Prospect of Jatropha Curcas and Pithraj Cultivation in Bangladesh

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ABSTRACT

This work investigates the prospect of Jatropha (Jatropha Curcas) and Pithraj (aphanamixis polystachya) plantation in Bangladesh and making of Bio-diesel from their seeds. Jatropha and Pithraj are the renewable and non-edible. They are wildly growing hardy plant, in arid and semi-arid regions of the country on degraded soils having low fertility and moisture. There is a huge unused amount of area about 0.32 million hectares in Bangladesh where Jatropha Curcas and Pithraj can be cultivated successfully. Jatropha and Pithraj oil is an important product from the plant for meeting the demand of diesel in Bangladesh. Around 2500 Jatropha tree can be planted in one hectare and around 300 Pithraj tree can be planted in one hectare. The seeds of Jatropha Curcas contain 30-40% oil. The seeds of Pithraj contain 30-35% oil .The oil can be converted to Bio-diesel by the well-known transesterification process. If Jatropha Curcas plantation is successful in 0.32 million hectare land, the amount of Bio-diesel production will be 0.58 million ton per year. Bangladesh imports approximately 2.4 million ton diesel each year. By planting of Jatropha Curcas, Bangladesh can reduce importing a huge amount (25%) of petroleum products from foreign countries. Bio-diesel from Jatropha

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could be blended by 20 per cent with the normal diesel. Similarly if Pithraj plantation is successful in 0.32 million hectare land, the amount of Bio-diesel production will be 0.50 million ton per year. By planting of Pithraj, Bangladesh can also reduce importing 21% of petroleum products. Pithraj could be blended by 20 per cent with the normal diesel.

Keywords: *Jatropha, Pithraj, Bio-diesel, Renewable and non-edible, Petroleum products.*

1 INTRODUCTION

Now-a-days, the world is highly dependent on petroleum fuels for generating power, vehicle movement, agriculture and domestic useable machinery operation and for running the different industries. Every year about 137000 vehicles comes from manufacturing region. Most of the vehicle based on petroleum fuel. So with technological progress and improvement of living standard of the people, the demand of the petroleum fuel increases simultaneously. But the reserve of the petroleum fuel is limited and is evenly distributed in such a way so that many regions have to depend on the others for their fuel requirements. The price of the petroleum fuel is also increasing day by day and use of the petroleum fuel in engine produces harmful products which pollute the environment. Due to the above reason, attention is going to the search of renewable source of fuel which can meet the demand locally.

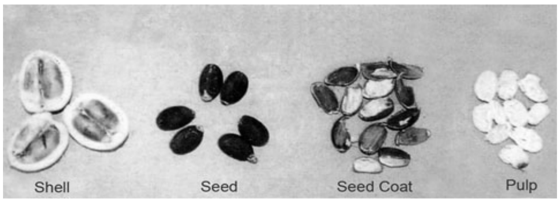
Vegetable oils may be an alternative renewable source of diesel fuel known as "Bio-diesel" which can be produced in any local area. Vegetable oils and their derivatives (especially methyl esters), commonly referred to as "Bio-diesel", they are technically competitive with or offer technical advantages compared to conventional diesel fuel. Many researchers have shown that using raw vegetable oils for diesel engines can cause numerous problems. Vegetable oils have increased viscosity, low volality, cold flow properties and cetane number causes injector cocking, piston ring sticking, fuel pumping problem and deposit on engine. These problems limit the direct use of vegetable oil in engine in place of conventional diesel. However the above limitation can be greatly minimized by converting the vegetable oil into ester through esterification which is named as Bio-diesel. But due to limited availability of agricultural land, the factor edibility of vegetable oil and its higher prices greatly restricts the scope of using esterified vegetable oil as fuel. There is a chance to overcome this restriction if waste and non-edible vegetable oil is used as feed stock for Bio-diesel plant. It has been found that used vegetable oils are primarily used as inexpensive feed stocks [1].

