AN EVALUATION OF YELLOW OLEANDER (THEVETIA PERUVIANA) SEED OIL AS A CUTTING LUBRICANT USING THE EXAMPLE OF MEDIUM CARBON STEEL FOR TURNING ON THE LATHE MACHINE

GUMA THOMAS NDYAR [1*], ALHASSAN ABDULLAHI [1]

[1] Department of Mechanical Engineering, Faculty of Engineering and Technology, Nigerian Defense Academy, P.M.B. 2109, Kaduna, Nigeria
* Correspondence: tnguma@nda.edu.ng

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Abstract: The yellow oleander (YO) is a notable plant of great technological importance. It grows naturally and is grown agriculturally widely and abundantly in Nigeria and many other countries around the globe. The potential of using pure oil extract from YO seed as a more environmentally friendly alternative cutting lubricant to the conventionally and widely used soluble oil was investigated in terms of some basic physicochemical properties, work cooling, and surface finishing performance using, for example, medium-carbon steel as the workpiece in turning on the lathe machine. The kinematic viscosities, pH values, unsaturated oleic acid contents, free fatty acid contents, flash points, pour points, and chloride contents, as well as the cooling and surface finishing capabilities of the steel by the two oils, were experimentally evaluated. The Soxhlet technique was used to extract the YO seed oil. The evaluated kinematic viscosity at 100 ºC, pH value, unsaturated oleic acid content, free fatty acid content, flash point, pour point, and chloride content of the YO seed oil through various ASTM and other standard methods were 21.13 cSt, 8.66, 31.23%, 0.91%, 191 ºC, 1 ºC, and 0.16%, respectively, while the respective values for soluble oil were 19.27 cSt, 6.51, 20.62%, 2.10%, 171 ºC, 3.18 ºC, and 0%. Comparative analyses of the YO seed oil and soluble oil values indicate a lower ability of YO seed oil to flow than soluble oil, an insignificant corrosivity difference between the two oils, better lubricity of YO seed oil than soluble oil, less tendency of YO seed oil to oxidize and become rancid than soluble oil, less proneness of YO seed oil to fire hazards than soluble oil, better suitability of YO seed oil for cold regions than soluble oil, and higher sterility and tendency towards increased emulsion life of YO seed oil. Turning experiments indicate that the two oils have similar cooling and surface finishing effects on medium-carbon steel. The overall information and analyses suggest that YO seed oil can be extracted sustainably in large quantities in many countries around the world, including Nigeria, and used effectively as a more environmentally friendly alternative lubricant to soluble oil in metal cutting operations such as turning medium-carbon steel on the lathe machine.

Keywords: medium carbon steel, lathe machine, cutting lubricants, YO seed oil, potentialities, soluble oil, comparative performances

* Corresponding author, email: tnguma@nda.edu.ng
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1. INTRODUCTION

Machining is a finishing manufacturing process that requires maximum efficiency and product quality at the lowest possible cost. Turning, drilling, milling, threading, reaming, grinding, etc., using cutting tools made of various materials such as alloy steel, carbon steel, aluminum, copper, bronze, cast iron, and brass necessitate the exploitation of various cutting fluids to achieve optimal productivity and product quality while minimizing environmental impacts. The machinability of a material decreases with an increase in its hardness and strength, so better cutting fluids are required when machining materials of higher hardness and strength. Carbon steel is the most commonly and widely machined material, but it is very hard and strong [1, 2, 3]. The hardness and strength of carbon steel increase with its carbon content at the expense of its machinability. Turning is the most common and versatile machining operation while carbon steel is the most common and versatile metal used in turning operations. Medium-carbon steel is stronger and more corrosion-resistant than low-carbon steel, so it is preferable to low-carbon steel in turning operations to produce critical parts such as gears, shafts, and fasteners like washers, bolts, nuts, studs, threaded rods, and stud bolts to the required accuracy specifications for various engineering applications [4-8].

