Investigation of the physical and chemical stability of biodiesel produced from *Jatropha Curcas Species in Zimbabwe*

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Abstract

Jatropha curcas L. seeds as a raw material for biodiesel production are a rapidly growing interest over the world because of their high oil content, ecological adaptability, and excellent fuel properties. Though there is an increase in productivity of biodiesel, showing solution for future energy insecurity, there still remains some concern for commercialization due to its susceptibility to degradation during long term storage. The aim of this research work is to investigate the effect of temperature and ambient condition on Jatropha biodiesel storage. A study was conducted for a period of 12 months, where Jatropha biodiesel samples were stored at different temperatures (4°C, 25°C, and 35°C) and environmental conditions (darkness, light, and air). At regular intervals, the samples were taken out to analyze acid value, density, kinematic viscosity, and fatty acid profile to monitor the quality of biodiesel. Analysis showed that acid value, density, kinematic viscosity, and fatty acid content increases with the increase in storage time of biodiesel samples. However, Jatropha biodiesel stored at 35°C, in contact with ambient air and light showed highest degradation compared to that which was stored at 25°C and 4°C. Among all the parameters studied, high temperature and air exposure are the two most important parameters which accelerate the degradation process. Light exposure had mild but significant effect on Jatropha biodiesel degradation over a long storage period.

Keywords:

Biodiesel; *Jatropha curcas*; Transesterification; Free fatty acids

1. Background

Jatropha Biodiesel is a monoalkyl ester of long-chain fatty acid derived from Jatropha *curcas* oil. [11]. It constitutes the most reliable renewable source for substituting diesel. The finite nature of fossil fuel reserves and growing green house gas emission has promoted research on alternative fuels. *Jatropha curcas* Biodiesel has advantages over conventional diesel fuels because of its renewable, environmentally friendly and biodegradable nature. The main disadvantage is that Jatropha biodiesel is severely prone to degradation than conventional diesel fuels during long storage[12]. Storage stability is a critical issue regarding the successful commercialization of biodiesel in fuel industry. Storage stability is the ability of a fuel to resist changes in its physicochemical characteristics brought by interaction with its environment. In the presence of air or oxygen, biodiesel will be hydrolyzed into alcohol and acid. The presence of alcohol reduces flash point, and the presence of acid increases the total acid value. All these make *Jatropha curcas* biodiesel unsuitable for use in diesel internal combustion engines. But in order to introduce biodiesel in the transport industry, it should meet accepted fuel standards and quality assurance.

There are various reports in the literature on the storage, oxidation stability, and the effect of antioxidant concentration on biodiesel. The effect of different synthetic and natural antioxidants on oxidation stability of biodiesel produced from rapeseed oil, sunflower oil, used frying oil, beef tallow, and soya bean oil has been reported[4]. Long time storage stability is also investigated on biodiesels synthesized from rapeseed oil, used frying oil, high oleic sunflower oil, high and low erucic *Brassica carinata* oil[2]. Dunn etal[4] examined the oxidative stability of soy-bean oil methyl esters by analyzing oil stability index. Most of the studies on the storage and oxidation stability are carried out on biodiesel derived from edible oil. However, the studies on biodiesel derived from non-edible oil seeds are scanty[3] Among non-edible oil crop, recently, Jatropha*curcas* is in the top priority in national biodiesel programs because of its high oil content and promising fuel properties. Several researchers have performed experiments for efficient Jatropha biodiesel production, physicochemical characterization[8] and engine performance[1]. Sarin et al.[10] monitored the effect of metal contaminants and antioxidant concentrations on the storage

stability of Jatropha biodiesel. However, no proper study has been conducted on the effect of different storage parameters like temperature and exposure to light and air on Jatropha oil biodiesel storage. The aim of this work is to investigate the influence of different parameters like temperature and exposure to light and air on Jatropha biodiesel degradation. Acid value, density, kinematic viscosity (μ), and fatty acid content results for methyl esters were analyzed for a period of 12 months and were compared with the initial values to monitor the changes in the quality of methyl esters. The study will provide knowledge on the factors influencing degradation of Jatropha biodiesel, which will be immensely helpful in maintaining the quality of *Jatropha curcas* oil biodiesel over long-term storage.

2. Methods and Materials

Jatropha seeds were collected from Mutoko District. The seeds were separated from the fruit mechanically and cleaned manually to remove all foreign materials. Then, the seeds were dried under similar temperature (35°C) and humidity conditions to reach constant weight. The oil was extracted from the seeds using a mechanical oil expeller. The oil was then purified by filtering it. All the other chemicals and reagents like methanol, ethanol, potassium hydroxide, sodium hydroxide, and phenolphthalein indicator were analytical reagent grade and were provided by the Chemistry Department at University of Zimbabwe. GC analysis was also carried out in the Chemistry Department Analytical Laboratory University of Zimbabwe.

2.1. Preparation of biodiesel from Jatropha oil

Due to low-acid value of the native oil, single-step direct transesterification procedure was followed. Jatropha oil biodiesel was synthesized by refluxing the oil at 60°C, employing 1:6 molar ratio of oil to methanol for 1.5 h. KOH (1 wt%) was used as the catalyst. After completion of the reaction, the mixture was cooled to room temperature and was transferred to a separating funnel, leading to the separation into two phases. The bottom glycerol layer was discarded. The top ester layer was washed several times with distilled water to remove all the trace of catalyst, glycerol, and soap.

2.2. The storage condition and analysis

The acid value, density, kinematic viscosity, and fatty acid analysis were performed and recorded as 0 month values after the preparation of Jatropha oil biodiesel. Then, the Jatropha oil biodiesel samples were stored for 12 months in three individual groups at different storage conditions. The groups were made on the basis of different storage temperatures: 4°C, 25°C, and 35°C. Each group consisted of three subgroups: in the first subgroup, the samples were kept in sealed and in dark environment. In the second subgroup, the samples were kept in a sealed environment but exposed to light, while in the third subgroup; the samples were kept but exposed to both light and ambient air. The samples from each group (in three replicates) were analyzed periodically at the intervals of 6 months for different fuel quality parameters such as acid value, density, kinematic viscosity, and fatty acid composition.

