Investigation of Jatropha Biodiesel Production on Experimental Scale

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Abstract-Jatropha is most promising non edible seed for biodiesel production. The Jatropha oil was extracted from pretreated Jatropha seed. The Jatropha oil was analyzed prior to Jatropha biodiesel production. The Jatropha oil contains total saturated fatty acid, mono unsaturated fatty acid and poly unsaturated fatty acids 19.45, 41.88 and 38.25 in weight% respectively. The Jatropha oil was converted to Jatropha biodiesel by two step transestrification reaction using methylate at 50 ^{o}C at 600 rpm in 30 minute reaction time. The prepared Jatropha Biodiesel was analyzed by Gas Chromatography on FID detector using Nitrogen as carrier gas. The research concluded that Jatropha Biodiesel was the best alternative of fossil biodiesel.

Keywords-Jactopha Oil, Biodiesel, Nitrogen, Chromatography, Acid

I. INTRODUCTION

The increasing population, urbanization, and industrial development increase the energy demand. Today's need is the continuous and cost effective energy supply. The energy has significant role in running the industrial units and machineries. It needed for powering our homes, vehicles, lighting our villages and towns. The industrial wheel can be stops and daily life activities would be affected if the energy would be beyond the access of common man [i-ii].

The renewable energy obtained from virtually inexhaustible or regenerative source exists in environment. The wind, solar and tidal energy are the renewable energy or non conventional energy. They are easily accessible round the clock, in real means they are the gift of nature. The non renewable energy sources depend to their exploration. That need the manpower, machinery, management, money and most important it's marketing. The marketing feasibly can be analyzed by its exploration cost verse the selling cost [iii]. The coal, petroleum, natural gas and fossil fuels are non renewable energy sources and exist beneath the earth surface.

The Pakistan is under the developing stage. The energy generation infrastructure nor fully developed or equipped with latest technology neither manage properly. The 60% energy generated from fossil fuels and 36% were from biomass including the animal dung, wood and agricultural waste. The commercial energy shares was as 1.2% from nuclear, 7.6% from coal, 11.0% from hydro, 50.3% from gas and 29.8% from oil [iv]. The primary energies are based on gas, oil and hydro. The biomass plays a role in primary energy generation in Pakistan and contributes the 36% of total energy matrix. The Pakistan posses the high bio fuel potential to meet the 80% of total bio fuels requirement of country which presently fulfills by their imports. In 2004-05 the energy consumption was 425kWh. In 2009-10 the energy supply decline 0.64 % and per capita 3.09 % compared to lasts few years. The country paid approximately $8 billion in 2006-2007 in respect of exporting the diesel and petrol [iv]. The biodiesel consumption is increasing by 437.06 thousand barrels/ day [v]. In early period of 1930-1940 all the vehicles were running on fossil fuels because it was plentiful and less expensive than after its scarcity and depletion were noted. Hence from 1970 the attentions were paid towards the generation of biofuels from non edible feedstocks [vi].

Pakistan existed on Asian south region with land area 888, 0000 km. The 70% population about 140million people belonging to agricultural land cultivation and earn about US$ 480 per capita and contribute 35% of total agricultural GDP[vii]. As the Pakistani's are agriculturalist hence the need is to explore the biomass which have high tendency to replace the fossil fuel and fulfils the country's energy demand. The non woody, woody, non edible seeds and edible seeds are the biomass and had conversion capability to biofuels. The biofuels are advantages because of their versatility, lower carbon emission, , cost effective, renewable , reduce the fossil fuel dependency and green house gases.

The biofuels (biodiesel and bioethanol) produced from crops, seeds, microorganism and organic waste. The researchers are engage to develop the biofuels from non edible crops and animal feed [vii-viii] that are environmentally and socially sustainable.

The Jatropha, neem, moringa, trisperma, caster beans and candlenut, linseed, rapeseed (Fig.1) are non edible seeds having high potential to biodiesel production [ix].