In aspect of Bangladesh, non-edible renewable Jatropha oil and Pithraj (local name) oil can play a vital role in the production of substitute diesel fuel. Attention is given to the Jatropha oil and Pithraj oil because it is non-edible renewable source of oil and it is a new research over the world. The climatic and soil condition of Bangladesh is also suitable for the production of this plant. The oil as well as Bio-diesel can be prepared with most economical way. By increasing Jatropha and Pithraj plantation in our country, we can meet our domestic demand and save our capital. Finally the by-product of transesterification can be used in the soap industry .This also save our capital and reduce cost. At present, 100 percent Bio-diesel is not used in place of diesel fuel to run the engine because 100 percent Bio-diesel causes significant reduction of brake thermal efficiency, higher specific fuel consumption and excessive NO_x formation. This problem can be greatly minimized by using diesel, Bio-diesel blend and additives. The most widely used blends are B10 (10 % bio, 90 % diesel) and B20 (20 % bio, 80 % diesel). Diesel, Bio-diesel blends do not cause significant increase of NO_x and reduction of brake thermal efficiency. Meanwhile the other performance parameter of the engine is like as net diesel fuel.

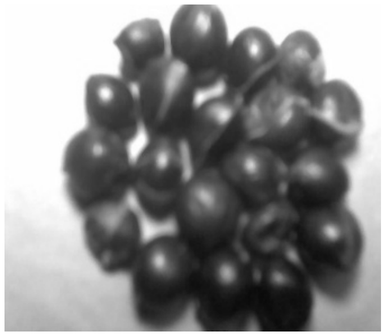
2 PROSPECT OF JATROPHA CURCAS AND PITHRAJ CULTIVATION IN BANGLADESH

In Bangladesh, Jatropha Curcas and Pithraj can be cultivated in all over the country and are generally grown as a live fence for protection of agricultural fields against damage by livestock as these are unpalatable to cattle.

The agro-climatic conditions prevailing in Bangladesh are conducive for Jatropha and Pithraj cultivation. A feasibility analysis of Jatropha and Pithraj cultivation can be done on a pilot scale over various regions in the country where climatic and agricultural conditions are suitable for this crop. The primary focus of this project would be the cultivation of Jatropha and Pithraj to get seeds and oil as final output. Jatropha, shown in Fig.1 (a), is a small tree or shrub with smooth gray bark, which exudes whitish colored, watery latex when cut. Normally, it grows between three and five meters in height but can attain a height of up to eight or ten meters under favorable conditions. Jatropha Curcas grows almost anywhere, even on gravelly, sandy and saline soils. It can thrive on the poor soils. It grows even in the crevices of rocks. It grows on well-drained soils with good aeration and is well adapted to marginal soils with low nutrient content. On heavy soils, root formation is reduced. Jatropha is a highly adaptable species but its strength as a crop comes from its ability to grow on very poor and dry sites. The leaves shed during winter months. The organic matter from shed leaves enhance earth-worm activity in the soil around the root-zone of the plants which improves the fertility of the soil. It is reported that Jatropha can grow on 0-500 meters above sea level. The mean annual temperature ranges from 25-30*℃* and annual rainfall is 500-1200 *mm* [2]. Jatropha has the ability to withstand extreme drought and light frost condition. Comparison to various other vegetable oils including copra, palm, groundnut, cottonseed, rapeseed, soya and sunflower, Bio-diesel has significant potential for use as an alternative fuel in compression–ignition (diesel) engines [3], [4].



(a) Jatropha Curcas (b) Jatropha seeds



(c) Pithraj tree (d) Pithraj fruits

Figure 1: Jatropha Curcas and Pithraj tree with their seeds.

The expected Jatropha oil from such land is as follows:

Total Jatropha plants *per hectare*: 2500 (2.0 *m* x 2.0 *m* per plant).
Fruiting trees *per hectare*: 2000.
Yield of seeds, shown in Fig.1 (b), *per fruiting tree*: 2.5 *kg* (5^{th} year).
Seeds *per hectare*: 5.0 *tons*.

The expected Pithraj oil from such land is as follows:
Total Pithraj plants, shown in Fig.1 (c), *per hectare*: 300 (3.0*m* x 3.0*m* per plant).
Yield of seeds, shown in Fig.1 (d), *per fruiting tree*: 15-20 *kg* (Average 18 kg).
Seeds *per hectare*: 5-6 *tons*.

3 PROCESSES INVOLVED IN THE PRODUCTION OF BIO-DIESEL

(i) Preparation of nurseries
(ii) Plantation.
(iii) Seed collection.
(iv) Oil extraction.
(v) Transesterification.
(vi) Blending with conventional diesel fuel.
(vii) Characterization of Bio-diesel.
(viii) Institutional arrangements.