The properties, actual performance, availability, and cost of a fluid are crucial for evaluating it as a lubricant. The choice and usage level of a fluid as a lubricant are essentially determined by its comparative level of service performance, meeting the required properties, and cost-effectiveness. No fluid has yet been developed with ideal properties to meet the needs of all-purpose lubrication for the diverse metal cutting operations, so there have been continued studies on developing better cutting fluids from the countless materials in existence and their levels of combinations for metal cutting under countless operations [6-9]. Various types of mineral oils and their formulations have been developed as lubricants with limited uses for cutting different metals under numerous conditions. Straight mineral oils and their formulations are the most commonly used cutting fluids because of their excellent job performance. However, rising environmental awareness, concerns about economic security, and more stringent regulations regarding mineral oils and their formulations have sparked renewed interest in natural oils as alternative lubricants. Research is now increasingly focusing on the use of plant extracts as alternative cutting fluids because they are generally rapidly biodegradable, renewable, inexpensive, typically environmentally friendly with minimal risk to personnel health, and excellent lubricants [8, 10, 11]. Some plant extracts are, however, of limited use for metal cutting lubrication because they can easily decompose and emit foul odors among other drawbacks [4, 9, 10]. Therefore, the development of cutting fluids from the widely available plant resources requires painstaking tests and engineering analyses to ensure that, in the first place, the fluids in pure or modified forms meet various physicochemical properties that include relative density, pH, flash point, pour point, percentage oleic acid content, percentage free fatty acid content, kinematic viscosity, sulfur content, color, and chloride content. Above all, a cutting fluid must be capable of cooling the cutting tool and workpiece as well as imparting a good surface finish to the workpiece [12-15].

A cutting fluid should have a low relative density to be able to diffuse more rapidly and penetrate better into the chip-tool interface. A cutting fluid should also have a neutral or near-neutral pH, a low chloride content, and a low sulfur content in order to prevent or minimize corrosion of machined parts caused by its interaction. Low kinematic viscosity is a desired attribute in any cutting fluid since it allows for increased flowability and faster chip and dirt settlement. The lubricity of a cutting fluid increases with its unsaturated oleic acid content, so a good cutting fluid must have a relatively high unsaturated oleic acid content. The lower the pour point of a cutting fluid, the better its ability to be used under various climatic conditions than a cutting fluid with a comparatively higher pour point. The original color of a cutting fluid determines its aesthetic value and deterioration level at any time, either during storage or usage, by observing the level of its changes. A cutting fluid should contain low fatty acids to not quickly oxidize and spoil, both in use and in storage, for its long life, and it should be non-toxic or non-hazardous and odorless to personnel. Such fluid should also have a high flash so that it is not easily flammable or smoky, does not foam easily, is chemically stable or inert by not adversely reacting with the work material, and is free from undesirable odor [6, 7, 10, 13, 14].

The YO plant grows naturally abundantly and can be grown agriculturally abundantly in Nigeria and many other parts of the world [15-17]. The use and importance of the YO plant have fundamentally revolved around clinical, toxicological, and pharmacological dimensions. The YO seed is known to be relatively biodegradable. The oil extracted from the seed has been under study for over ten years now for various uses in engineering, such as an environmentally friendly bio-diesel alternative to petroleum diesel, which has adverse environmental effects [18-21]. Guma and Alhassan [22] investigated the potential of using pure YO seed oil as a metal cutting bio-lubricant or for developing metal cutting lubricants through analyses of its acid value, iodine value, saponification value, peroxide value, refractive index, and percentage foam capacity relative to the commonly and widely used soluble oil. The purpose of this study was to further explore the potential of using the YO seed oil to replace soluble oil as the commonly and widely used cutting lubricant through comparative analyses of their kinematic viscosities, pH values, unsaturated oleic acid contents, free fatty acid contents, flash points, pour points, and chloride contents, as well as the cooling and surface finishing effects of the two oils in actual turning on the lathe machine using, for example, medium-carbon steel as the workpiece.