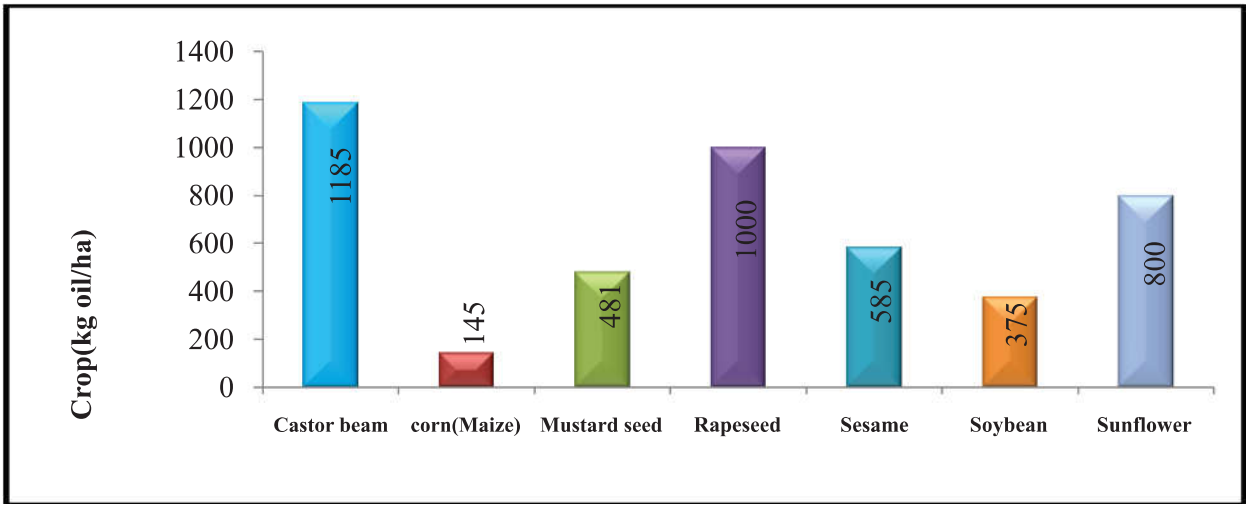

Fig. 1. The Comparison of potential energy crops for biodiesel production

The Jatropha is non edible feedstock and preferable because of 14% free fatty acid content and 80 % unsaturated fatty acid [x] which can be converted into biodiesel by estrifiaction reaction and gave 90-85% yield. The less moisture and saponifiables were favorable in biodiesel production [xi-xii]. The estrifiaction reaction is the reaction in which the unsaturated free fatty acids converted into biodiesel. The high biodiesel production puts remarkable impact on country and enhanced the rural economy [xiii].

The vehicles are the main consumer of diesels. The Jatropha biodiesel can be applicable in pure or in blended form without alteration of engine and toxic emission. [xiv- xv]. The performance, emission and combustion characteristics were comparable to fossil diesel. The brake thermal efficiency, brake specific fuel consumption and power output were within the allowable range. The emissions of carbon monoxide, carbon dioxide, un-burnt hydrocarbon, oxides of nitrogen and smoke were found satisfactory [xvi- xvii].

This research paper focused the synthesis of biodiesel from non edible feedstock "Jatropha". The attempt was made to minimize the free fatty acid content from Jatropha oil by two step tranestrification reaction. The synthesized Jatropha biodiesel was analyzed and its characteristics were compared to petroleum diesel. The objective of study was to highlight the jatorpha biodiesel as best substitute of petroleum diesel.

II. Bionomical Description of Jatropha

The bionomical name of Jatropha is Jatropha caurcas belonging to spurge family. The Jatropha is flowering plant with height of around 6m and was cultivated in tropical and subtropical regions. It became mature and yielding in 9-10 month and 2-3 times per year. On the maturation the Jatropha plant appeared with green rounded shaped seeds. Then turn into light blue or purple colored hard shells. The oil bearing mass was inside the shells known as meat or Kernels (Fig. 2). The oil recovered by screw pressing mechanically.

