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USE OF WASTEWATER AND TREATED WATER FOR *Jatropha curcas* CULTIVATIONAND THE POSSIBILITY OF OIL SEED USEAS A BIOFUEL

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ABSTRACT

In the present work, eight water mixtures were used for germination and cultivation of Jatropha in pot experiments. The results showed that germination percentages of Jatropha seed ranged from 54 to 87% and the highest percent was recorded when irrigation with untreated drainage water (100%UDW) was used and the lowest one (54%) was observed for sample irrigated with 50% tap water+50% untreated drainage water (50%TW+50%UDW). Generally, higher germination percentages were recoded when untreated drainage water (raw) was applied and lower ones were reported when tap water was used. Characteristic fuel properties of Jatropha oil were studied to assess compatibility of blends with diesel. The relative density at 15^0C of raw Jatropha oil is 0.876 higher than that determined for diesel (0.839). The values of the kinematic viscosity of raw Jatropha oil and diesel at 40^0C are found to be 5.8 and 3.08 respectively. The cetane number of Jatropha raw oil determined in the present study was ranged from 46 to 70. The flash and fire point of Jatropha oil was found to be 128^0C and 136^0C respectively. Our results showed that higher heating value (HHV) of Jatropha oil ranged from 39.24 to 41.87 and the lower heating value (LHV) ranged from 36.53 to 38.94. The heating value (MJ/kg) for Jatropha biodiesel is lower than those reported for petro diesel, nucleus dates biodiesel and olive biodiesel but higher than those reported for castor biodiesel and coconut biodiesel.

Determination of iodine number of Jatropha crude oil revealed to high iodine number to be 101. Sulphur weight % in Jatropha oil determined in the present work which was 0.0024%. Specific heat capacity (SHC) of Jatropha oil determined which was 0.80 $Jk^{-1}g^{-1}$.

Fractionation of fatty acids process was done using GC. Jatropha oil had more than 19% saturated fatty acids (C16:0, C17:0, C18:0, and C20:0) and more than 80% unsaturated fatty acids (C16:1, C17:1, C18:1, C18:2, C18:3 and C20:1).

Levels of total saturated fatty acids (TSFA) in Jatropha sample are 19.16 and the most abundant fatty acid in Jatropha was palmitic acid (C16:0) followed by stearic (C18:0) and the lowest one was arachidic acid (C20:0). These results also, showed existence of odd chain saturated fatty (OCS-FAs) margaric acid C17:0 with level of 0.29. Results showed that levels of total unsaturated fatty acids (TUSFA) in Jatropha sample was 80.81 and the most abundant fatty acid in Jatropha oil was linoleic acid C18:2 followed by oleic acid C18:1 and the trienoic acid (linolenic acid C18:3) which was the lowest one.

Key words: Biofuel, Fatty acids fractionation, Jatropha oil, Jatropha, *Jatropha curcas*, L. wastewater

INTRODUCTION

Biodiesel is a non-toxic, biodegradable, and renewable diesel fuel and can be used neat or blends with petroleum diesel fuels. Biodiesel has many advantages compared to diesel fuels. It has higher cetane number than diesel fuel, and contains no aromatics, almost no sulfur and 10-12% oxygen by weight. Biodiesel-fueled engines produce less CO, HC and particulate emissions than petroleum diesel-fueled engines (Graboski and McCormik 1998 and Tomasevic and Marinkovic 2003). Biodiesel improves the lubricity, which results in longer engine component life (Boehman, 2005; Kinast, 2001 and Gerpen, 2005). Attempts have been made by various researchers to determine the best composition of biodiesel that would enhance the combustion process. It was observed that the fuel properties of biodiesel play a significant role in the combustion process. One of such properties is cetane number, (CN) influence the combustion process and engine performance. The CN is a commonly used indicator for the determination of diesel fuel ignition the quality. It measures the readiness of the fuel to auto-ignite when injected into the engine (Bamghoye and Hansen, 2008). Many performance characteristics such as density, heating value are related to cetane number (Lakshmi *et al*., 2008). Cetane number is the parameter used to determine the quality of biodiesel; it is proportionate to the fuel ignition delay time in CI engines. A fuel’s CN rating can be applied to determine ignition characteristics of biodiesel fuels (Knothe *et al*., 2003).

As the future lack of petroleum will be a current concern, that biodiesel seems to be "part of the solution", by replacing partial or totally petro-diesel fuel in diesel engines. This reason, added to an increasing environmental concern, creates a scenario in which biodiesel production is expected to have a big development over the next few years. Biodiesel is an alternative fuel produced from different types of renewable vegetable oil, animal fats or different types of recycled cooking oil, by transesterification reaction. In conventional processes, biodiesel is manufactured by alkaline catalyzed transesterification of oil, in methanol (Murugesan *et al*., 2009). The alkalis frequently used are KOH, NaOH or their corresponding alkoxides. Some solid catalysts were also assayed (Vyas *et al*., 2009).

The oil to produce biodiesel can be obtained from different crops such as soy, rapeseed, *Jatropha curcas* L. and others. Nowadays, Argentinian biodiesel is largely made out of soy oil, but the industry is considering the possibility of using Jatropha oil (Falasca and Ulberich, 2008). The main differences are: 1- the Jatropha seeds, due to its toxicity, are not edible (Cai-Yan *et al*., 2010), 2- Jatropha crop can tolerate harder climate conditions than soy and rapeseed (Jones and Miller 1992), 3- the Jatropha seeds can give four times more oil than soy (Aceites and Grasas, 2009) and 4- the aptitude of the Jatropha oil extraction residue to recover infertile land (Gübitz *et al*., 1999).

The leaves of *J. curcas* are used in traditional medicine against coughs or as antiseptics after birth, and the branches are chewing sticks (Gübitz *et al*. 1999). The latex produced from the branches is useful for wound healing and others medical uses. Each fruit contains 2-3 oblong black seeds which can produce oil. The seed kernel oil contained 40-60% (w/w) oil (Makkar *et al*. 1997). The seed oil extracted is found useful in medicinal and veterinary purposes, as insecticide, for soap production and as fuel substitute (Gübitz *et al*. 1999).