2.3. Experimental Analysis

2.3.1. Acid value

Acid value denotes free fatty acid content of oil. It is defined as the amount of potassium hydroxide (in mg) required for neutralizing 1 g of oil sample. It was determined by titrating solution of Jatropha oil biodiesel in neutral ethanol with 0.5 N KOH. Phenolphthalein solution was used as an indicator for titration. Acid value was calculated using the following expression:

$$AV = \frac{V_{titrant} \times N \times 56.10}{M_{sample}}$$

AV = Acid Value ($\frac{mgKOH}{g}$)

N = the normality of accurately standardized sodium hydroxide solution.
$V_{titrant}$ = volume of titrant (ml)
M_{sample}= mass of sample (g)

2.3.2. Density

The density of a material is defined as mass per unit volume. The densities of the stored Jatropha oil biodiesel samples were determined at 25°C, using a specific gravity bottle. Density was calculated using the following expression:

$D = \frac{M}{V}$ *Where D= density (* $\frac{kg}{m^3}$ *), M = mass (kg) and V= volume (*m^3*)*

2.3.3. Kinematic Viscosity

Kinematic viscosity is the measure of resistance of a fluid flow against gravity and is determined as the ratio of dynamic viscosity to the density. Dynamic viscosity was measured for stored Jatropha oil biodiesel samples with Rheometer at 40°C. At three different shear rates (50, 100, and 150 s^{-1}), the dynamic viscosities were measured, and the average values were considered. Kinematic viscosity was calculated using the following expression: $\nu = \frac{\mu}{\partial}$ **Where**

ν = kinematic viscosity ($\frac{m^s}{s}$)

μ = dynamic viscosity (Pa.s or $\frac{kg}{m.s}$)

∂ = density

2.3.4. Fatty acid composition

There are differences in fatty acid composition (as indicated in Table 1 below) from the *Jatropha curcas* seeds collected from different regions due to different climatic and environmental conditions, and attention should be given to these differences in the use of jatropha oil biodiesel.

Table 1. Fatty Acid Content of Jatropha oil from different regions

Country seed	JatrophaCurcas % Fatty Acids Content							
	16:0 Palmitic FA	**18:0 Stearic FA**	**18:1 Oleic FA**	**18:2 Linoleic FA**	**Others**	**Saturated FA**	**MUFA**	**PUFA**
Argentina	10.0	5.4	30.2	53.3	1.1	15.4	30.2	53.3
Paraguay	13.2	3.0	40.2	42.6	1.0	`16.2	40.2	42.6
Malasiya	14.2	7.0	44.7	32.8	0.6	21.6	45.4	33.0
Mexico	11.8	2.5	45.6	38.5	1.6	14.3	45.8	38.3
Zimbabwe	14.3	6.9	43.1	34.3	1.4	21.2	43.1	34.3
Dehradun	15.39	6.26	44.93	33.40	0.02	21.65	44.93	33.40
Rudropryag*	14.57	6.82	42.74	35.88	0.01	21.39	42.74	35.88
Kotdwara*	14.66	7.10	43.32	34.90	0.02	21.76	43.32	34.90
Haridwar*	16.41	6.39	42.75	34.43	0.02	22.8	42.75	34.43
Tehri*	15.32	6.34	40.65	37.99	0.3	21.66	40.65	37.99
Chmoli*	16.46	5.90	37.43	40.19	0.02	22.36	37.43	40.19

*Regions in India
MUFA: Monounsaturated fatty acid
PUF: Polyunsaturated fatty acids
The fatty acid composition was determined using theVarian Gas Chromatography as shown in diagram below.

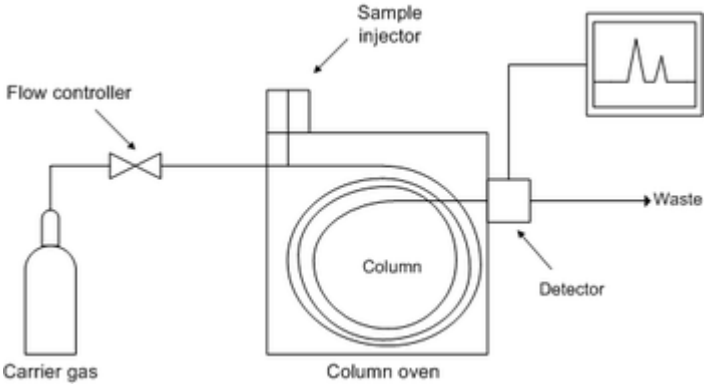

Fig. 1 Schematic Diagram of Gas Chromatograph

Methyl esters were prepared from the *Jatropha curcas* oil by the method of transesterification. These methyl esters were analysed by gas chromatography using a Varian GC equipped with a Silar Column and a flame ionisation detector (FID). The columntemperature gradient ranged from 160 to 225^{o}Cand nitrogen, at a flow rate of 1 ml per min, was used as a carrier gas. Standard fatty acid methyl ester were run and retention times were used in identifying thesample peaks. Fatty acid levels were estimated as area percentof total peak area of methyl esters.

4.0. Results and discussion

The degradation behavior of Jatroha oil biodiesel samples on long storage under different conditions was assessed by monitoring the changes in their physicochemical properties such as acid value, kinematic viscosity, fatty acid composition with respect to their initial value at 0 month.

4.1. Effect of temperature on biodiesel storage

Temperature plays an important role in the degradation of Jatropha oil biodiesel. High temperatures accelerate the process of oxidation which results in the increase in density and viscosity of the fuel[5]. The acid value is one of the promising methods to monitor the degradation of Jatropha oil biodiesel. Figures 1, 2 and 3 represent the change in the acid value of the Jatropha oil biodiesel samples stored under different conditions. The Jatropha oil biodiesel degradation shows direct correlation with acid value. Therefore, increase in acid value with storage time indicates gradual degradation of the Jatropha oil biodiesel sample. According to Zimbabwean Standards of biodiesel (ZWS 719) the standard maximum allowable limit of the acid value for biodiesel is around 0.5 mg KOH/g. At the beginning (i.e., at 0 months), the acid value of the sample was measured to be 0.40 mg KOH/g which is well below the maximum allowable limit. After 6 months of storage, the acid value of the Jatropha biodiesel sample stored at 35°C was found to be the highest 3.6 mg KOH/g, whereas the sample stored at 4°C showed the lowest value of 0.41 mg KOH/g. Further extending the storage period, Jatropha biodiesel stored at 4°C showed increase in acid value from 0.40 to 0.418 mg KOH/g. For the samples stored at 25°C, increase in the acid value was found to increase from 0.40 to 0.90 mg KOH/g, but the acid value

was found to be increased up to 4.8 mg KOH/g for samples stored at 35°C. This clearly indicates that prolonged exposures of Jatropha oil biodiesel to high temperature can deteriorate the biodiesel quality.