2. MATERIALS AND METHODS

2.1. Materials and facilities

YO seeds, N-hexane, ethanol, a commercially available soluble oil as a standard conventional cutting fluid purchased for usage at the Mechanical Engineering Workshop, Nigerian Defense Academy, Kaduna, and medium carbon steel were utilized in the research.

The facilities used for the research were: a weighing balance with a sensitivity of 0.001 g, infrared thermometers, beakers, spatula, cooling bath, round bottom flasks, water bath, heating mantle, Soxhlet extractor, extraction thimble, 3510 Jen Way pH meter, Brookfield DVE viscometer, MY-64 multimeter, HACH DREL/2400 UV spectrometer, GCMS-QP2010 PLUS SHIMADZU gas chromatograph mass spectrometer, Pensky-Martens flash point tester, Phenom ProX scanning electron microscope/EDS elemental analyzer, X-ray fluorescence analyzer, tintometer, 181059 Model F (U.K), CVR 135 surface roughness tester, ARL QUANT'X EDXRF analyzer, and the Centre lathe machine.

2.2. Methods

2.2.1. Extraction of the YO seed oil

Ripe YO fruits were hand-picked near Nuhu Bamalli Polytechnic and Barewa College in Zaria, Kaduna State, Nigeria. After drying the fruits, the seeds were removed from them by hand. The fruit seeds were then ground with a grinding stone to a flowable paste. The produced seed paste (sample) was placed in the extraction thimble of the Soxhlet extractor, and the equipment's parts, the extractor, condenser, and flask, were assembled. Oil was extracted from the paste (sample) using petroleum ether as the solvent. A filter paper was folded into a thimble for the extraction thimble. After inserting the paper into the inlet point of the Soxhlet extractor thimble, 250 ml of petroleum ether was added to the paste (sample) through the paper thimble using a glass container. The extractor assembly was then heated by turning on its heating mantel. From the water inlet of the extractor, water was permitted to flow continuously into the device's condenser. In the condenser, the vapor was gradually cooled and collected in the thimble. The extraction process continued and was complete when the color of the condensed solvent changed from its original form to a consistently unique color. The YO seed oil extraction was carried out at NARICT, a chemical research institute in Zaria, Nigeria. The Soxhlet extraction method was used because it could yield better YO seed oil at a faster rate and was more cost-affordable than other commonly available extraction techniques in Nigeria [20, 22, 23]. Figure 1 depicts schematically the process view of extracting YO seed oil using the Soxhlet extractor.

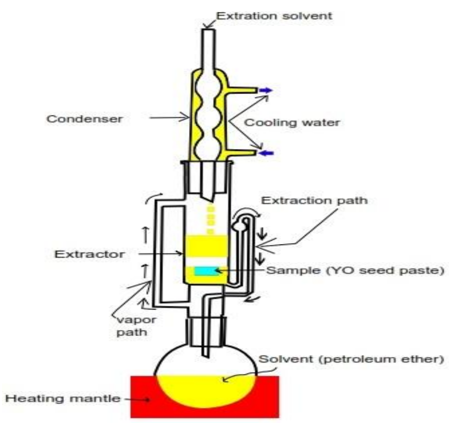

Fig. 1. A view of the YO seed oil extraction process using the Soxhlet extractor.

2.2.2. Determining the chemical compositions of the YO seed oil and the acquired steel

The chemical composition of the extracted YO seed oil was determined using an X-ray fluorescence analyzer at the National Steel and Raw Material Exploration Agency, Kaduna, Nigeria. while that of the acquired medium carbon steel for the study was determined using the Phenom ProX scanning electron microscope/EDS elemental analyzer at Umaru Musa Yar'adua University, Katsina, Nigeria.

2.2.3. Basic physicochemical properties of the study oils

The density of oil was determined at NARICT by pouring its sample of mass (m_o) kilograms into a volume-graduated standard laboratory glass beaker to a volume level of (v_o) cubic meters. After that, the density of the oil sample (ρ_o) was calculated using the equation (1) according to FSSAI [24].

$$\rho_o = \frac{m_o}{v_o} \quad (1)$$

Where, m_o was the determined mass difference between the empty beaker and its content with a given oil sample type using the precision weighing balance.