Jatropha curcas L., commonly known as Jatropha, physic nut, or purging nut, belongs to the family Euphorbiaceae. It is a perennial oilseed shrub that originated in Tropical and Subtropical America. *J. curcas* is a drought-resistant non-edible tree that can thrive in a wide range of soils and climates. For these reasons, it is considered as the most promising biodiesel feedstock worldwide. *J. curcas* is a fast growing crop and can produce seeds for up to 50 years (Achten *et al*., 2008) The full potential of J. curcas has however not been realized due to several technological and economic reasons (Divakara *et al*., 2010) .*J. curcas* seed kernel contains 40–60% (w/w) oil (Makkar *et al*., 1997), and the oil contains around 80% unsaturated fatty acid which makes it suitable for biodiesel production *J. curcas* oil can be converted to biodiesel using transesterification, the production depends on the free fatty acid content of the oil (Jain and Sharma 2010 and Patel, *et al.*, 2010). The resulting biodiesel can be used as a substitute for petroleum diesel fuel. The seed cake remaining after oil extraction is an excellent source of plant nutrients (Martınez-Herrera *et al.*, 2006).

The composition of *J. curcas* oil from Nigeria consists of main fatty acid such as palmitic acid (13%), stearic acid (2.53%), oleic acid (48.8%) and linoleic acid (34.6%) (Martínez-Herrera *et al.*, 2006). *J. curcas* oil contains high percentage of unsaturated fatty acid which is about 78- 84%. This made the oils suitable for biodiesel production. However, the chemical compositions of the oil vary according to the climate and locality.

J. curcas was cultivated in Egypt in Luxor, Sohag and Suez (OEJC, 2008) the plant seeds generally used for the purpose of extracting oil which primary source from which the oil is extracted. Oil has very high saponification value and being extensively used for making soap in some countries. Also oil is used as in illuminant in lamps as it burns without emitting smoke. It is also used as fuel in place of, or along with kerosene stoves. Jatropha oil cake is rich in nitrogen, phosphorous and potassium and can be used as organic manure. By thermodynamic conversion process, pyrolysis, useful products can be obtained from the Jatropha oil cake. The liquid, solid and gaseous products can be obtained. The liquid can be used as fuel in furnace and boiler. It can be upgraded to higher grad fuel by trans esterification process (Kamrun and Hampton 2011).

The main objectives of the present investigation are (a) to study the possibility of cultivation of *Jatropha curcas* on wastewater (b) to study *Jatropha curcas* seed oil properties and the possibility of its use as a biofuel.

MATERIALS AND METHODS

Jatropha cultivation

It was conducted experiment using a randomized complete block design, Jatropha plants irrigated with mixture drainage water: Fresh water,(1) Irrigation using tap water (100%), (2) Irrigation using (100%) untreated drainage water (3) Irrigation utilizing treated drainage water (100%), (4) Irrigation using (50%) water tap + (50%) utilizing treated raw wastewater,(5) Irrigation using (50%) water tap + (50%) treated water,(6) Irrigation using (75%)water tap+(25%) utilizing treated raw wastewater, (7)Irrigation using (25%) water tap + (75%) utilizing treated raw wastewater water,(8)Irrigation using (25%) water tap + (75%) treated water .

Physicochemical properties of Jatropha oil;-

Some of the physical properties of oil extracted from the Jatropha seeds were determined using different kinds of machines. In the present work ten characteristic properties of Jatropha raw oil were determined. The characteristic fuel properties such as:(1)-relative density, (2)-kinematic viscosity, (3)-flash and fire point, (4)-cetane number, (5)-higher heating value, (6)-lower heating value, (7)-specific heat capacity (SHC) (8)-sulphur weight% (9)-iodine number(10)-acid number of Jatropha oil were studied to assess compatibility of blends with diesel.

(1)-Relative density at 15^0C (gm/cm^3):-

The relative density of the fuels at 15^0C was determined as per IS: 1448 [P: 32]: 1992 and detailed by Shambhu *et al*., (2013). The empty pyknometers of 50 ml capacity were weighed. The pyknometers were then filled with fuel samples and weighed. The samples were maintained at 15^0C by keeping them in a Saveer Biotechmake walk-in temperature control chamber. The weights of the empty pyknometers were subtracted from the weights of the filled ones to get the weight of the fuel samples. Density is the mass per unit volume of any liquid at a given temperature. This value when divided by the volume of the fuel sample gave the density (ρF) of the fuel sample at 15^0C. The density of distilled water (ρw) at 15^0C was also determined.

$$\text{Relative density} = \frac{\text{Density of the fuel}/15\ {}^0\text{C}}{\text{Density of the water}/15\ {}^0\text{C}}$$

2- Kinematic viscosity

Kinematic viscosity of samples was measured by using Redwood Viscometer [WISWO make]. Time of gravity flow in seconds of a fixed volume of the fluid (50ml) was measured as Per IS: 1448 [P : 25] 1976. The experiment was performed at 38^0C. Kinematic viscosity was calculated using the relationships given by Guthrie, (1960).

$$V_k = 0.26\,t - \frac{179}{t}$$

when 34 < t< 100 and

$$V_k = 0.24\,t - \frac{50}{t}$$

when t > 100

where:

V_k = Kinematic viscosity in centistokes

t = Time for flow of 50 ml sample iv second

3- Flash and fire point

The flash and fire point of the fuel samples was determined as Per IS: 1448 [P: 32]: 1992. A Pensky Martin Flash Point (closed) apparatus was used to measure the flash and fire point of the fuel samples. The sample was filled in the test cup up to the specified level and was heated and stirred at a slow and constant rate. The temperature was measured with the help of a thermometer. At every 1^0C temperature rise, flame was introduced for a moment with the help of a shutter. The temperature at which a flash appeared in the form of sound and light was recorded as flash point. The fire point was recorded as the temperature at which fuel vapour catches fire and stays for minimum of five seconds.