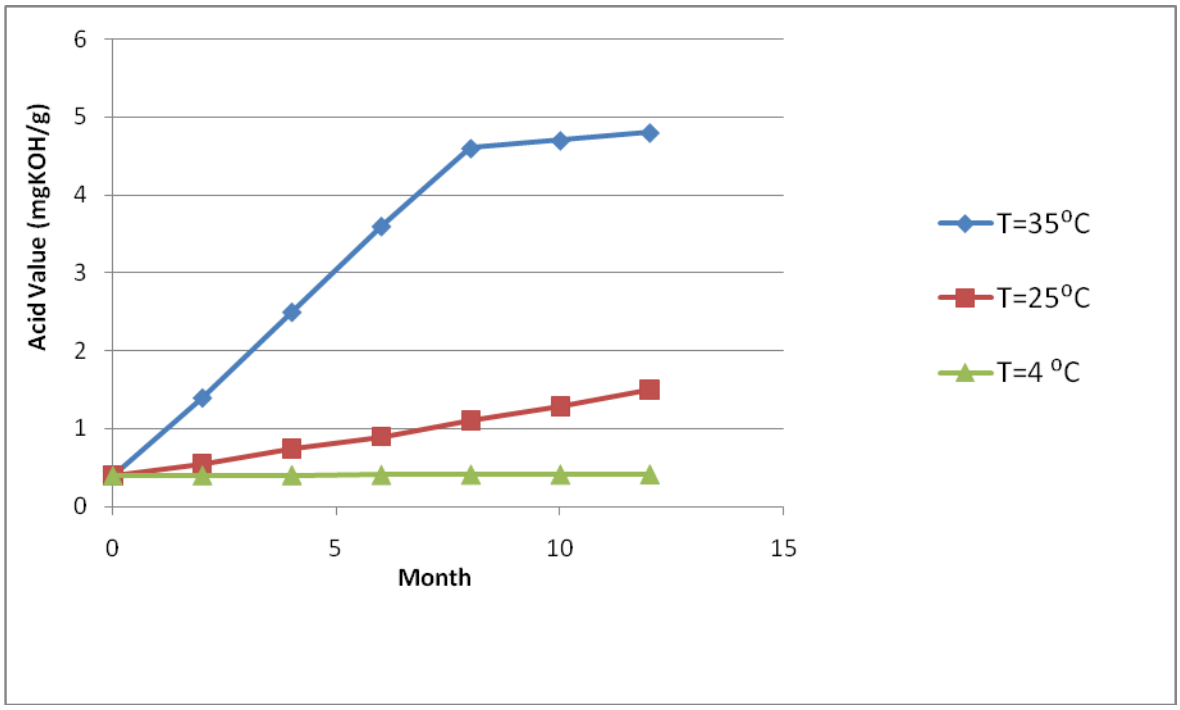

Fig.2. Acid Value-Container of biodiesel sealed and devoid of light and air

4.2. Effect of light on biodiesel storage

To study the influence of light on degradation, Jatropha oil biodiesel samples were stored in light and as well as in dark conditions. Fig.2 shows the change in acid value of the biodiesel samples stored under dark and sealed conditions, whereas Fig.3 represents acid value change for samples exposed to light and sealed condition. After 6 months of storage, the samples stored at 4°C under dark and sealed conditions were analyzed for acid value. The acid value of the sample kept in dark condition was found to be increased from 0.40 to 0.41 mg KOH/g. Further extending the storage period over 12 months, the increase in acid value of Jatropha oil biodiesel was up to 0.418 mg KOH/g. On the other hand, for the sample stored over a period of 6 months at 4°C in light and sealed condition, increase in the acid value was measured as 0.40 to 0.58 mg KOH/g.

After, 12 months of storage, the acid value further increased up to 0.80 mg KOH/g. In the samples stored at 25°C over a period of 12 months in sealed and dark condition, significant increase in the acid value (i.e., 0.40 to 1.5 mg KOH/g) was observed. Whereas, in the same sample stored in sealed condition but exposed to light, the acid value after 12 months of extended storage increases from of 0.40 to 1.58 mg KOH/g. The acid value of Jatropha oil biodiesel after 12 months of storage which was kept at 35°C under dark and sealed condition increases from 0.40 to 4.80 mg KOH/g; whereas, in light and sealed condition, the acid value increased from 0.40 to 5.90 mg KOH/g. From this, it is clear that prolonged exposure of light on Jatropha oil biodiesel samples fastens the degradation rate compared to the dark condition. This finding was found to be in agreement with the previously published report on degradation of rapeseed biodiesel, where the sample kept in exposure to light showed higher degradation than in dark condition[6].