4 TRANSESTERIFICATION PROCESS

Transesterification or alcoholysis is the displacement of alcohol from an ester by another in a process similar to hydrolysis, except than alcohol is used instead of water [4].

Transesterification is the process of using an alcohol (e.g. methanol, ethanol or butanol), in the presence of a catalyst, such as sodium hydroxide or potassium hydroxide, to break the molecule of the raw renewable oil chemically into methyl or ethyl esters of the renewable oil, with glycerol as a by product [5].
Transesterification of vegetable oil is shown in Fig.2.

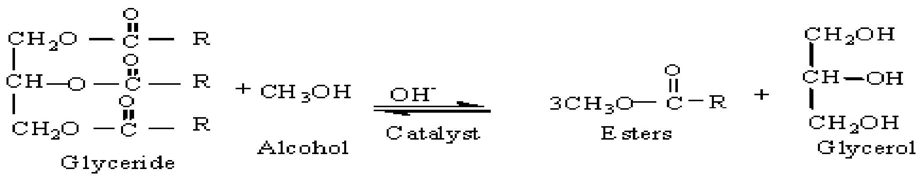


Figure 2: Transesterification of fatty acid and typical chain structure of fatty acid methyl ester.

The conversion of component TGs (triacylglyceryl esters) to simple alkyl esters (transesterification) with various alcohols reduces the high viscosity of oils and fats. Base catalysis of the transesterification with reagents such as sodium hydroxide is preferred over acid catalysis because the former is more rapid. Transesterification is a reversible reaction. The transesterification of soybean oil with methanol or 1-butanol proceeded with pseudo-first order or second order kinetics, depending on the molar ratio of alcohol to soybean oil (30:1 pseudo-first order, 6:1 second order; sodium methoxide catalyst) while the reverse reaction was second order.

Methyl esters are the most “popular” esters for several reasons. One reason is the low price of methanol compared to other alcohols. Generally esters have significantly lower viscosities than the parent oils and fats. Accordingly they improve the injection process and ensure better atomization of the fuel in the combustion chamber. The effect of the possible polymerization reaction is also decreased. The advantages of alkyl esters were noted early in studies on the use of sunflower oil and its esters as DF. Another advantage of the esters is possibly more benign emissions, for example, with the removal of glycerol (which is separated from the esters) the formation of undesirable acrolein may be avoided, as discussed above. These reasons as well as ease and rapidity of the process are responsible for the popularity of the transesterification method for reducing the viscosity-related problems of vegetable oils. The popularity of methyl esters has contributed to the term “Bio-diesel” now usually referring to vegetable oil esters and not neat vegetable oils. The reaction parameters investigated were molar ratio of alcohol to vegetable oil, type of catalyst (alkaline .vs. acidic), temperature, reaction time, degree of refinement of the vegetable oil and effect of the presence of moisture and free fatty acid. Although the crude oils could be transesterified, ester yields were reduced because of gums and extraneous material present in the crude oils.

Besides sodium hydroxide and sodium methoxide, potassium hydroxide is another common transesterification catalyst. Both NaOH and KOH were used in early work on the transesterification of rape seed oil. Recent work on producing Bio-diesel (suitable for waste frying oils) employed KOH. With the reaction conducted at ambient pressure and temperature, conversion rates of 80 to 90% were achieved within 5 minutes, even when stoichiometric amounts of methanol were employed. In two steps, the ester yields are 99%. It was concluded that even a free fatty acid content of upto 3% in the feedstock did not affect the process negatively and phosphatides upto 300 ppm phosphorus were acceptable. The resulting methyl ester met the quality requirements for Austrian and European Bio-diesel without further treatment. In a study similar to previous work on the transesterification of soybean oil, it was concluded that KOH is preferable to NaOH in the transesterification of safflower oil, where the optimal conditions were given as 1% wt. of KOH at $69{\pm}10^{o}C$ with a 7:1 alcohol: vegetable oil molar ratio to give 97.7% methyl ester yield in 18 minutes [6].

A successful transesterification reaction produces two liquid phases: ester and crude glycerin. Crude glycerin has heavier liquid, will collect at the bottom after several hours of settling. Phase separation can be observed within 10 minutes and can be complete within 2 hours of settling. Complete settling can take as long as 20 hours.