Flash point: 150 ml of extracted oils was poured into a metal container and heated at a controlled rate temperature of 36^oC after, which, the flame being passed over the surface of the extracted oils was observed at a regular intervals of 5 secs for 1 min. The flash point was determined by

ASTM D-93 method (Shambhu *et al*., 2013). The flash point temperature of biodiesel fuel is the minimum temperature at which the fuel will ignite (flash) on application of an ignition source.

Fire point is the lowest temperature at which a specimen will sustain burning for 5 seconds. These two parameters have great importance while determining the fire hazard (temperature at which fuel will give off inflammable vapour). Flash point of the samples were measured in the temperature range of 60 to 190°C by an automated Pensky-Martens closed cup apparatus.

4- Cetane number:-

Cetane number is measured using blends of two reference fuels, namely n-cetane (100 CN) and heptamethylnonane (15 CN). Cetane number of the test fuel is the percentage by volume of *n*-cetane in a blend of n-cetane (100 CN) and heptamethylnonane (15 CN) having the same ignition quality when tested in the same engine under the same test conditions Bamgboye and Hansen (2008).

5- Determination of Cetane Number and Higher Heating Value

The Cetane number (CN) and higher heating value (HHV) (MJ/Kg of oil) of the biodiesel was determined using ASTM D 613 standard procedures through the following empirical formula as described by Cocks and Vanrede, (1984), and Eshetu and Gabiyye (2013). The calculation was based on the results from saponification value (SV) and iodine value (IV) of oil.

Cetane number(CN)=$46.3+\left(\frac{5458}{SV}\right)-(.0225IV)$

HHV)=$49.43-\frac{(0.041SV)+(0.015IV)}{Ws}$ (Higher Heating Value

6- Lower heating value:

The Lower heating value of Jatropha oil was determined according to ASTM D240.

7- Specific heat capacity (SHC):

A copper calorimeter was weighed and recorded. 150 ml quantity of oil was also weighed and its temperature which is 15°C was noted and transferred to the calorimeter. A known volume of water (53 ml) was heated to a temperature of 20°C above that oil, the hot water was transferred to the oil in the calorimeter, which was closed and stir until it reaches the equilibrium temperature and it was recorded. Specific heat capacity was calculated using the following equation: C=t/m where C = SHC of calorimeter, (kJ/kg/K), t = heat loss, (°C), m = mass of oil, (ml). Ambient temperature, Ta = 20.1°C (degree to minimize error due to heat transfer to or from the surroundings).

8- Determination sulphur weight %

Determination of sulphur content of Jatropha oil combustion was done in a bomb calorimeter. The washings were collected and titrated with standard sodium carbonate followed by neutralization with aqueous ammonia. Solution was boiled, filtered and 10ml of concentrated HCl was added. 10% Barium chloride was added whilst boiling the solution. Solution was then covered and precipitate allowed to settle for an hour after which it was filtered through an ash-less filter paper. After several washings, the filter paper and sample was placed in a weighed crucible and ignited (Mohammed and Adamu, 2009).

9- Iodine number

Jatropha oil (0.2 g) was weighed accurately by transfer method into a 250 mL iodine flask and dissolved in chloroform (20 mL). Wij's reagent (20 mL) was added by means of a pipette. The flask was stoppered and kept in darkness for one hr. with intermittent shaking. Then 15% of potassium iodide solution (10 mL) and 50 mL of distilled water were added to the flask and mixture was shaken well. The liberated iodine was titrated with 0.1 N sodium thiosulphate solution using fresh starch solution as indicator. A blank titration was also conducted side by side (Nayak and Patel 2010).

10- Acid Value

Acid value is, therefore, an important characteristic to be measured. The acid value or number defined as the mg KOH required to neutralize the free fatty acid present in one gram of oil sample. The total acid value of Jatropha sample was measured as per method describe by Cox and Pearson (1962). A known amount of sample was dissolve in 50 ml of the neutral solvent (neutral solvent is the mixture of 25 ml ether, 25 ml alcohol and 1 ml of 1% phenolphthalein solution and titrated with aqueous solution of KOH of 0.1 N. The total acidity was calculated and a blank titration was also conducted side by side.

RESULTS AND DISCUSSION

Cultivation of *Jatropha curcas*:-

In the present experiment, eight water mixtures were used for cultivation and germination of Jatropha in pot experiments, these combinations water mixture are given in Table (1) and Fig (1). The results showed that germination percentages of Jatropha seed ranged from 54 to 87% and the highest percent was recorded when irrigation with untreated drainage water (100%UDW) was used and the lowest one (54%) was observed for sample irrigated with 50%tap water+50% untreated drainage water (50%TW+50%UDW). Generally, higher germination percentages were recoded when untreated drainage water (raw) was applied and lower ones were reported when tap water was used (Fig. 2). Drainage water contains salts and heavy metals in varied degrees led to oxidative stress in plant irrigated with waters and cause several physiological changes due to chance in metabolic pathway (Lee *et al*., 2001 and Panda and Upadhyay, 2003).

It was conducted experiment using a randomized complete block design, Jatropha plants irrigated with mixture drainage water:, and Irrigation utilizing treated wastewater and Irrigation utilizing treated raw wastewater and Jatropha plants irrigated with % freshwater.

Hussein *et al*., (2013) concluded that, even if oxidative stress is induced in Jatropha plants irrigated with 25, 50 and 75% industrial waste water, application of NPK could be provide protection against this oxidative stress by increase the antioxidant protective system, which involved as one of the factors responsible for salt tolerance of Jatropha plants. Therefore, the irrigation of Jatropha plants by mean of industrial west water at 75% (v/v) is possible when fertilized with NPK.