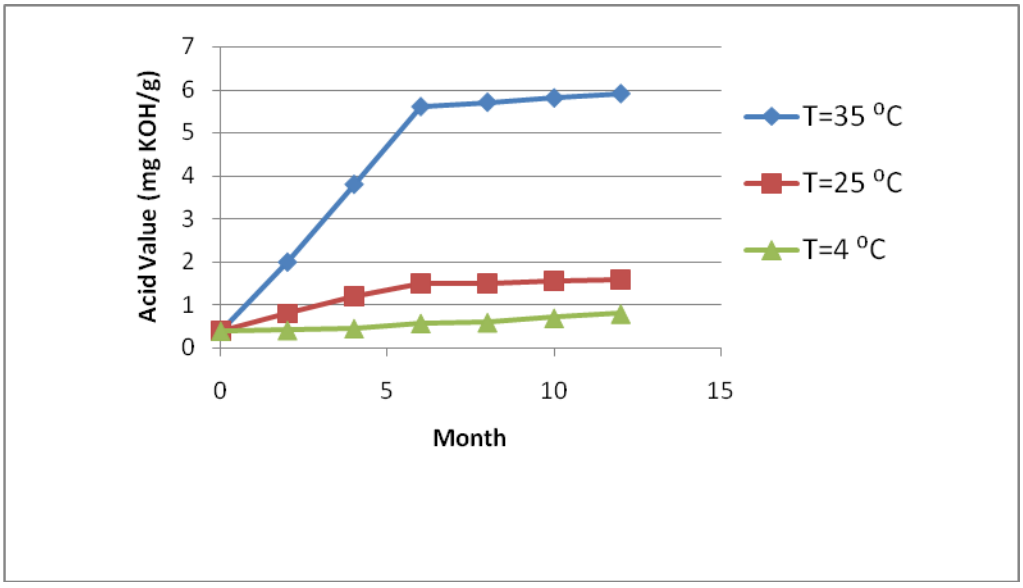

Fig. 3 Acid Value Change – Container of biodiesel sealed and exposed to light

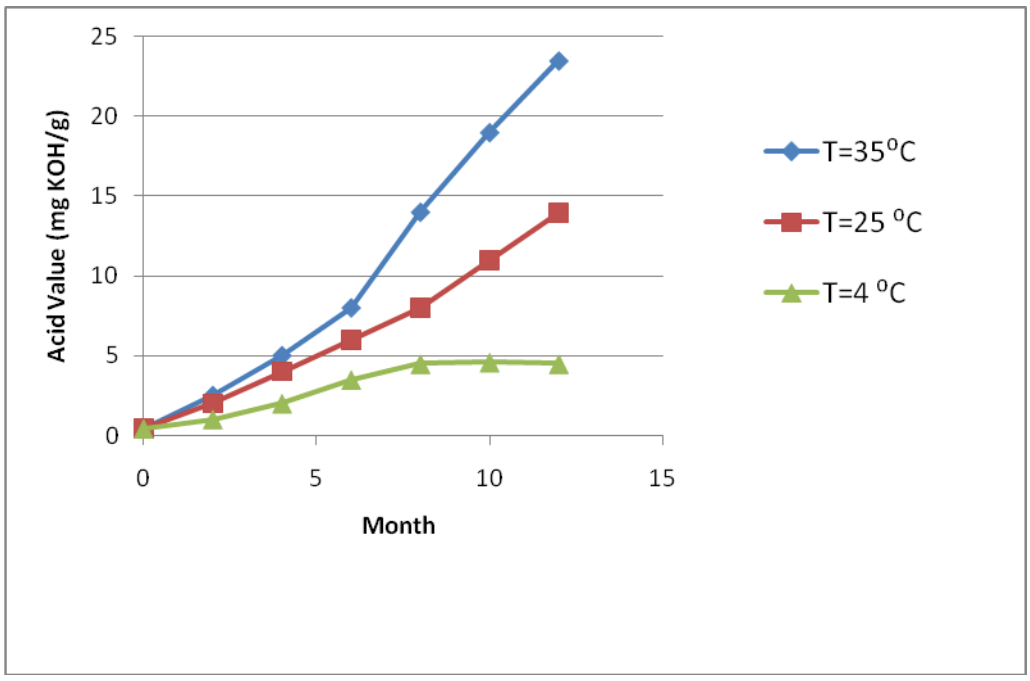

Fig. 4. Acida Value Change-Container of biodiesel with air and exposed to light

4.3. Change in density

Comparison of density of the stored sample with initial value (i.e., 0 month value) over time also gives an idea about the changes in quality of the biodiesel upon extended storage. Figures 4,5 and 6 show that with increase in storage time, the density of Jatropha oil biodiesel also increases proportionally. The increase in the density of methyl ester is mainly due to the interaction of peroxide molecules which formed due to the degradation of esters.[9] The density values found to be increased for all Jatropha oil biodiesel samples kept under extended storage. The initial density values of the samples for 0 months were measured to be around 0.85 g/cm^3. After 6 months of storage period, maximum increase in density of the biodiesel stored at 35°C was measured to be 1.96 g/cm^3.On the other hand, biodiesel samples stored at 4°C and 25°C, maximum increase in density was observed around 1.15g/cm^3 and 1.70 kg/m^3, respectively (Figure 6) Further extending the storage period, the maximum increase in density of the samples stored at 35°C over 12-months period was measured as 2.3 g/cm^3. Whereas, in the case of the other samples stored at 4°C and 25°C, the density increase was from 0.85 to 1.3 g/cm^3 and 0.85 to 1.7 g/cm^3, respectively. The data clearly revealed the influence of higher temperature on

Jatropha oil biodiesel degradation. The increase in density of biodiesel is the first indication of Jatropha oil biodiesel degradation.

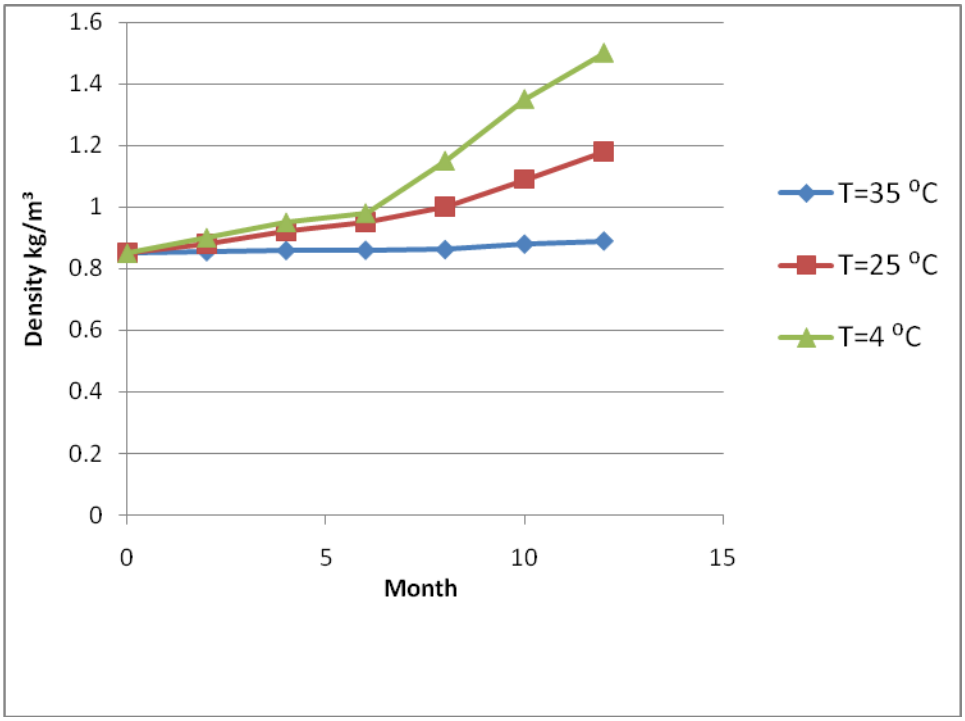

Fig. 5 Change in density of Jatropha biodiesel in sealed container devoid of light and air.

