiesel. The Jatropha biodiesel characteristics were analyzed and compared with ASTM Standard. The characteristics includes the Color, Kinematic Viscosity, Sulfur Content, total Acid Number, Pour point, Cetane number and cloud point. The kinematic viscosity was the ratio of dynamitic viscosity to the density of Jatropha biodiesel. The Kinematic viscosity was within the range. This showed that viscosity and density were ideal. The viscosity played important role in running of the diesel engines with Jatropha biodiesel. The viscous Jatropha biodiesel chocks the filters and fuel lines hence the optimum condition of combustion cannot attend. Also the lubrication of moving parts of diesel engines would be poor. The piston, pumps shafts, piston, groves and other would not function properly. The presence of fatty acids gave the gummy look and reduced the flowing property of Jatropha biodiesel (Berchmans, and Hirata, 2008).. The sulfur content was found > 1. This showed that it was environment friendly. The high percentage of sulfur emission causes the air pollution. It alliance with environmental oxygen and form SO_X. The flash point was the temperature at which the air and vapor above the Jatropha biodiesel could ignite. The flash point of Jatropha biodiesel at 40^0C was higher than petroleum diesel hence safer from fire hazards standpoint. The acid value actually showed the free fatty acids percentage. During synthesis reactions the Alkali reacted with the free fatty acids and forms the soap precipates. This reaction known as saponification reaction. The soap precipates was separated by filtration. The low acid value was preferable. The Jatropha biodiesel exhibited low acid value. The temperature at which the liquid Jatropha biodiesel became Sami solid and losses its flow characteristic was the pour point. It was the important quality factor refers to diesel engines designing specification and was always lower than cloud point. Because in the cold, cooled and chilled areas it was difficult to ignite the fuels hence diesel engines were designed in the way to warm up by the electric heaters with other isolated tanks. The pour point was found exactly within the allowable band. The long run distillation purified the Jatropha biodiesel and removed the volatile matters and trace impure. The Jatropha biodiesel was distilled and achieved 90% recovery. This showed the purity level. The cetane number reflects the ignition delay in other words ignition quality. The shorter ignition delay achieved when cetane number was higher. The cetane number was responsible for the easy ignition of compression and diesel engines. The Jatropha biodiesel showed nearly equivalent value. The cloud point showed the performance of Jatropha biodiesel at low temperature. At low temperature the wax formation occurred which gave the cloudy look. It increases the thickness of Jatropha biodiesel resulting clogs filters, fuel lines and injectors. It was actually the tendency of wax formation. The cloud point was higher so it was recommended to blend with petroleum diesel in diesel engines. The minute quantity of water molecule was found. Though the quantity was low but causes the corrosion in iron, and metallic body parts of diesel engines

5. CONCLUSION

The present study confirmed that Jatropha was most suitable and preferable non edible seeds for the Jatropha biodiesel production. The Jatropha plants were easily administrated in all conditions and circumstances. So this indigenous biodiesel source should be promoted on national scale. The Jatropha was popular because of high yield and equivalent characteristics as petroleum diesel possessed. The higher percentage of free fatty acids in Jatropha oil can be reduced by two step estrification prior to Jatropha biodiesel preparation.

The characteristics of biodiesel as density and viscosity were within ASTM standards and other parameters like sulphur content, pour point, total acid number, water content were found lower than ASTM standards and significantly high flash point and slightly

higher cloud point were noted. This showed the high potential of Jatropha biodiesel over conventional petroleum diesel. The collected data revealed that the Jatropha found in Sindh Pakistan were of excellence quality, indigenous and less expensive source for Jatropha biodiesel production. It was concluded that it is feasible to blend with petroleum diesel with various ratios in order to get the required physiochemical properties and utilized as fuel in vehicle or power generation specially the remote and less developed areas of Pakistan.

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