Table (1): Water mixtures used in germination and cultivation of Jatropha seeds

No	Treatment	(%)
1	Irrigation with tap water (100%TW)	65±2
2	Irrigation with untreated drainage water (100%UDW)	87±4
3	Irrigation utilizing treated drainage water (100% TDW)	79±2
4	Irrigation with 50%tap water+50% untreated drainage water (50%TW+50%UDW)	54±1
5	Irrigation with 50% tap water + 50% treated drainage water (50%TW+50%TDW)	75+±2
6	Irrigation with 75% tap water + 25% untreated drainage water (75%TW+25%UDW)	83±3
7	Irrigation with 25% tap water + 75% untreated drainage water (25% TW+75%UDW)	68±2
8	Irrigation with 25% tap water + 75% treated drainage (25%TW+75%TDW)	65±2

Mean ± SD of SE

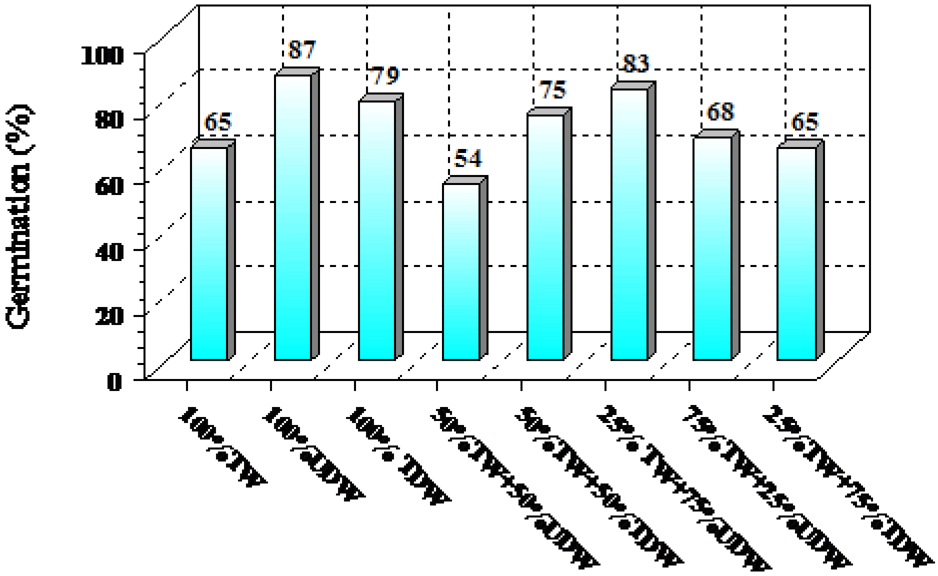

Fig. (1): Effect of use of drainage water on the Jatropha seed germination

Preparation of soil of Jatropha seed

Germination of Jatropha seed in pots

Irrigation with 100% treated drainage water

Irrigation with 100% untreated drainage water

Irrigation with 100% tap water

Irrigation with 100% untreated drainage water

Irrigation with50%tapwater+50%treated drainge water

Irrigation with 75% tap water + 25% treated drainge water

Irrigation with 25%tapwater + 75% untreated drainage water

Irrigation with 75%tapwater + 25% untreated drainage water

Irrigation with 25%tapwater + 75% untreated water.

Irrigation with 50%tapwater + 50% treated drainage water.

Fig. (2): Germination of Jatropha seed

Rajaona, *et al*., (2012) concluded that in the global context, it is evident that effluent reuse in agriculture will increase in water scarce countries in the near future, particularly in the vicinity of cities. This is necessary to release precious freshwater resources for the drinking water supply of the growing urban areas and to ensure irrigation. Since Jatropha has been reported to be salt sensitive, the use of waste water while controlling soil salinity has to be considered, even if the nutrient and water supply can be satisfied. The feasibility of such an irrigation system depends to a large extent on environmental factors, such as climate, soils and the overall water availability, and thus, transferability of the model results presented here needs to be studied further.

According to the present comparisons (Table 2) between plants in terms of productivity per acre, prices and various chemical properties of biofuels output from these plants, it can be deduced that the most suitable plants for producing the biofuels in Egypt are caster and Jatropha due to the following reasons

Table (2): Comparisons between the average productivity of previous plants/acre and price.

Plant	**Production/Acre**	**Oil per ton**	**Price***
Jatropha	600-800 kg of seeds	180-272 L	13-17$ for 1kg/oil, 2-2.5$ for 1kg/seed
Caster	1-1.5 ton of seeds	600L	7$ for 1kg/oil 0.7$ for 1kg/seed
Coconut	400 kg of copra	420 L/ton copra	10$ for 1L/oil
Dates nucleus	600 kg of nucleus	Not available	Not available
Olive (after 9 years)	3 ton/acre	170 L	5$ for 1L/oil 0.7$ for 1 kg/ seed

*In accordance with the prices in the Egyptian market.

Comparisons between the average productivity of previous plants per acre showed that The heating value and the flash point for the biofuels output from the previous oil plants are compared with those values of petro diesel as in figs. 1and 2. It is shown that the petrol diesel oil has higher heating value and lower flash point compared with the other biofuels. On the other hand the biofuels oil can be considered as a renewable energy (clean energy).

Physicochemical properties of Jatropha oil;-

Results given in Table (3) show ten physicochemical properties of oil extracted from the Jatropha seeds in compared to diesel. In the present work the characteristic fuel properties of Jatropha oil were studied to assess compatibility of blends with diesel.

Table (3): Physicochemical properties of Jatropha oil

	Properties	Values of Jatropha oil	Values of Diesel
1.	Relative density at 15^0C (gm/cm^3)	0.876	0.839
2.	Kinematic viscosity at 40°C	5.8	3.08
3.	Flash point (°C)	128	63.2
4.	Fire point	136	235.2
5.	Cetane number	46 to 70	38.0*
6.	Higher heating value (HHV)	39.21	39.24 – 41.87
7.	Lower heating value LHV)	36.55	36.53 – 38.94
8.	Iodine value (Iv)	101	60 – 135
9.	Acid value (Av)	101	60 – 135
10.	Sulphur weight %	0.0024	0.0165**

*Sivaramakrishnan and Ravikumar, (2012), ** Barua, (2011).

Relative density at 15^0C (gm/cm^3):-

The relative density at 15^0C of raw Jatropha oil is 0.876 higher than those determined for diesel (0.839) and these results are in a good agreement with those found by Shambhu *et al*., (2013).Density is an important property of biofuel and our results also showed that relative density of raw Jatropha oil is 4.41% percent higher than that of diesel. The results are also in line with the findings of Foidl *et al*. (1996) who have reported the relative density of ethyl and methyl ester of Jatropha oil to be 0.886 and 0.879 respectively.