III. Methodology

The Jatropha seeds were obtained in bulk quantity from Pipri Model farm Karachi owned by PSO Pakistan. The Jatropha seeds were hard and of blue color. The Jatropha seeds were fresh and possessed the high moisture content. It was pretreated before oil expelling. The dirty white oil bearing mass was appeared after shell cracking

Fig. 2. The non edible feedstock "Jatropha caurcas"

VI. JATROPHA OIL EXTRACTION

The Jatropha seeds were pretreated in order to avoid the impurities and unwanted foreign particles and agrochemical sprays which were adhere the seed's outer surface. The pretreatment is necessary for maintaining the accuracy and precession in research process [xviii]. The pretreatment of Jatropha oil extraction was started from the collection of Jatropha seeds. The seeds was sorted and washed twice with double distill water. As the moisture was unfavorable for biodiesel production so it was minimized by sun drying to make the process more economical. The Jatropha seeds were dried in open air for 72 hours.

By drying the tensile and compression strength were lower down and needs less energy for crushing. After deseeding the stream were screened 10mm screen. Before that it was shuffled for separation of seeds coat and seed meat or Kernels. The screening process promotes the uniform oil extraction process. The shells were discord and meat portion or Kernels were collected and introduced in mechanical oil expeller. The Jatropha oil was collected in air sealed glass bottles. Prior to that glass bottles were sterilized, rinsed with double distilled water and oven dried. The yield of Jatropha oil extraction was 38% verses the 51% press cake.

V. SYNTHESIS OF JATROPHA BIODIESEL

The Jatropha Biodiesel was produced by Transesterification reaction. At first stage the triglycerides were converted to triglycerides, then to monoglycerides and finally to glycerol. The biodiesel was the methyl esters of long chain fatty acids present in Jatropha oil. The 800ml preheated (50 ^{0}C) Jatropha oil and sodium methylate (200 ml) was mixed in reaction vessel. The Sodium methylate was prepared by dissolving the 5.0gram Sodium Hydroxide (Merck Company) in methanol (BDH 99%). The mixture was kept in magnetic stirrer for 30 minutes stirring at 600 rpm with fixed temperature of 50 ^{o}C. Then it was cooled at room temperature and transferred in separating funnel for settling. After 24 hours settling the two distinct layers were obtained. The upper layer was biodiesel which was recovered while the lower layer was crude unwanted Glycerin. The collected Biodiesel was washed twice with Glacial acetic acid (BDH) and water (0.002: 1) to dissolve the organic matters. The pH was 7.8 (JENCO Model 6010N pH meter) was lies slightly alkaline. It was neutralized by acid washing. The synthesized Jatropha Biodiesel was heat at 100 ^{0}C to remove the moisture content. Filter by filter paper (Double Rings Filter Paper 11.5 cm) and filtrate was collected in sample bottle for further analysis.

VI. JATROPHA BIODIESEL ANALYSIS

The Gas Chromatographic technique was applied for determination of free fatty acid content in synthesized Biodiesel. Biodiesel sample of biodiesel was directly injected into Gas Chromatograph (Fig 3). The ester content of the biodiesel was determined with gas chromatography (GC-FID). The filtered samples were injected into Perkin Elmer 8700. The RT -2560, 100 m (0.25 mm, internal diameter and 0.2 µm film thicknesses) column was used to separate the esters. The GC was set up according to the following conditions: Nitrogen was used as carrier gas with a linear velocity of 35 cm/s; 1 µL samples were injected into the column. The temperature profile was as follows: 280°C inlet temperature; 130 °C ramp at 4 °C/min up to 220 °C and hold for 10 min; A flame ionization detector (FID) was used at 300°C.

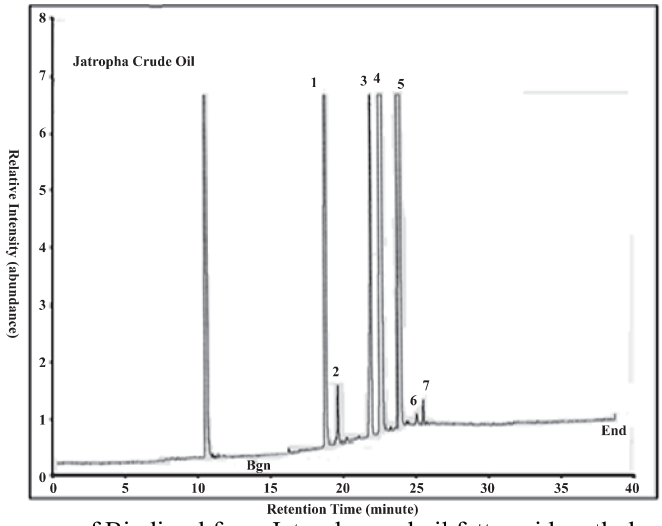

Fig. 3. Gas chromatogram of Biodiesel from Jatropha seed oil fatty acid methyl esters. 1. Palmitic acid 2. Palmitoleic acid 3. Stearic acid 4. Oleic acid 5. Linoleic acid 6. Eicosenic acid 7. Gamma-linolenic acid