5 THE POSSIBLE REDUCTION OF IMPORTING DIESEL BY PLANTING JATROPHA CURCAS IN BARREN LANDS OF BANGLADESH

Total barren lands in Bangladesh = 0.32 *million hectares* [7]

Let 80% barren land can be used for cultivation that means 256000 *hectares*.

Annual Demand of Diesel =2.4 *million tones*.

Around 2500 Jatropha tree could be planted in one hectare and 2000 contains seed.

Each tree gives seeds =2.5 *kg* (approximately).

1 hectare land gives seeds = 5000 *kg*.

256000 *hectares* land gives seeds = 5000*256000 *kg*.

It has been found that 3.8 *kg* Jatropha oil is obtained from 10 *kg* Jatropha seeds that means 38% can be converted from Jatropha seeds to Jatropha oil.

So 256000 *hectares* land gives oil = 5000*256000 *0.38 *kg*

= $48.64*10^7$ *kg*.

Again,

1 *kg* Jatropha oil = 3.8*0.96 *kg* Bio-diesel (It has been found that 1*kg* Jatropha oil converted to 0.96 *kg* Bio-diesel).

So $48.64*10^7$ *kg* Jatropha oil gives Bio-diesel = $48.64*10^7$ *0.96 *kg*

= $46.69*10^7$ *kg*

= 0.4669 *million tones*.

Annual Demand of Diesel = 2.4 *million tones*.

By using our used barren lands, Bangladesh can reduce importing diesel fuel from foreign countries by

= (0.4669 /2.4)*100 %

= 19.45 %

= 19.5% (approximately).

If Jatropha plantation is successful in barren lands of Bangladesh, the country can saves a huge amount of currency which needed for importing diesel fuel. Bangladesh can reduce importing 19.5 % (approximately) diesel fuel from foreign countries.

6 THE POSSIBLE REDUCTION OF IMPORTING DIESEL BY PLANTING PITRAJ IN BARREN LANDS OF BANGLADESH

Amount of 80% barren land in Bangladesh = 256000 *hectares*.
Around 300 Pithraj tree could be planted in *one hectare*.
Each tree gives seeds =18 *kg*.
1 *hectare* land supplies seeds = 5400 *kg*.
256000 *hectares* land supplies seeds = 13.82 x 10^8 *kg.*
Considering 30% Pithraj oil is extracted from seed.
So 256000 *hectares* land supplies oil = 13.82 x 10^8 x 0.30 *kg*
= 4.14 x 10^8 *kg*.

Again,

Considering 97% Pithraj oil is converted to Bio-diesel.
So 4.14 x 10^8 *kg* Pithraj oil gives Bio-diesel = 4.14 x 10^8 x 0.97 *kg*
= 4.02 x 10^8 *kg*
= 0.402 *million tones*.

Annual Demand of Diesel = 2.4 *million tones*.

By using our used barren lands, Bangladesh can reduce importing diesel fuel from foreign countries by

= (0.402/2.4)*100 %
= 16.75%
= 17% (Approximately).

7 ECONOMICS OF BIO-DIESEL PRODUCTION FROM JATROPHA CURCAS AND PITRAJ SEED OIL

In Bangladesh, it is estimated that the cost of Bio-diesel production by transesterification process of oil obtained from Jatropha and Pithraj seed oil will be slightly higher than that of conventional diesel fuel. 1.5 *liters* vegetable oil will be needed to obtain 1(one) *liter* Bio-diesel. After transesterification, the amount of by-product in the form of glycerin is upto 0.40 ml. After cost analysis the following result is found.

Total cost of Jatropha plantation is Tk.35337.00 *per hectare* and *one hectare* gives 5000 *kg* Jatropha seeds.

- Cost of 1.5 *litres* Jatropha oil = Tk.22.00
- Cost of 200 *ml* (20% vol.) methanol = Tk.110.00
- Cost of 3.5 (0.5% wt.) (NaOH) = Tk.2.00
- Cost of khoil (2.8 *kg*.) = (-) Tk.85.00
- Cost of raw glycerin = (-) Tk.5.00

Net cost of 1 *litre* Bio-diesel = Tk.44.00

Total cost of Pithraj plantation is Tk.30000.00 *per hectare* and *one hectare* gives 5400 *kg* Pithraj seeds.