Kinematic viscosity:-

The values of the kinematic viscosity of raw Jatropha oil and diesel at 40^0C are given in Table (3). Values of kinematic viscosity of raw Jatropha oil and diesel were found to be 5.8 and 3.08 respectively. These results are lower than reported by Foidl *et al*. (1996) and much lower than those recently reported by Shambhu *et al*., (2013) who reported that kinematic viscosity of raw Jatropha oil diesel at 38^0C 32.67

Cetane number in Jatropha oil;-

The cetane number of Jatropha raw oil determined in the present study was ranged 46 to 70. The ignition quality of a fuel can be deduced through its cetane number. A fuel with good ignition quality has a high cetane number, where the ignition delay period between the start of fuel injection and the onset of auto ignition is short. Cetane number of biodiesel varies with the feed stock used, but it is generally in the higher end of the typical diesel fuel range. The value of cetane number is found to generally increase with increasing carbon chain length. It was observed from the tables that vegetable oils have a low cetane number; this is due to the presence of bulkier molecules in the triglycerides which have a high viscosity. Babassu oil records the highest CN of 63. Sun flower oils have a lowest of 37.1. Methyl esters (biodiesel) are observed to possess a higher CN when compared to their corresponding oils. The babassu oil methyl ester has the highest CN, whereas soybean methyl ester records the lowest among the oils tested. Methyl esters have a lower viscosity than their corresponding vegetable oils. Biodiesel records high CN values; these values are higher than that of diesel fuel with CN of 52. The high CN of biodiesel may be influenced by their characteristics of the feed stock. Factors that affect the CN in the biodiesel are, e.g. the number of carbon atoms of the original fatty acids, the number of double bonds and the ester yield (Sivaramkrishnan and Ravikumar, 2012). It can also be observed from the readings that non edible oils blends have CN values close to those of the diesel fuel samples; this is due to the presence of diesel in blends. It is clear that, the higher the density the lower the Cetane number.

The cetane number (CN) of the fuel is one such important parameter which is responsible for the delay period. Cetane number of a fuel is defined as the percentage by volume of normal cetane in a mixture of normal cetane and α-methyl naphthalene which has the same ignition characteristics (ignition delay) as the test fuel, when combustion is carried out in a standard engine under specified operating condition. A fuel of higher cetane number gives lower delay period and provides smoother engine operation. Biodiesel has a higher CN than petrodiesel because of its higher oxygen content. The cetane number is one of the most commonly cited indicators of diesel fuel quality. It measures the readiness of the fuel to autoignite when injected into the engine. It is generally dependent on the composition of the fuel and can impact the engine's startability, noise level, and exhaust emissions.

Flash and fire point:-

The flash and fire point of Jatropha oil was found to be 128^0C and 136^0C respectively (Fig. 3). The observed results on flash and fire point are not in accordance with the findings of Foidl *et al*. (1996) who reported flash point of Jatropha oil as 240^0C. The observed results are lower than those reported by Ouedraogo *et al*. (1991). Shambhu *et al*., (2013) recorded very high values for flash and fire point of Jatropha raw oil, these were 229.3 and 235.2. Flash point varies inversely with the fuel's volatility. Minimum flash point temperatures are required for proper safety and handling of diesel fuel.

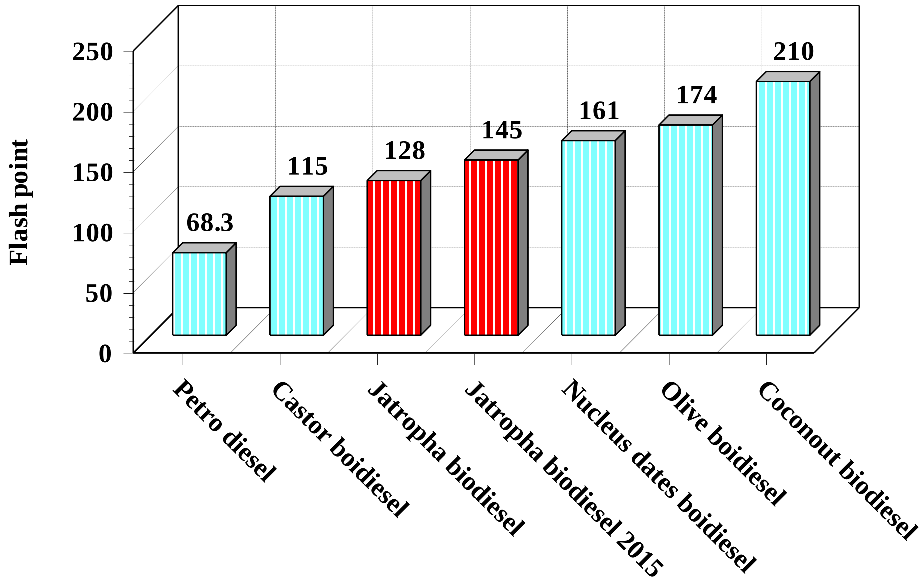

Fig. (3): The flash point of petro diesel and biofuels from plant oils

Flash point is the lowest temperature at which application of the test flame causes the vapor and air mixture above the sample to ignite. Flash point specifies the temperature to which a fuel needs to be heated for the vapour and air above the fuel could be ignited. The flash points of the biodiesels are generally higher than that of geodiesel. It is higher than 90^0C, and is thus safer than diesel from the standpoint of fire-hazards (Sarma, 2006).

The flash point is related to the safety requirement in handling and storage of fuel however, Jatropha oils have very high flash point values. This makes them safer to handle and store. When compared with standard base oil, it was discover that base oil of 240^oC was higher than the two extracted oils of 145^oC and 113^oC respectively. But the two sampled oils are good and can be use (Olasheu *et al*., 2015).