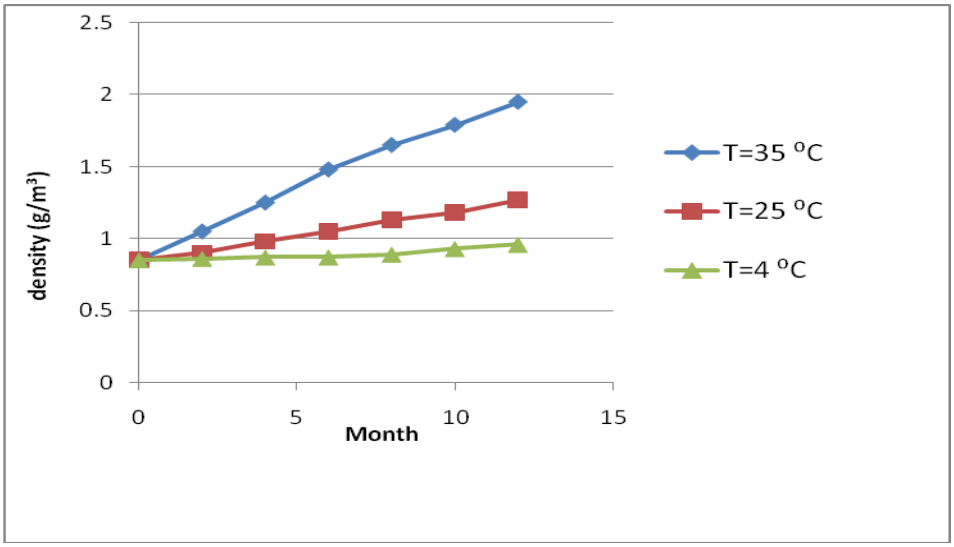

Fig. 6 Change in density of Jatropha biodiesel in container sealed and exposed to light

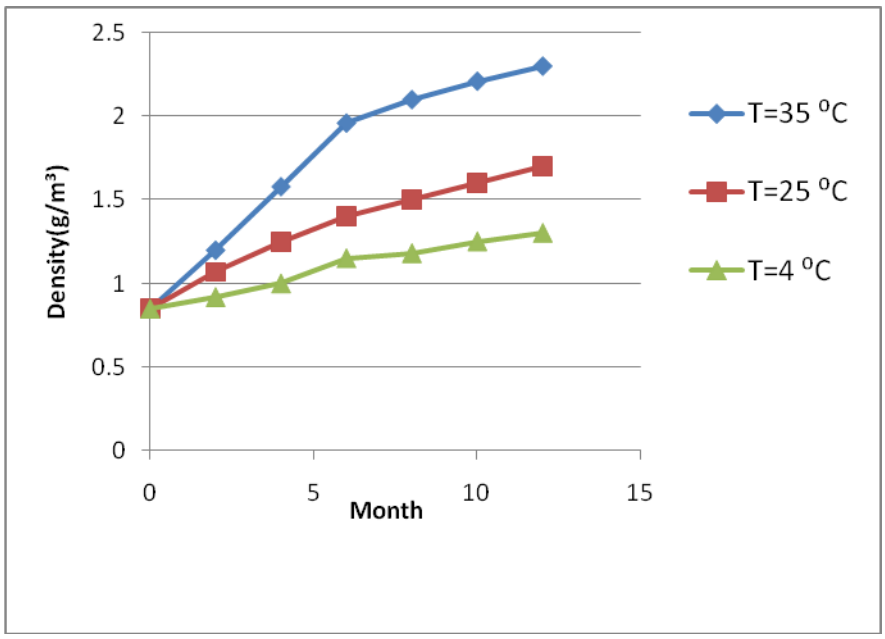

Fig. 7. Change in density of Jatropha biodiesel in container with air and exposed to light

4.4. Kinematic Viscosity

Kinematic viscosity is another suitable method for monitoring the oxidative degradation of Jatropha oil biodiesel. Kinematic viscosity tends to increase upon further oxidation due to the formation of secondary oxidative product. Figures 6, 7 and 8 represent the change in kinematic viscosity of Jatrophaoil biodiesel over 12 months of storage. At the beginning, the kinematic viscosity of Jatropha oil biodiesel was found to be around 6.15×10^{-6} m^2/s (0-month value) which was within the specified range of ZWS 719 standards. During the storage over a period of 12 months, the kinematic viscosity values of all the Jatropha oil biodiesel samples were found to have been increased. After 6 months of storage, maximum increase in kinematic viscosity of the Jatropha oil biodiesel stored at 35°C was measured to be 1.08×10^{-5} m^2/s. On the other hand, Jatropha oil biodiesel samples which were stored at 4°C and 25°C, maximum increase in kinematic viscosity was found to be around 7.95×10^{-6} and 9.00×10^{-6} m^2/s, respectively (Figure 9). Further extending the storage period over 12 months, the Jatropha oil biodiesel stored at 35°C showed highest viscosity value of 1.5×10^{-5} m^2/s compared to 4°C (8.25×10^{-6} m^2/s) and 25°C (1.15×10^{-5} m^2/s). This increase in viscosity of the samples might be due to the formation of

acids and polymeric compound as a result of oxidation, which further can lead to the formation of gums and sediments. The gum and sediment formation is detrimental to engine operation. The increase in kinematic viscosity is a clear indication of Jatropha oil biodiesel degradation which was also observed in stability studies in rapeseed and palm oil biodiesel over longer period of storage[7]

