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Determination of Some Rheological Properties of Jatropha Curcas L. Seed OIL

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Abstract: *This research was carried out to investigate the rheological properties of Jatropha Curcas L. seed oil. The parameters studied were the dynamic viscosity of the oil and the shear stress at different shear rate and temperatures. The dynamic viscosity was measured to be 151.8cp to 98.8cp at 6rpm, 82.0cp to 51.9cp at 12rpm, 42.2cp to 22.9cp at 30rpm, and 25.3cp to 14.9cp at 60rpm all at varying temperatures of 30°C to 70°C using NDJ-S5 viscometer. The shear stresses obtained ranged from 91.8 N/m² to 59.28 (N/m²) at varying temperatures ranging from 30°C to 70°C at 10°C intervals, and were dependent on the shear rates. The results showed that viscosity decreased with an increase in temperature. Power law model was used to describe the viscosity to shear stress relationship and the flow b ehavior index (n) obtained which were closed to one indicated that Jatropha Curcas L. seed oil exhibited a Newtonian behavior. The results can be used to predict the design texture, storage and flow processes of Jatropha Curcas L. seed oil.*

1. Introduction

The name ''Jatropha'' was derived from Creek word jatro means physician and trophe means nutrition Brittania and Lutaladio, (2010). Jatropha Curcuas. L is also called Vomit nut, bubble bush, physic nut or purging nut Salawu *et al*., (2011), it has a high potential uses and thus, can generate income in rural areas of developing countries Isam *et al.,* (2011). Its yield per hectare is more than four times soya beans and ten times corn Sepidar, *et al*., (2009), Nobrega & Sinha, (2007). *Jatropha Curcas L* is known in Nigeria local languages as Olulu-idu for the Igbos, Lapa/zugu for the Hausa and Botuje for the Yorubas. *Jatropha Curcas L* has a very good quality feed stock for diesel production. The biodiesel produced from Jastropha oil meets the America and European diesel standard Makkar *et al*., (1998). Makkar and Becker, (1997) investigated that after extraction of oil from the seed the by-product which is called seed cake has high nutrition composition such as crude protein 55-63%,1-15% of lipid 8.1-9.1% of crude fiber. The seed cake has significant potential in biomass, biodiesel production, produces more energy on fermentation than cattle dung and also can be used as microbe's substrate to produce enzymes such as proteases and lipases Carels, (2009).

Jatropha fruit shell and seed husk can be used for direct combustion, the fruit shell can be dried and grinded to powder and formed into fuel briquettes. The left-over ash after the combustion process has high potassium which can be applied to crops Singh *et al*., (2008).

Heller, (1996; Nath and Dutta, (1992) investigation shows that *Jatropha Curcas L* has lots of medicinal benefits such that the seed oil can be applied to soothe rheumatics pain, paralysis and the latex is used for healing wounds and curing different skin diseases such as ringworms, eczema, derma mycosis, scabies, ulcers, remove pains and stings of bees and wasps, and sarcoptic manger in sheep and goats.

Openshaw, (2000); Messenmaker, (2008); Warra, (2010); shows that *Jatropha Curcas L* seed oil is used for cosmetics production, it has a viscous oil potential that is used for the production of soap he also investigated that the soap has medicinal characteristics and therefore used for the treatment of various skin affections.

Investigations has been carried out on the physical, chemical, physiological properties, and the by-products of Jastropha Curcas L, but there is silent in technical literature on the rheological properties of the oil extraction methods from *Jatropha Curcas L* seed. Therefore, objectives of the research work are to extract oil from *Jatropha Curcas L* seed using Soxhlet method, fitting the power law model using viscometer and to determine the dynamic viscosity of the oil. The knowledge of the property and flow behavior aids proper design of equipment for handling, transportation, storage, processing and quality assessment of its products.