Higher and lower heating value:

Our results are given in Fig. (4) and Table (3) showed that higher heating value (HHV) of Jatropha oil reached to be 39.21 and the lower heating value (LHV) is 36.53. These recorded values are within the range of diesel fuel. The heating value (MJ/kg) for Jatropha biodiesel is lower than those reported for petro diesel, nucleus dates biodiesel and olive biodiesel but higher than those reported for castor biodiesel and coconut biodiesel Fig (2). Biodiesel is a mixture of esters of short chain alcohols, produced as an alternative fuel for mineral diesel substitution. It is originated from renewable sources (fats and oils) and is less pollutants. But for its implementation, it is necessary to analyze some important quality parameters (Oliveira and Da Silva, 2013).

Iodine number:

Determination of Iodine number of Jatropha crude oil revealed to high Iodine number to be 101. These results are in a good agreement with those reported by Nayak and Patel (2010). The Iodine value (IV) is a measure of the average amount of unsaturation of fats and oils and is expressed in terms of the number of milligrams of iodine absorbed per gram of sample (Gerhard 2002). The oil shows a high iodine value due to its high content (80%) of unsaturated fatty acids (Table 1). The IV has found applications to various chemical and physical properties of fats and oils, having physiological applications, and serving as a quality control method for hydrogenation, these applications include use in standards for biodiesel and in assessing oxidative stability. Jatropha collected from rural area of Bardoli (Gujarat) has nearer iodine value 106 to that reported 105.2 in Nigerian and 135.85 in Malaysian (Salimon and Abdullah 2008).

Sulphur weight %

Sulphur weight % in Jatropha oil determined in the present work is 0.0024%. This result given in Table (3) is lower compared with petroleum diesel (0.0165%). These results is not in a good agreement with those reported by Barua, (2011) who stated that sulphur content % in Jatropha is 0.0094.Sulphur content in the biodiesel is important parameter and it can be evaluated using energy dispersive X-ray Fluorescence Spectrometry (XRF). This testing method covers the measurement of sulphur in naphtha, kerosene, diesel, fuel oils, lube base oils and crude oils. The applicable concentration range is 0.015 to 5.00 mass% sulphur and time taken for testing is 5 minutes per sample. The conventional lamp or bomb method usually takes 8 hours. The sample is placed in the beam emitted from an X-ray source. The resultant excited characteristic X-radiation is measured and the accumulated count is compared with counts from previously prepared calibration samples. To protect the environment from sulfur dioxide emission, the sulfur content in diesel, petrol, etc. are restricted to certain maximum value. Also, in processing the hydrocarbon, different types of catalysts are used, some of which are poisoned by sulfur. Sulfur creates corrosion problems and hence its tolerance is limited.

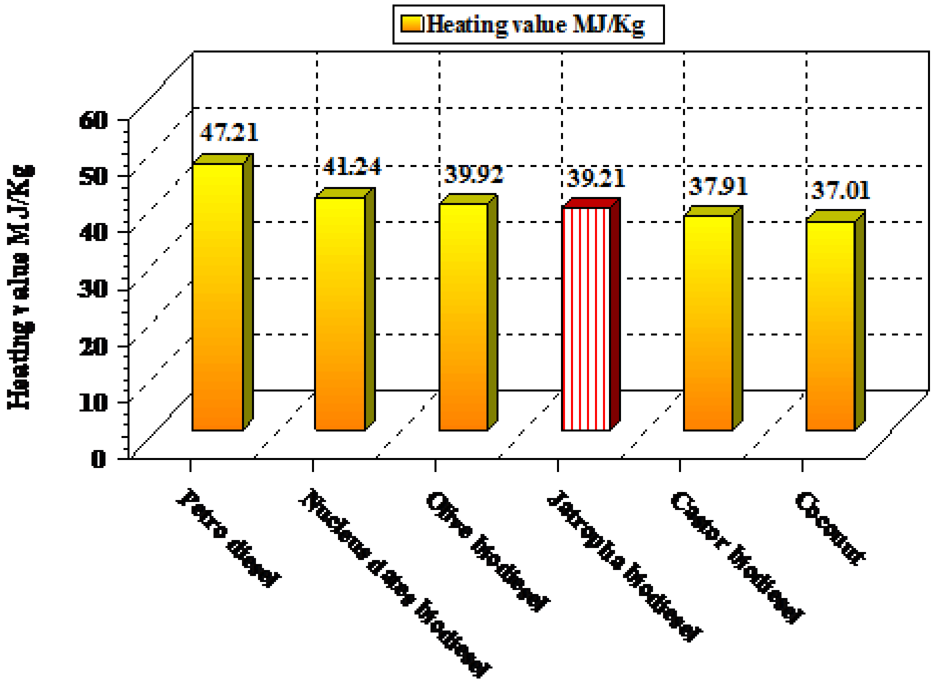

Fig. (4): Comparative study of heating value among *Jatropha curcas*, some common plant biodiesel and petro diesel.

Specific heat capacity

Specific heat capacity (SHC) of Jatropha oil determined in the present work given in Table (4) is 0.80 $Jk^{-1}g^{-1}$ these results are in a good agreement with those reported by Olasheu *et al*., (2015) who stated that the specific heat capacity for Jatropha oil that was 0.080 kJ/kg/K.

Table (4): Specific heat capacity

Analyte/parameter	Test method	Description
Specific heat capacity	ACAL-APR-10-00	Value :0.80 $Jk^{-1}g^{-1}$

Analytical chemistry unit (ACAL)

The use of Jatropha oil as diesel fuel depends on its characteristics fuel properties. The fuel property, such as, viscosity, ash content, carbon residue, flash point and acid value of Jatropha oil was found to be far greater than that of petro diesel and therefore, make it unsuitable for use as fuel in diesel engines. Esterification of Jatropha oil to methyl and ethyl ester brought the fuel properties closer to that of petro diesel. The viscosity of methyl ester, ethyl ester and their blends with diesel was within the recommended limit. It could also be concluded from the study of the physical and chemical properties of Jatropha biodiesel are in agreement with those of petro diesel and meet the existing standards for vegetable oil derived fuel. Therefore, it can be used as an alternate fuel in compression ignition engines after esterification.