VII. Results and Discussion

The fatty acid played important role in Biodiesel production from Jatropha oil. It was directly taken part in estrification reaction. The free fatty acids are long chain molecules their molecular weight varies on molecular length. The Jatropha oil contents the saturated, mono unsaturated and poly unsaturated fatty acids. The free fatty acids content in Jatropha oil given in Table I. The Total fatty acids (Palmatic acid) content was 14.7% by weight. The Eicosenic and Behinic acids were present in small and nearly in equivalent quantity. The Oleic acid and Palmitoleic acid were present 41.39% and 0.499% by weight respectively. The Linoleic acid conjugated and Alpha-Linolenic acid are the poly unsaturated fatty acid present in trace quantity.

TABLE I
THE FATTY ACID CONTENT IN JATROPHA OIL

Total Saturated Fatty acids (Weight %)	Palmitic acid ($C_{14}H_{28}O_2$)	Steric acid ($C_{18}H_{36}O_2$)	Eicosenic acid ($C_{20}H_{38}O_2$)	Behinic acid ($C_{22}H_{44}O_2$)
	14.7	4.407	0.160	0.183
Total MUFA* (Weight %)	Palmitoleic acid ($C_{16}H_{30}O_2$)		Oleic acid($C_{18}H_{34}O_2$)	
	0.499		41.39	
Total PUFA** (Weight %)	Linoleic acid non conjugated ($C_{18}H_{32}O_2$)		Gamma-Linolenic acid ($C_{18}H_{30}O_2$)	
	37.952		0.307	

MUFA*= mono unsaturated fatty acid
PUFA**= poly unsaturated fatty acid

The quality of Jatropha biodiesel strongly influence by native Jatropha nature and Process condition. Another important factor was the viscosity. The Biodiesel became viscous because of long chain structure of Jatropha oil. The Jatropha seed was pretreated to minimize the unwanted contents.

The extracted oil was processed at optimum experimental condition for conversion of Jatropha oil into biodiesel. The sodium Hydroxide was used as catalyst. Through gravitational settling in separating funnel the biodiesel was collected and analyzed on Gas chromatography. The Gas Chromatographic tests were done in Centre of Excellence in Analytical Chemistry, University of Sind Pakistan.

The chromatograph showed the Jatropha Biodiesel contained palmitic acid, palmitoleic acid, stearic acid , Oleic acid , Llioleic acid and Eicosenic acid and gamma – linolenic acid . The sharp peaks showed the distinct separation of fatty acid.

VIII. Conclusion

The industries and some house hold appliances needed continuous supply of diesel. As the resources of fossil diesel are limited that is why efforts are made to switch on Jatropha biodiesel. The research is going on to synthesize the Jatropha biodiesel on laboratory scale and then after scale up on commercial level.

The diesel engines design in the line of stable and knocking free fuel under variety of operating condition and have clean and smoke free burring. The main advantage of biodiesel was that it can directly used in diesel engines without any engine alteration and can be blended with any ratio to generate the required properties [xix]. The first and second generation bio diesel was feasible for long run at can be scale up [xx].

The present study lightened the Jatropha Biodiesel production on Laboratory scale. It is suggest that Laboratory data should be scale up on national level to over the energy crises. The Jatropha Biodiesel is best alternative to fossil diesel. The double estrification reaction was followed to convert the Jatropha oil to Jatropha biodiesel. The results fatty acids were found satisfactory. The study revealed that jatropha biodiesel is feasible to blend with petroleum diesel with various ratios in internal combustion engine without modification.

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The research work is part of PhD thesis named" Production of biodiesel, analysis and testing the performance of biodiesel engine by using indigenous resources".

Conflict of Interest

The authors declared that there is no conflict of interests.

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