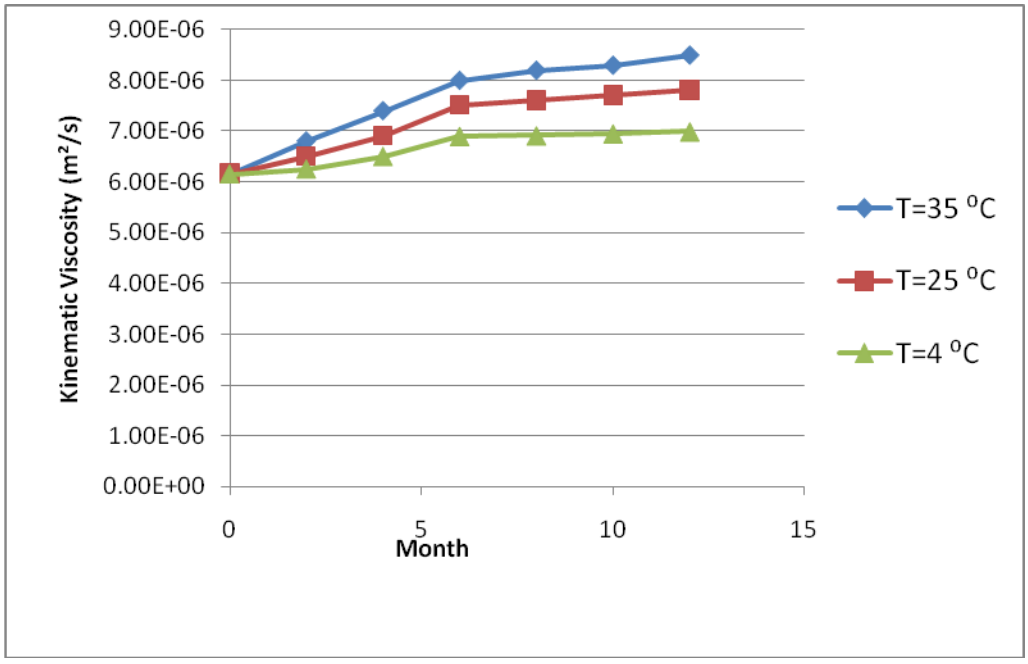

Fig 8. Change in Kinematic Viscocity of Jatropha biodiesel in container sealed devoid of light and air

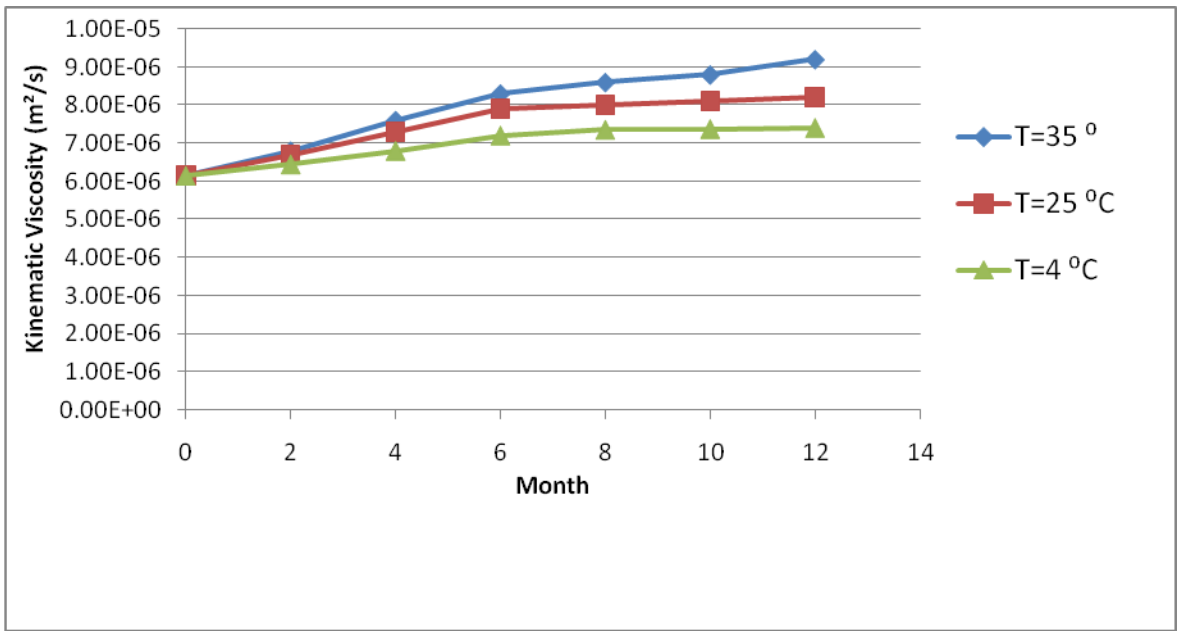

Fig. 9. Change in Kinematic Viscosity of Jatropha Biodiesel in container sealed exposed to light

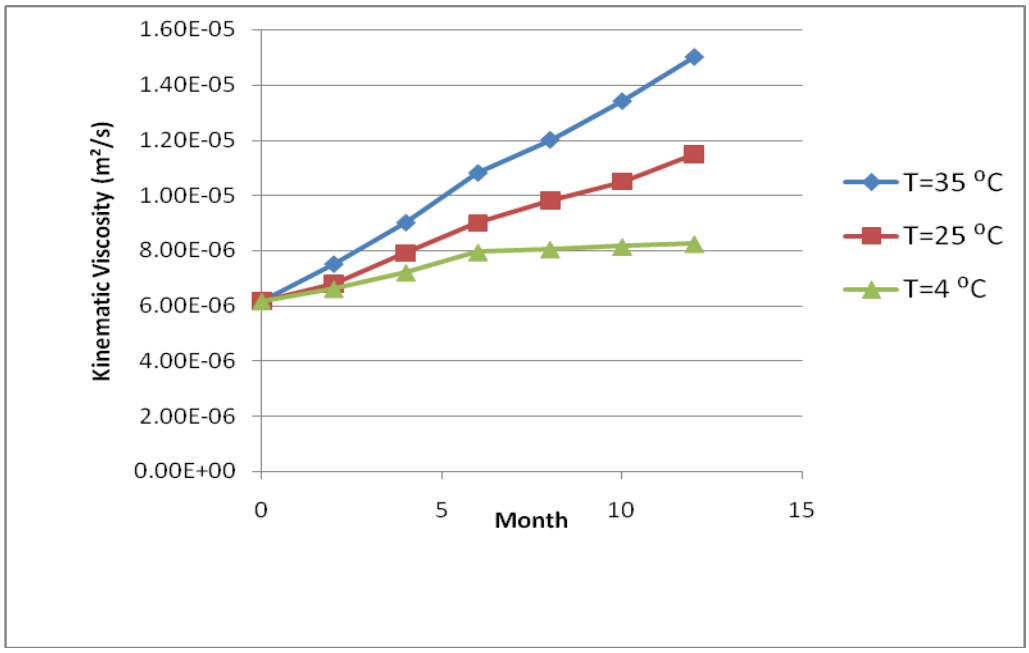

Fig 10. Change in Kinematic Viscosity of Jatropha biodiesel in container exposed to air and light.