The specific gravity (ρ_{sp}) of the oil was calculated from the relation given by equation (2) [24].

$$\rho_{sp} = \frac{\rho_o}{\rho_w} \quad (2)$$

where ρ_o was the density of the oil, and ρ_w was the density of water in the same unit.

A DVE Brookfield viscometer at NARICT was used to determine the kinematic viscosities of the YO seed oil and soluble at 100 ^oC in accordance with the ASTM D44-96 standard protocol. The components of the viscometer were properly connected. After that, the viscometer was attached to its power source. On the viscometer panel, a spindle and its rotating speed were chosen. In a 500 mL beaker accessory of the viscometer, the oil whose kinematic viscosity was to be measured had been gradually heated to 100^oC and held at that temperature. The chosen viscometer spindle was immersed in the oil sample in the beaker. The spindle was started by turning on the viscometer's power switch, which turned on the spindle motor. The kinematic viscosity of the oil was related to the torque produced by the spindle rotation in the oil [25]. This torque was electronically detected and exhibited as a direct, steady reading representation of the oil's viscosity level. New spindle and speed were chosen when there was no visible kinematic viscosity reading display. This method was continued until the viscosity of the YO seed oil and soluble oil was determined using the greatest spindle size and rotational speed of 100 rpm. On the viscometer, the acquired kinematic viscosity value was indicated in centipoises (cP). This was recorded and converted to centistokes (cSt) by dividing the centipoises by the relative density of the oil in line with [25].

The ASTM D93-94 standard protocol for measuring oil flash points was used to determine the flash point of each oil type using a Pensey Marten flash point tester at NARICT [24]. A sample of the test oil was heated electrically in an open steel container at a steady and gradual temperature incremental rate while occasionally running a flame across the container's surface using this approach and the flash point tester. The flash point of the oil is defined as the temperature at which vapor produced from the oil causes a momentary igniting of the flame.

The 3510 Jen Way pH meter was used at NARICT to determine the pH of an oil. The meter's electrode was immersed in the oil in a laboratory glass beaker after calibration, and the oil's pH indication was read immediately on the meter scale.

Using a spatula and a weighing scale, the weight of free fatty acids was determined at NARICT in line with British Norm Institute Standard No. 684-2.42 (1989). In a 250 mL conical flask, 1 g of oil was weighed. 2 drops of phenolphthalein indicator were added to 25ml of methanol. A 0.1 M NaOH solution was added to the mixture and titrated until a light pink color was seen for about a minute. The end point was marked on the map. Equation 3 was used in accordance with FSSAI [24] to calculate the fatty acid weight.

$$\mathrm{FFAW} = \frac{28.2 M_b}{w} \quad (3)$$

where M_b denoted the base's mole and w denoted the base's weight (NaOH).

The ASTM D97 standard test procedure for establishing the pour points of crude oils was used to determine the pour points of the oils [24]. Similar samples of the YO seed oil and soluble oil contained separately in similar glass tubes were cooled from ambient temperature to roughly 6 ºC in a cooling bath equipped with a temperature-monitoring facility. For every 1 ºC further cooling, the tubes were taken from the bath and tilted horizontally for 5 seconds to see if the oils flowed or not. The lowest temperature at which an oil sample flowed under the horizontal tilt was taken as the pour point of the oil. The test was conducted at NARICT.

Active sulfur and chlorine weight contents were determined using average results obtained with the help of X-ray fluorescence analysis in accordance with Guma & Abubakar [26], and also by measurements with the HACH DREL/2400 UV spectrometer, at the National Steel and Raw Material Exploration Agency, Kaduna, Nigeria.

The oleic acid contents of YO seed oil and soluble oil were evaluated at NARICT, using the GCMS-QP2010 PLUS SHIMADZU gas chromatograph mass spectrometer. The spectrometer was calibrated according to its manual, and a 3 mL sample of provided oil was automatically injected into its column via its injection port at a flow rate of 1.2 mL/min, at a pressure of 750 kPa, and at a temperature of 250 ºC, for 10 minutes. The chromatograph's inbuilt software automatically captured and evaluated peak regions. The software assessed the oleic acid concentration of the oil based on the sample's peaks from its retention durations in comparison to the software standard for oleic acid. The percentage of oleic acid content in the oil was automatically displayed on the chromatograph's panel.