2. Materials and Methods

2.1. Sample Preparation.

20g *Jatropha Curcas L* seed used in the work was purchased from Ti oluwa ni multipurpose farm Ibadan Oyo State Nigeria. The solvent used was n-hexane purchased from Yenagoa, Bayelsa State and was taken to the chemical engineering laboratories (Reaction engineering and kinetic laboratory and

Reservoir/production laboratory) faculty of engineering, Niger Delta University. The good and healthy seeds was manually selected from the damaged ones and the bad ones were discarded. The selected 20g of good seeds were cracked and shell was removed, the kernels were then dried at high temperature of 100°C to 105°C for 35minutes which ensures removal of moisture from the seed. The dried seeds plate 1 were grinded using a grinder to ensure free oil entrapped and the oil was extracted using a Soxhlet extraction method see plate 2. The oil retained in the sample flask was weighed using golden meter USA electronic balance see plate 3. The Extraction of oil from raw materials using Soxhlet extraction method as described by Akbar *et al.*, (2009). At the end of each experiment, the yield of the oil was obtained as the percentage of the extract from the seed using equation 1

$$\% \text{ oil yield} = \frac{\text{weight of oil extracted (g)}}{\text{weight of seed sample used (g)}} \times 100. \quad (1)$$

Plate.1: *Jatropha Curcas L.* Dry seed

Plate 2: Soxhlet apparatus

Plate 3: Golden meter USA electronic balance

2.2 Determination of Rheological Properties

The rheological properties of *Jatropha Curcas L.* seed oil were determined using NDJ-5S viscometer see plate. 4. The viscosity of the oil was measured with spindle number sp-4 at different shear rates of 6, 12, 30 and 60rpm and temperatures ranging from 30 to 70°C at 10°C intervals. The temperature of the oil was increased using Stuart water bath-RE300Bsee plate.5 and temperatures measured using laboratory thermometer. The shear stress was determined using the shear stress to shear rate relationship as represented in the equations 2.

$$\eta = \tau/\gamma \quad (2)$$

Where; η= Dynamic viscosity in (cP,) τ = shear stress (N/m^2); and, γ = shear rate (1/s).

Plate 4: NDJ-S5 Viscometer

Plate 5: Stuart water bath-RE300B

2.3 Power Law

The experimental data of viscosity of *Jatropha Curcas L.* seed oil were evaluated fitting the power law as shown in equation 3

$$\tau = k\gamma^n \quad (3)$$

Where;

k = consistency coefficient

n = the flow behaviour index

τ = shear stress

γ = shear rate (1/s).

For shear thinning (pseudoplastic) fluids n<1

For shear thickening fluids n> 1.

Newtonian fluids, n = 1 and k = μ

The flow behavior index and consistency coefficient was determined using the Microsoft Excel 2010.

3. Results and Discussion

3.1 Oil yield of Jatropha Curcas L. seed

The 20g of the *Jatropha Curcas L.* ground meal used for the extraction process yielded 78% oil. This means that *Jatropha Curcas L.* ground meal yielded 78% oil, using n-hexane as the solvent in the soxhlet extraction.

3.2 The Rheological Parameters

The result of the experiment showed the dependence of shear stress on shear rate, viscosity on temperature and shear stress on temperature. This is shown in figure 1, figure 2. Table 1 shows the experimental data for the viscosity of the experimented bio-oil at different temperatures and share rates

Table 1: The experimental data for the viscosity of *Jatropha Curcas L.* seed oil at varying temperatures and shear rates.

	Viscosity (cp)			
TEMPERATURE(^{0}C)	**6RPM**	**12RPM**	**30RPM**	**60RPM**
30	151.8	82.0	42.2	25.3
40	131.9	72.7	36.3	21.1
50	127.6	67.8	31.2	18.8
60	101.2	55.0	25.4	16.0
70	98.8	51.9	22.9	14.9

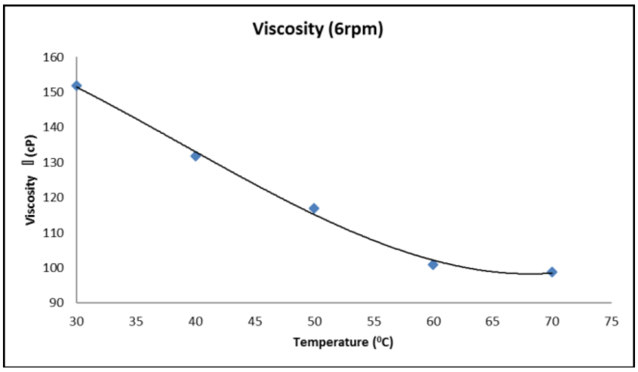

Figure 1: The shear stress of *Jatropha Curcas L.* seed oil as a function of temperature at 6rpm