Increase in the formation of degraded product increases the density and kinematic viscosity of Jatropha oil biodiesel. Fig.4 represents the changes in density of stored sample in sealed and dark condition, and Fig.5 is for the sample in sealed condition but exposed to light. The density of the biodiesel samples kept in dark condition was increased to a maximum of up to 0.98 and 1.5 kg/m^3 in 6 and 12 months of storage, respectively. On the other hand, the density of the biodiesel samples in sealed and light condition increased to a maximum of up to 1.48 and 1.95 kg/m^3 in 6 and 12 months of storage, respectively.

Kinematic viscosity also followed the same pattern. The kinematic viscosity of the biodiesel samples stored in dark and sealed condition increased to a maximum of up to 8.00×10^{-6} and 8.5×10^{-6} m^2/s for 6 and 12 months of storage, respectively; whereas, the kinematic viscosity of the biodiesel sample stored in light increased to a maximum of up to 1.08×10^{-5} and 1.50×10^{-5} m^2/s in 6 and 12 months, respectively. The above result gives clear evidence in support of evolution of higher density and kinematic viscosity of stored methyl ester in light over long periods than in dark condition.

4.5. Fatty Acid Composition

Like the other parameters, the variation of fatty acid content of Jatropha oil biodiesel has also been studied in detail (fig.11.) To understand the sample behavior, Jatropha oil biodiesel stored at 35^oC and exposed to air and light analysis was performed by using Gas Chromatograph Equipment. Samples were analyzed after every two months. Therefore, from the Gas Chromatograph results, it can be concluded that the variation in major fatty acids in the sample is insignificant.

Fig. 11 represents the fatty acid profile of Jatropha oil biodiesel stored in a container exposed to air and light and at 35^oC for a period of 12 months.

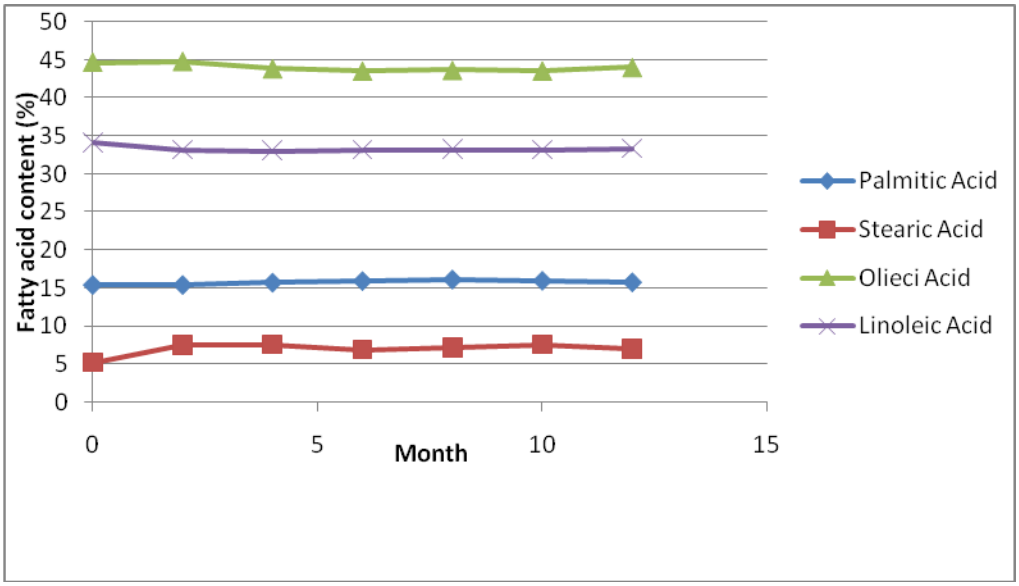

Fig. 11. Variation of Fatty Acid Content of Jatropha biodiesel with time in a container exposed to air and light at 35°C.

However the graph shows that with storage time, the composition of oleic acid and linoleic acid decreases slightly due to chemical reactions with atmospheric oxygen which tends to saturate the double bonds present. Whilst the concentration of palmitic and stearic acids remain unchanged.

Table 2 Fattty acid composition of *Jatropha curcas* oil in Zimbabwe

Fatty Acid	**%**
Myristic acid (C14:0)	**0.43**
Palmitic Acid (C16:0)	**14.81**
Stearic Acid (C18:0)	**6.79**
Oleic Acid (C18:1)	**45.2**
Linoleic Acid (C18:2)	**31.54**
Linolenic Acid (C18:3)	**0.82**

4.6. Effect of air exposure on biodiesel storage

Air exposure enhances the degradation of Jatropha oil biodiesel. During the oxidation process of Jatropha oil biodiesel, it usually forms a radical next to double bond which quickly binds with oxygen in air. This forms peroxide, which immediately forms new radical, and thus, the process