The color of the oils was determined at NARICT at an ambient laboratory temperature of 30 °C using the Lovibond tintometer 181059 Model F (U.K.) and glass cells of sizes 10, 20, and 50 mm by performing the appropriate probable match among the tintometer's standard color slides, all in accordance with AOCS official method Cc 13b 45 (97) and as used by Jabir et al [27].

2.2.4. Evaluation of turning performances with YO seed oil and soluble oil

Turning operations of a procured AISI 1040 medium carbon steel were performed on a center lathe using five different spindle speeds of 108, 140, 190, 260, and 360 rpm and feed rates of 1, 1.5, 2, 2.5, and 3 rpm, respectively, at the same cut depths of 0.5mm with YO seed oil as the cutting lubricant and similarly repeated with soluble oil. The oils were similarly applied to the cutting point during the turning process by holding the oil in a 1.5-liter plastic container and allowing the oil to pour continuously onto the cutting point through a 3-mm perforated hole at the bottom of the container. An infrared thermometer was used to measure the temperature of the steel at its interface with the cutting tool while the turning operation was being conducted. Three temperature readings were obtained for each cutting speed, and their average was determined and recorded as the interface temperature. After about a five-minute cycle of each machining at different given conditions, the roughness of the machined steel surface was measured at five different points on the surface using the CVR 135 surface roughness tester. The five readings in each case were averaged and recorded. The experiments were conducted at the Department of Mechanical Engineering's production workshop at the Nigerian Defense Academy in Kaduna, Nigeria, which had all of the necessary equipment. Figure 2 shows a view of some of the medium carbon steel samples produced by turning operations on the lathe machine at various cutting conditions, while Figure 3 is a side view of the CRV 135 surface roughness tester that was used to measure the surface finishes of the steel samples.

Fig. 2. Some of the produced medium-carbon steel samples at various turning conditions and their sequentially labelled identification marks.

Fig. 3. A side view of the CRV 135 surface roughness tester used to measure the surface finishes of the produced steel samples.

3. RESULTS AND DISCUSSION

3.1. Results

The XRF-analyzed chemical composition of the YO seed oil is presented in Table 1. The evaluated physicochemical properties of the extracted YO seed oil and soluble oil are presented in Table 2. Results of the determined average surface temperatures at the interface of the medium carbon steel and the cutting tool during experimental turning of the steel are presented in Table 3. The average surface roughness values of produced work-pieces at different cutting conditions in turning medium carbon steel with YO seed oil and soluble oil as cutting lubricants are presented in Table 4.

Table 1. The XRF-determined elemental compositions of the extracted YO seed oil.

S/No.	Element	Concentration (%)	Peak(cps/ma)	Background(cps/ma)
1.	Fe	0.000371	6	13
2.	Cu	0.000069	3	19
3.	Ni	0	0	16
4.	Zn	0.000743	54	25
5.	Al	0.02776	794	1651
6.	Mg	0.1051	102	199
7.	S	0.03650	611	1921
8.	P	0.00302	40	1881
9.	Ca	0.01745	99	4
10.	K	0.00125	6	11
11.	Mn	0	0	446
12	Rb	0.000058	0	2
13.	Sr	0	0	3
14.	Br	0	0	2
15.	Cl	0.00064	1	11
16.	V	9.000000e-07	0	38
17.	Cr	0.00016	3	135
18.	Na	0	0	34

Table 2. Determined physicochemical properties of YO seed oil and soluble oil.