Oil has very high saponification value and being extensively used for making soap in some countries. Also oil is used as in illuminant in lamps as it burns without emitting smoke. It is also used as fuel in place of, or along with kerosene stoves. Jatropha oil cake is rich in nitrogen, phosphorous and potassium and can be used as organic manure. By thermodynamic conversion process, pyrolysis, useful products can be obtained from the Jatropha oil cake. The liquid, solid and gaseous products can be obtained. The liquid can be used as fuel in furnace and boiler. It can be upgraded to higher grade fuel by transesterification process (Kamrun and Hampton 2011).

Fractionation of fatty acids in Jatropha oil:

Fractionation of fatty acids process was done using GC. Soybean oil contains 10 fatty acids Table (5). Two of these fatty acids linoleic (C18:2), and linolenic (C18:3), are considered essential fatty acids because the human body cannot synthesize it. A lack of the daily requirements of these fatty acids leads to serious health problems (Chapkin, 1992). Many healthcare professionals recommend replacing saturated fats with unsaturated fats. Jatropha oil has more 19% saturated fatty acids (C16:0, C17:0, C18:0, and C20:0) and more than 80% unsaturated fatty acids (C16:1, C17:1, C18:1, C18:2, C18:3 and C20:1). These results are in good agreement with those reported by Salimon and Abdullah (2008) and also similar with those reported by Neff and List (1999) and Gamal-Fakhry *et al.*, (2016).

Given results in Table (5) showed that levels of total saturated fatty acids (TSFA) in Jatropha sample were 19.16 and the most abundant fatty acid in Jatropha was palmitic acid (C16:0) followed by stearic acid (C18:0) and the lowest one was arachidic acid C20:0. These results also, showed existence of odd chain saturated fatty (OCS-FAs) margaric acid C17:0 with value of 0.29. The role of C17:0 in human health has recently been reinforced following a number of important biological and nutritional observations (Jenkins *et al.,* 2015). Historically, odd chain saturated fatty acids (OCS-FAs) were used as internal standards in GC-MS methods of total fatty acids and LC-MS methods of intact lipids, as it was thought their concentrations were insignificant in humans. One possible mechanism for the endogenous production of OCS-FAs is α-oxidation, involving the activation, then hydroxylation of the α-carbon, followed by the removal of the terminal carboxyl group. Differentiation human adipocytes showed a distinct increase in the concentration of OCS-FAs, which was possibly caused through α-oxidation. Further evidence for an endogenous pathway, is in human plasma, where the ratio of C15:0 to C17:0 is approximately 1:2 which is contradictory to the expected levels of C15:0 to C17:0 roughly 2:1 as detected in dairy fat (Jenkins *et al*., 2015).

Table (5): Fatty acids composition of Jatropha

Fatty acid	Test results of fatty acid
Palmitic C16:0	13.84
Margaric acidC17:0(OCS-FAs)	0.29
Stearic C18:0	4.84
Arachidic acidC20:0	0.19
Total saturated fatty acids (TSFA)	19.16
Palmitoleic acidC16:1	1.19
cis-10-Heptadecenoic acid C17:1	0.40
Oleic C18:1	34.81
Linoleic C18:2	44.03
Linolenic C18:3	0.28
Paullinic acidC20:1	0.10
Total unsaturated fatty acids (TUSFA)	80.81

C17:0= Heptadecanoic acid, OCS-FAs= odd chain saturated fatty acids, C20:0= Eicosanoic acid, C22:0= Docosanoic acid

Given results in Table (6) showed that levels of total unsaturated fatty acids (TUSFA) in Jatropha sample is 80.81 and the most abundant fatty acid in Jatropha oil is linoleic C18:2 followed by oleic C18:1 and the trienoic acid (linolenic C18:3) is lowest one.

Monounsaturated fatty acids with an odd number of carbon atoms C17:1are relatively rare in mammals but common in plants and marine organisms. Odd chain fatty acids are oxidized in the same way as even chained fatty acids up until the formation of propionyl CoA. Propionyl CoA is converted into succinyl CoA which then enters into the citric acid cycle. *cis*-10-Heptadecenoic acid has been claimed to be a minor component of ruminant fats (Alves *et al*. 2006). *cis*-10-Heptadecenoic acid has been shown to have some inhibitory activity against human cancer cells HL-60 although less than some other saturated long chain fatty acids (Fukuzawa *et al*., 2008). This fatty acid has a *cis* double bond at an even carbon (carbon 10) and therefore cannot be enzymatically degraded via the usual beta-oxidation pathway. Instead, a reductase-isomerase or an epimerase pathway must be employed in the metabolism of this fatty acid (Allenbach and Poirier 2000).

Oils with a higher saturated fatty acid content (C18:0) have increased melting temperatures. Interesterified oils, high in C18:0 can be processed into softer margarines that have suitable spread ability, sensory characteristics, and acceptable oil-off properties. Such products are favorable when low *trans* acid contents are required (List *et al*., (1979).

Jatropha oil contains 40% dienoic and trienoic acids, amounts that are large enough to influence formation of considerable levels of *trans* isomers of linoleic and linolenic acids (Table 5). These results disagree those reported by Boskou and Elmadfa (1999).

The composition of *J. curcas* oil from Nigeria consists of main fatty acid such as palmitic acid (13%), stearic acid (2.53%), oleic acid (48.8%) and linoleic acid (34.6%) (Martínez-Herrera *et al*. 2006). *J. curcas* oil contains high percentage of unsaturated fatty acid which is about 78-84%. This made the oils suitable for biodiesel production. However, the chemical compositions of the oil vary according to the climate and locality.

To date, Malaysian varieties of *J. curcas* oil have yet to be characterized. Fatty acids composition of the Malaysian *J. curcas* oil is rich in oleic and linoleic acids and the oil can be classified as unsaturated oil. Hence the Malaysian *J. curcas* oil has a great potential for oleochemical application such as surface coating and low pour point biodiesel. Therefore, it is convivial to have more research on *J. curcas* seed oil in the future to explore its potentials for future industrial oilseeds crop (Salimon and Abdullah 2008).