- Cost of 1.2 *litres* Pithraj Oil = Tk.36.00
- Cost of 200 *ml* (20% vol.) methanol = Tk.165.00
- Cost of 3.5 (0.5% wt.) (NaOH) = Tk.1.50
- Heating cost = Tk.3.00
- Total cost = Tk.205.50
- Cost of by products of seeds = Tk.155.00
- Cost of raw glycerin = Tk.6.00

Net cost of 1 *litre* Bio-diesel = Tk.44.50

The cost will be reduced substantially when it will be used in large scale. The seed waste may be used as good fertilizer. In considering whole situation, the use of Jatropha Curcas and Pithraj seed oil as a Bio-diesel is economically feasible and economic option in comparison with conventional diesel.

8 COMPARISON OF JATROPHA AND PITHRAJ BIO-DIESEL WITH DIESEL

The properties of Jatropha and Pithraj Bio-diesel are obtained and shown in Table.1. It is clear from the table that the properties of Pithraj and Jatropha Bio-diesel are very closer to diesel.

Table 1: Comparison of Jatropha and Pithraj Bio-diesel with diesel

Properties	Jatropha Bio-diesel	Pithraj Bio-diesel	Ordinary diesel
Density (*gm/cc*)	.87	.88	.86
Kinematic viscosity at 30^0C	4.50	4.35	4.00
Heating value(*MJ/Kg*)	39.5	39.85	44
Cetane number	51.5	50	48

9 EFFECT OF METHANOL PERCENTAGES ON (METHYL ESTER) BIO-DIESEL RODUCTION

Fig.3 and Fig.4 shows the effect of methanol (CH_3OH) percentages on Bio-diesel production. The volume percentage of methanol is varied from 15 to 20 keeping the weight percentage of catalyst (NaOH) constant at 0.5. It can be seen in Fig.3 and Fig.4 that with the increase in reaction temperature up to 55*ºC*, Bio-diesel production increases and then decreases for all methanol percentages. It is found that maximum 96% methyl ester (Bio-diesel) is obtained with

20% vol. methanol. Decrease in Bio-diesel production with further increases in reaction temperature after 55℃, may be associated with the methanol evaporation. Thus it is concluded that 20% vol. of methanol is optimum for maximum Bio-diesel production**.**

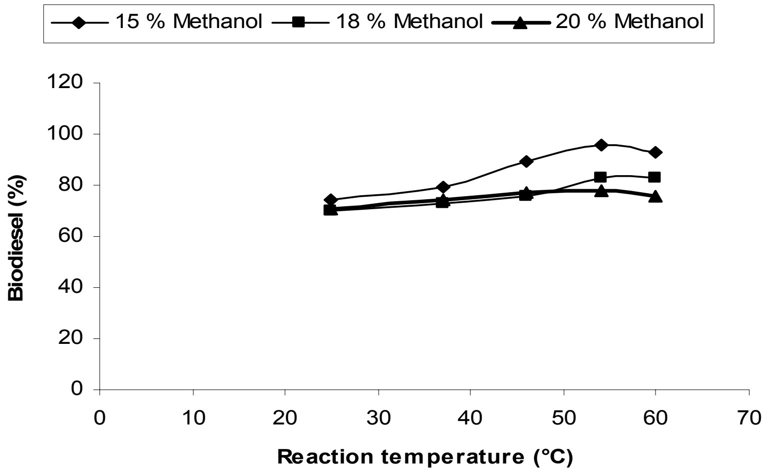


Figure 3: Effect of methanol (CH_3OH) percentage on Bio-diesel production for Jatropha (NaOH = 0.5% wt.).

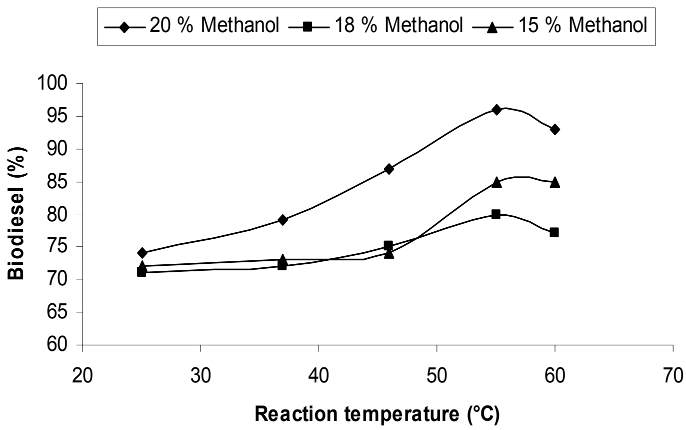


Figure 4: Effect of methanol (CH_3OH) percentage on Bio-diesel production for Pithraj (NaOH = 0.5% wt.).