S/No.	Parameter	YO oil	Soluble oil
1	Relative density	1.820	0.847
2	Ph	8.66	6.51
3	Flash point	191ºC	171ºC
4	Pour Point	-1ºC	3.10ºC
5	Oleic acid content (%)	31.23	20.62
6	Free fatty acid content (%)	0.910	2.10

7	Kinematic viscosity at 100ºC	21.13 Cst	19.27 Cst
8	Sulfur content by weight	0.013	1.001
9	Color	Golden	Reddish brown
10	Chlorine content by weight (%0	0.16%	Nil

Table 3. Average attendant tool work-piece interface temperatures measurements during turning of medium carbon steel with YO seed oil and soluble oil as cutting lubricants.

S/No.	Cutting speed (rpm)	Feed rate (mm/rev)	Average temperature (ºC) with YO seed oil	Average temperature (ºC) with soluble oil
1	108	1.00	35.7	35.5
2	140	1.50	35.7	35.6
3	190	2.00	35.8	35.8
4	260	2.50	36.1	36.0
5	360	3.00	36.7	36.4

Table 4. Surface roughness of the test medium carbon steel after various the turning conditions.

S/No.	Cutting Speed (rpm)	Surface Roughness (μm) with	
		YO seed oil	Soluble oil
1.	108	3.23	3.50
2.	140	3.06	3.34
3.	190	2.47	2.94
4.	260	1.91	1.87
5.	360	2.46	2.35

3.2. Discussion

Table 1 demonstrates that YO seed oil has a mixture of inorganic and metallic elements but no corrosion-causing chemical compounds. This is because the absence of elements such as carbon, hydrogen, oxygen, and nitrogen in the composition of the YO seed oil signifies the absence of water, NOx gases, nitric acid, CO, CO_2, and carbonic acid in the oil, all of which are well-known corrosive chemicals to steel and other oil-related materials. The only elements in the oil that can affect its corrosivity are chlorine and sulfur, but even then, the effects of these elements on the oil's corrosivity level are negligibly small, as evidenced by the extremely minute contents of 0.00064 % and 0.0365 % by weight of the elements in the oil, respectively, as shown in Table 1. This is due to the absence of SOx gases and sulfuric acid, hydrogen sulfide, and chlorides or hydrochloric acid, all of which are known to be corrosive to most metals in oil [26]. As a result, the oil's composition indicates that it is potent and not corrosion-causative.

The determined viscosity of the YO oil was 21.13 cSt, which is greater than the value of 19.27 cSt for soluble oil, as shown in Table 2. The resulting relative density value of 1.82 for YO oil is larger than the 0.847-value for soluble oil, as shown in Table 2. These characteristics indicate that the flowability of YO seed oil in use as a cutting lubricant may be lower than that of soluble oil. This agrees with Shah [28] and Guma et al [29], that the less violent and dense a liquid medium is, the better its capacity to flow.

Table 2 shows that the pH of the YO oil was 8.66, which is slightly alkaline compared to the slightly acidic pH value of 6.51 for soluble oil. Generally, it is known that steel can corrode appreciably in acid media [29]. However, it can be seen from these results that the deviations of the pH values from the neutral pH value of 7 are 0.49 for soluble oil on the acidic side and 1.66 for the YO seed oil on the alkaline side. It is inferred from these deviations that there is no substantial difference in corrosivity between YO seed oil and soluble oil in their service uses as lubricants.

From Table 2, it is noticeable that oleic acid, which is an unsaturated acid, constitutes 31.23 % by weight of YO seed oil and is the major component of the oil. This gives the YO oil a greater lubricity advantage over soluble oil, which has a lower oleic acid content of 20.62 %. According to Bouchet et al. [30], the higher level of unsaturated acid content of oil enables its easier reaction to form a film adherent layer which adheres to the surface of the metal to prevent direct metal-to-metal contact.

The greater the free fatty acid content in a cutting oil, the more susceptible it is to oxidation and rancidity [24]. Table 2 shows that the YO oil has a free fatty content of 0.910 %, which is lower than the soluble oil's value of

2.10 %. This suggests that YO seed oil may have a longer storage life than soluble oil since it is less likely to go rancid.