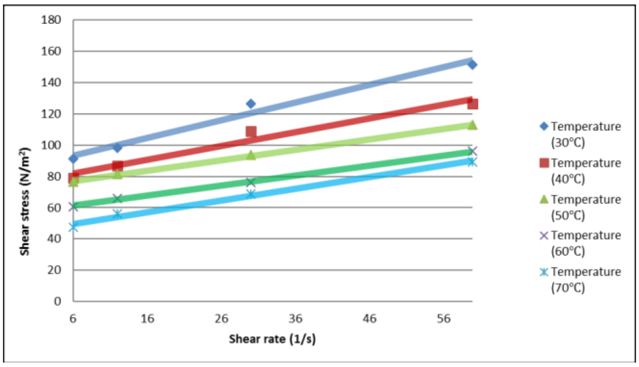

Figure 2: The shear stress of *Jatropha Curcas L.* seed oil as function of shear rate

From the results, it was observed that the dynamic viscosity of *Jatropha Curcas L.* seed oil decreased with increase in temperature. This trend is shown in figure 1 and 2 where the viscosity of *Jatropha Curcas L.* seed oil decreased with an increase in temperature at varying viscometer speed, this is in conformity with the study of Abdelraziq and Nierat, (2015); and Davies, (2016). This was due to the higher thermal movement among the oil molecules, reducing the intermolecular forces making the flow among them easier as the oil became lighter.

Figure 2 showed the dependence of shear stress of *Jatropha Curcas L.* seed oil on shear rate fitting the power law model, and the flow behavior index (n) values of the oil were between 1.10, 0.99, 0.96, 0.98, 0.97 at temperatures ranging from 30°C to 70°C which were very close to 1 and the consistency coefficient (K) values ranged from 0.86, 0.73, 0.57, to 0.45 for temperatures 30°C, 40°C, 50°C, 60°C, 70°C respectively. From the result, *Jatropha Curcas L.* seed oil showed a Newtonian behavior at temperatures ranging from 30°C to 70°C.

The results of shear stress of *Jatropha Curcas L.* seed oil in this research indicates that the shear stress of *Jatropha Curcas L.* seed oil decreases as a function of increase in temperature and shear rate. All plots of shear stress against shear rate have straight lines which indicate that *Jatropha Curcas L* seed oil is a Newtonian fluid.

4. Conclusion

This research was aimed at investigating the rheological properties of *Jatropha Curcas L.* seed oil. The oil was successfully extracted from *Jatropha Curcas L.* seed using soxhlet extraction method and the experimental investigations on the rheological properties of showed that it exhibited a Newtonian behavior at temperatures ranging from 30°C to 70°C and different shear rate. The viscosity of *Jatropha Curcas L*. seed oil was measured as a function of temperature and shear rate and viscosity decreased with increase in temperature and shear rate. The highest viscosity of *Jatropha Curcas L*. seed oil was observed at 30°C at 6rpm and the lowest was observed at 70°C at 60rpm. The shear stress to shear rate relationship was successfully used to determine the shear stress of *Jatropha Curcas L*. seed oil and the viscosity to shear rate relationship of the oil was successfully represented by the power law model. The flow behavior index, n and the consistency coefficient were also determined with the flow behavior index, n being less than one which indicated a Newtonian behavior. On the basis of observations and findings of this research, the following recommendations have been offered. Further research should be conducted on the rheological properties of *Jatropha Curcas L.* seed oil using different models to describe viscosity dependence on temperature, further research should be carried out to investigate other engineering properties of *Jatropha Curcas L*. seed oil to provide detailed information which will aid in the design of its processing, storage, and handling equipment and Viscosity of *Jatropha Curcas L.* seed oil should be investigated at lower temperatures to ascertain its behavior at lower temperatures.

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