of radical auto-oxidation cycle starts which exponentially increases the degradation of Jatropha oil biodiesel. Fig.4. shows the change in acid value of the Jatropha oil biodiesel sample stored in a container,with exposure to air. At the beginning (0 month), the acid value of Jatropha oil biodiesel was around 0.4mg KOH/g. After 6 months of storage, the acid value increased from 0.4 to 3.9 mg KOH/g for the samples which were kept at 4°C and exposed to air; whereas, for the sample stored at the same temperature but under sealed condition, the increase was not significant, i.e., 0.58 mg KOH/g (Fig. 3,4). Further extending the storage period over 12 months, the increase in acid value was up to 0.8 mg KOH/g for the sample which was kept in exposure to air; whereas, maximum increase in the acid value was found up to 0.8 mg KOH/g for the sealed sample (Fig.3,4). For the samples which were kept at 25°C in exposure to air, the acid value after 6 months of storage was also found to increase from 0.4 to 6.0 mg KOH/g (Fig. 4). On the other hand, maximum increase in the acid value was up to 1.5 mg KOH/g for air-tight sample (Fig.3.). Over 12 months of storage, the increase in acid value was up to 14.0 mg KOH/g for Jatropha oil biodiesel sample exposed to air and 1.58 mg KOH/g for air-tight sample stored at 25°C (Fig.3,4). On the other hand, the samples that were stored at 35°C and exposed to air, the acid value after 6 months of storage was found to increase to 8.0 mg KOH/g; whereas, in sealed condition, the maximum increase was up to 5.6 mg KOH/g (Fig.2.3). In this case, also after 12 months of storage, the increase in acid value was up to 23.5 mg KOH/g for air-exposed sample. For the sealed sample, the maximum increase in acid value was up to 5.9 mg KOH/g (Fig.3,4). The results obtained showed that air exposure makes biodiesel more susceptible to degradation. When the stored Jatropha oil biodiesel samples were compared, the rate of degradation was found to be significantly less for the air-tight samples than that for the air-exposed samples.

Fig.5. represents the change in density of stored Jatropha oil biodiesel which was exposed to air for a period of 12 months. Density values were also found to follow the same pattern as the acid value of the stored Jatropha oil biodiesel sample. For all the samples, the density value was found to increase with increase in storage time. After 6 months of storage at 4°C, the density of the air-exposed sample was found to be increased from 0.85 (0 months) to 1.15 g/cm^3 (Fig.7) On the other hand, no significant change was observed in the density value of 0.85 to 0.87g/cm^3(0

months) for the samples stored in air-tight condition (Fig.6). After 12 months of storage, the density increased up to 0.96 kg/m^3 for samples that were exposed to air and reached a maximum of up to 0.96g/cm^3 for sealed samples (Fig.6, 7). The density values were found to be increased for the samples that were kept in exposure to ambient air than those for the samples in sealed condition for all storage temperatures considered in this study (4°C, 25°C, or 35°C). Results obtained showed that air exposure increases the methyl ester degradation over long storage period.

Fig. 8, 9 and 10 represent the change in kinematic viscosity of Jatropha oil biodiesel over 12 months period of storage. Kinematic viscosities of all samples were found to be increased with increase in storage period. When the kinematic viscosity of Jatropha oil biodiesel samples stored in exposure to air and air-tight condition were compared, a significant difference was observed. After 6 months of storage, for the Jatropha oil biodiesel samples that were kept at 4°C in exposure to air, the kinematic viscosity increased from 6.15×10^{-6} (initial value) to 6.9×10^{-6} m^2/s (Fig.8); whereas, in sealed condition, the value increased to a maximum of up to 7.2×10^{-6} m^2/s (Fig.9). After 12 months of storage, the increase in kinematic viscosity was up to 7.40×10^{-6} m^2/s for air-exposed sample, and for air-tight sample, the maximum increase was up to 7.5×10^{-6} m^2/s (Fig.9,10). For the samples that were kept at 25°C and 35°C in exposure to air, the kinematic viscosities after 6 months of storage were also found to be increased up to $9.0 \times 10^{-6}$and 1.05×10^{-5} m^2/s, respectively (Fig.10); whereas, in sealed condition, the maximum increase in kinematic viscosity was up to $7.9 \times 10^{-6}$and 8.3×10^{-6} m^2/s for the samples kept at 25°C and 35°C, respectively (Fig.9). Similarly, after 12 months of storage, the increase in the kinematic viscosity was found to be $9.0 \times 10^{-6}$and 1.08×10^{-5} m^2/s for samples kept in exposure to air at 25°C and 35°C, respectively (Fig.10). On the other hand, for the same sample kept in sealed condition, the increase in kinematic viscosity was up to 8.2×10^{-6} and 9.2×10^{-6} m^2/s at 25°C and 35°C, respectively (Fig.9). The result clearly revealed the detrimental effect of air exposure on the quality of Jatropha oil biodiesel over long storage period, which was also observed in long-storage stability of vegetable oil and used frying oil-based biodiesel[2]. From the above

discussion, it is clear that air exposure was one of the driving factors for worsening the quality of Jatropha biodiesel over long-term storage.

6.0 Conclusions

For successful commercialization of Jatropha oil biodiesel, maintaining the quality of biodiesel during storage period is of considerable significance. The study investigated experimentally the effect of storage parameters on Jatropha biodiesel stability. Results showed that Jatropha oil biodiesel quality deteriorates over long storage period. Increase in the value of qualitative parameters such as acidity, density, kinematic viscosity, proves that the process of degradation increases with the increase in storage period. Jatropha oil biodiesel deterioration was more pronounced at 35°C compared to 25°C and 4°C. The degradation levels of Jatropha oil biodiesel stored at 25°C and 4°C were of similar pattern and less than the biodiesel stored at 35°C. Increase in the acid value of biodiesel stored at 4°C (from 0.40 to 4.5 mg KOH/g) and 25°C (from 0.40 to 14.0 mg KOH/g) was found to be moderate, while increase in the acid value was abrupt for the sample stored at 35°C (from 0.40 to 23.5 mg KOH/g). This abrupt increase in the acid value was observed for the sample stored under conditions in which it was exposed to ambient air. The analysis of the other two parameters, the density and kinematic viscosity, also supports this finding. The maximum increase in density value was found to be from 0.85 to 1.30g/cm^3 in case of 4°C storage temperature, from 0.85 to 1.7g/cm^3 for 25°C, and for 35°C, it increased up to 2.3 g/cm^3 for the sample that was kept exposed to air. The kinematic viscosity of biodiesel kept exposed to air increased from 6.15×10^{-6} m^2/s to maximum of 1.50×10^{-5} m^2/s for sample stored at 35°C, and 1.15×10^{-5} m^2/s for sample stored at 25°C; whereas, in case of the sample stored at 4°C, it only increases slightly up to 8.25×10^{-6} m^2/s. Although light exposure did not show profound effect on biodiesel degradation, a significant difference was observed in degradation level between the Jatropha oil biodiesel kept in light and in dark. Comparing all the data obtained from the analysis, it can be concluded that among all storage parameters, high temperature and air exposure were the two strong factors in accelerating the Jatropha oil biodiesel degradation. Proper care should be taken for these parameters during storage; otherwise, Jatropha oil biodiesel may become unusable.

7.0. References

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