Table 2 demonstrates that the soluble oil has a flash point of 171 ^oC, while the YO seed oil has a flash point of 191^oC. This shows that YO seed oil is less prone to fire hazard than soluble oil, according to Guma et al [29]. Because YO seed oil has a higher flash point than soluble oil, it can be a better lubricant in higher temperature metal cutting situations than soluble oil.

The pour point of YO seed oil is -1°C as can be seen in Table 2. This appears to make it more suitable for use in a wider range of climatic conditions than soluble oil, which has a pour point of 3.10 ^oC as shown in Table 2.

Table 2 shows that the YO seed oil had a chlorine content of 0.16 % by weight when compared to a soluble oil with no chlorine content. In small concentrations, chlorine can function as an antibacterial and extend the life of an oil emulsion, but it can also suggest the existence of chlorides or hydrochloric acid, both of which are known to be corrosive to most metals when present in moderate proportions [26]. However, the 0.16%-quantity appears to be insufficient to affect the corrosivity of YO seed oil.

The color of cutting oil is significant for determining how much it has deteriorated in storage or use compared to its initial quality color. Cutting oils with the same color after a long shelf life or after use, are better than those whose color changes according to Japir et al [27]. Table 2 shows that the soluble oil has a reddish-brown color in its original form, whereas the YO seed oil has a golden or yellowish orange color in its natural form.

Table 2 shows that YO seed oil has a very low sulfur content of 0.013 % by weight when compared to soluble oil, which has a sulfur content value of 1.001 %. Because of the increasing corrosivity levels that are known to be connected with the increasing concentrations of sulfuric gases and acid, the lower sulfur content in YO oil is a benefit for the oil over soluble oil [26].

Table 3 shows that the average attendant cutting temperature attained while turning medium carbon steel on the lathe machine with YO seed oil as a cutting lubricant was 35.7 ^oC at 108 rpm-spindle speed, 1mm-feed rate, and 0.5mm-cut depth, and the value for soluble oil was 35.5 ^oC. The attendant cutting temperature results for the YO seed oil and soluble oil were 35.7 ^oC and 35.6 ^oC, respectively, at 140 -rpm spindle speed, 1.5 mm/rev-feed rate, and 0.5 mm-cut depth. The pattern of more-or-less performances of the two oils appears to be the same even at higher spindle speeds and feed rates for the same depth of cut as can be observed in Table 3. Based on these findings, the YO oil can be compared to soluble oil as a cutting lubricant in terms of ability to conduct heat away from the cutting zone when turning medium carbon steel on the lathe.

Table 3 shows that at 108-rpm turning speed, 1-mm feed rate, and 0.5 -mm depth of cut, the surface roughness created in turning the test steel with YO seed oil as a lubricant was 3.23 µm, while the result with soluble oil was 3.50 µm; at 140 -rpm turning speed, 1.5 -mm feed rate, and 0.5 -mm cut depth, the surface finish results with lubrication by the oils were 3.06 µm and 3.34 µm, respectively. The best surface finish in turning the steel under YO seed oil lubrication was 1.91 µm, which was achieved at 260 rpm. These data imply that YO seed oil can also measurably, in comparison with soluble oil, improve the surface finishing quality of medium carbon steel in turning processes.

4. CONCLUSIONS

An evaluation of Yellow Oleander (YO) seed oil as a cutting lubricant relative to conventional soluble oil in terms of basic physicochemical properties, work cooling, and surface finishing performance using the example of a medium-carbon steel (AISI 1040) workpiece for turning on the lathe machine has been detailed. Analyses of test results reveal that YO seed can have an edge over soluble oil in lubricity, pouring point, corrosion prevention, flash point, atmospheric stability, and perennial storability without going rancid, but it can be less able to flow than soluble oil when used as a cutting lubricant. Moreover, YO seed oil can have comparable cooling and surface-finishing effects to soluble oil in turning steel materials. The study further indicates that YO seed oil can be sustainably extracted in large quantities in many countries across the world, including Nigeria, where the YO plant grows abundantly naturally, and can also be grown agriculturally in large quantities utilizing low-cost extraction technologies.

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