10 EFFECT OF CATALYST (NAOH) PERCENTAGES ON BIO-DIESEL PRODUCTION

Fig.5 and Fig.6 show the effect of catalyst (NaOH) percentages on Bio-diesel production. The weight percentage of catalyst (NaOH) is varied from 0.5 to 0.7. Here the volume percentage of methanol is kept constant as 20% vol. which is optimized earlier. It can be seen in Fig.5 and Fig.6 that with the increase in reaction temperature up to 55℃, Bio-diesel production increases for all catalyst (NaOH) percentages and then decrease. It is found that maximum 95% methyl ester (Bio-diesel) production is obtained at 0.6 % wt. of catalyst (NaOH)

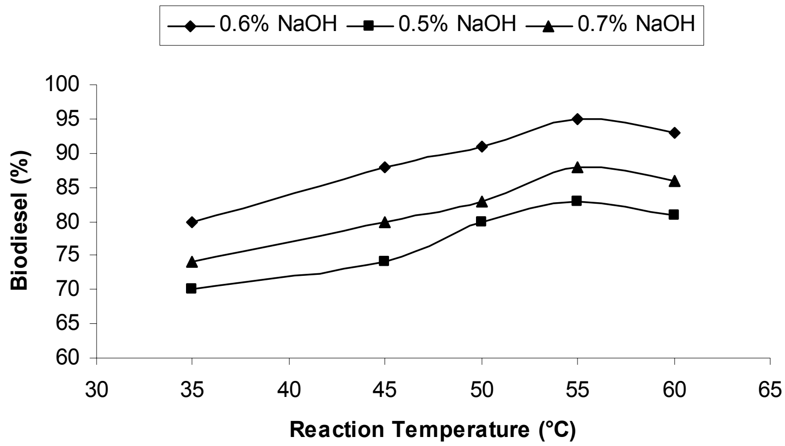


Figure 5: Effect of catalyst (NaOH) percentages on Bio-diesel (Jatropha).

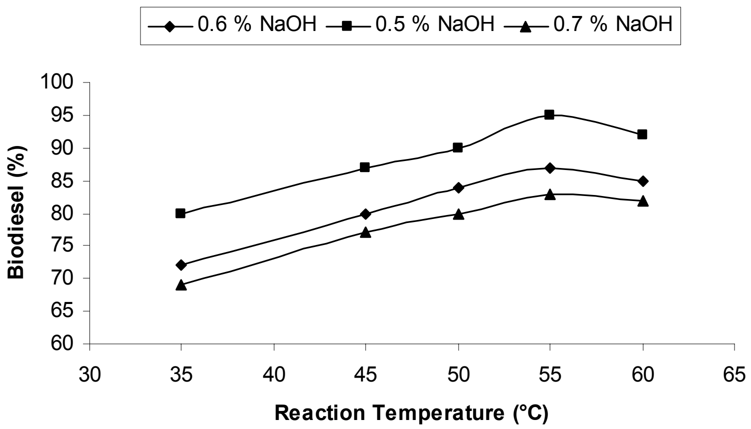


Figure 6: Effect of catalyst (NaOH) percentages on Bio-diesel (Pithraj) production (methanol = 20% vol.).

percentage. Increasing the reaction temperature beyond 55℃, Bio-diesel production decreases which may be due to evaporation of methanol at higher temperature. Therefore, it can be concluded that 20% vol. of methanol and 0.6% wt. of NaOH are the best for maximum Bio-diesel production.