Jatropha curcas oil was extracted using *n*-hexane as solvent in the Soxhlet extraction method. The physicochemical properties of Malaysian *Jatropha curcas* oil were evaluated by Salimon and Abdullah (2008). The result showed that the Jatropha seeds consist of 60% (dry w/w) crude oil. The physicochemical properties showed that the seed oil contained low moisture level of 0.02 ±0.01%, acid value of 1.50±0.07%, iodine value of 91.70±1.44 mg/g, peroxide value of 0.66±0.04 miliequivalence/kg and saponification value of 208.5±0.47 mg/g. Gas chromatography analysis showed that oleic acid (O) (46.00±0.19%) appears as dominant fatty acid in seed oil followed by linoleic acid (L) (31.96±0.19%) and palmitic acid (P) (13.89±0.06%). High performance liquid chromatography (HPLC) results showed that the dominant triacylglycerols present were PLL (20.40%), OOL (17.98%), POO (15.02%), OOO (14.89%) and OLL (14.00%).

CONCLUSIONS

Jatropha curcas L. can be a revolutionary crop in Egyptian biodiesel industry, by replacing or complementing the use of soy to produce the renewable fuel. It has many advantages in comparison to soy and rapeseed, (e.g. it does not compete for land use, it is not an edible crop and it has more oil). Nevertheless, nowadays lack of information about some crucial aspects, like vulnerability to national pests, diseases and climatic adaptability, are the main obstacle to its large scale development. The main difference between Jatropha's and other oil sources for fuel production is the higher acid number, which affects the processing for biodiesel production. About the Jatropha cake obtained by pressing, three different uses can be pointed out: 1- as animal feed (studies should be performed); 2- as fertilizer for exhausted lands, and 3- as boiler fuel.

In this study we introduce Jatropha oil as solution in the next ten decades because of the following properties, suitable heating value, suitable flash point, and low agriculture cost, non-edible, farming conditions are visualizations with the conditions of agriculture in Egypt. Seeds contain a large amount of oil, extracting oil simply, reasonable price in the Egyptian market, better properties when they are mixing with petro diesel, wastewater used to irrigate these plants does not need a lot of water difficulties facing extraction of biofuels from other plants, such as:- difficulty of extracting the oil from the dates nucleus. -high prices of olive and coconut crops are edible. -productivity of the olive harvest begins in abundance after the 9thyear. In the irrigation process, these plants need clean water at a time when the world is suffering water shortages where Jatropha plants can be irrigated by wastewater.

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إستخدام مياه الصرف الصحى الخام و المعالجة فى زراعة الجاتروفا وإمكانية إستخدام زيت بذور الجاتروفا كوقود حيوى

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تم فى هذا البحث دراسة إمكانية زراعة الجاتروفا باستخدام مياه الصرف الصحى فى الرى حيث تم تنفيذ التجربه فى أصص وذالك باستخدام ثمانية معاملات من مخاليط الماء المستخدمة لرى وإنبات بذور الجاتروفا. أظهرت النتائج أن نسبة الإنبات تتراوح من 54– 87% . كما أشارت النتائج إلى أن أعلى نسبة إنبات سجلت عند إستخدام ماء صرف غير معالج فى الرى87%. بينما أقل نسبة إنبات لبذور الجاتروفا سجلت (54%) عند إستخدام المعامله 50% ماء صنبور + 50% ماء صرف غير معالج.

تطرقت الدراسة أيضا إلى دراسة خصائص ومميزات زيت الجاتروفا ومدى قابليته للخلط مع وقود الديزل البترولى وتشير النتائج إلى أن الكثافه النسبية لزيت الجاتروفا الخام (0.876) و هي أعلى من تلك التى قدرت فى وقود الديزل البترولى والتى تبلغ (0.839) وكانت اللزوجه الكيناميتيكية فى زيت الجاتروفا الخام (5.08) بينما فى وقود الديزل البترولى (3.08) كما تم تقدير رقم السيتان لزيت الجاتروفا الخام والذى تتراوح نسبته ما بين 46– 70. كما أشارت النتائج إلى أن كلا من نقطة الوميض والاحتراق $128\ {}^{0}C$ و $136^{0}C$على التوالى . كما أظهرت النتائج ان القيمة الحرارية العليا لزيت الجاتروفا تتراوح من 39.24–41.87 وأن القيمة الحرارية السفلى من 36.53– 38.94 (MJ/kg) كما تشير النتائج إلى أن القيمة الحرارية لزيت الجاتروفا أقل من تلك التى قدرت فى وقود الديزل البترولى وزيت النخيل وزيت الزيتون بينما كانت أعلى من تلك التى وجدت فى زيت الخروع وزيت جوز الهند. كما أوضحت النتائج أن الرقم اليودى لزيت الجاتروفا الخام(101) كما تم تقدير الكبريت كنسبه مئويه حيث بلغت نسبته 0.0024%. كما تبين من النتائج أن الحرارة النوعية لزيت الجاتروفا تصل إلى 0.80$(Jk^{-1}g^{-1})$. تم تفريد الأحماض الدهنيه بواسطة GC و اظهرت النتائج ان زيت بذور الجاتروفا يحتوى على أكثر من 19% أحماض دهنيه مشبعة (palmetic C16:0, margaric C17:0, stearic C18:0, and arachidic C20:0). كما يحتوى على أكثر من 80% أحماض دهنيه غير مشبعه.(C16:1, C17:1, C18:1, C18:2, C18:3 and C20:1).

تصل نسبة الأحماض الدهنيه المشبعه إلى 19.16% أكثرها وفره فى الزيت هو حمض البالمتيك (C16:0). ويليه حمض الإستياريك (C18:0) بينما اقل الأحماض الدهنيه المشبعه تواجداً فى زيت الجاتروفا هو حمض الأراشيديك C20:0 . كما تشير النتائج إلى وجود حمض دهنى مشبع فردى السلسله الكربونيه وهو حمض المارجاريك (C17:0 (0.29)..) . كما توضح النتائج أن نسبة الأحماض الدهنيه غير المشبعه تصل إلى 80.81% وأكثرها تواجداٍ فى الزيت هو حمض اللينوليك ويليه حمض الأوليك . بينما أقلها تواجداً هو حمض اللينولينك .