11 EFFECT OF REACTION TIME ON BIO-DIESEL PRODUCTION

Fig.7 and Fig.8 shows the effect of reaction time on Bio-diesel production. The volumetric percentage of methanol is kept at 20 while the catalyst weight percentage is set to 0.6 (both optimized earlier). It is evident in Fig.7 and Fig.8 that with the increase in reaction time, the Bio-diesel production increases upto

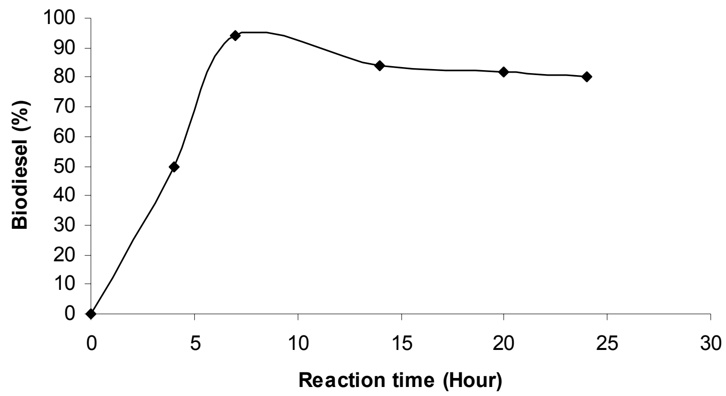


Figure 7: Effect of reaction time on Bio-diesel (Jatropha) production (CH_3OH = 20%, NaOH=0.6%).

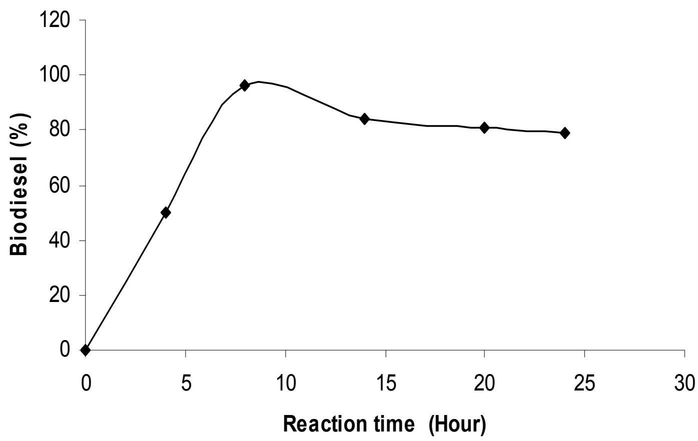


Figure 8: Effect of reaction time on Bio-diesel (Pithraj) production (CH_3OH = 20%, NaOH=0.6%).

6 hours and then decreases. This is due to the fact that the tendency of soap formation increases with increase in reaction time. It is found that for 6 hours the maximum Bio-diesel production is 96%. When the mixture of Jatropha oil, methanol and catalyst is kept for 24 hours, the Bio-diesel production is reduced to 80%. Most recently, a novel technology is invented for producing Bio-diesel from waste, cooking grease, recycled vegetable oils and agricultural seeds in a much faster, simpler and as much less as expensive way [8].

12 CONCLUSIONS

Bangladesh is fully depended on petroleum import as of now, creating pressure on balance of payment, especially after the price hike of oil in the global market. And the government is looking for alternative fuel. Jatropha Curcas and Pithraj cultivation can be the solution for the alternative in Bangladesh. It may also improves the security of Bio-diesel supply, creating employment opportunities, increasing foreign earnings (supposed it can be exported) and supporting equal plantation development, particularly for the barren lands in Bangladesh. In this report, prospect of Jatropha Curcas cultivation is discussed. Bio-diesel is produced with Jatropha oil. The properties of Jatropha Bio-diesel is determined and compared with those of conventional diesel fuel. The results of this work may be summarized as follows:

(i) Jatropha Curcas and Pithraj can be cultivated even on arid, barren and fallow lands. There are hills in southern part of Bangladesh. Jatropha Curcas and Pithraj are cultivated on such hills or other barren or uncultivated lands, Bangladesh can save a huge currency importing petrol and diesel. If Jatropha is cultivated on uncultivated land Bangladesh can reduce (19.5% for Jatropha, 17% for Pithraj) importing petrol and diesel from foreign countries.

(ii) It can generate rural employment for cultivation, seed collection and processing.

(iii) Jatropha and Pithraj seeds are crushed for oil. 38% and 30% oil are obtained by crushing of Jatropha and Pithraj seeds in a conventional mustard seed crushing machine. 96% and 97% Bio-diesel have been obtained from Jatropha and Pithraj oil respectively.

(iv) Characterization of Bio-diesel is done. The properties of Bio-diesel are closer or even better than those of conventional diesel fuel. Thus Bio-diesel from Jatropha Curcas and Pithraj may be used as alternative diesel fuel in Bangladesh.

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