INVESTIGATION OF PHYSICOCHEMICAL PROPERTIES OF OIL BLENDS OF CITRULLUS LANATUS (MELON SEED) AND ARACHIS HYPOGEA (GROUNDNUT) FOR MACHINE OPERATIONS

[1]Sadiq Sius Lawal, [2]Mohammed Mustapha, [3]R.I. Olalekan, [4]Alkali Babawuya
[1,2,3]Department of Mechanical Engineering, Federal University of Technology Minna, Niger State
[4]Department of Mechatronics Engineering, Federal University of Technology Minna, Niger State
Corresponding E-mail: sadiq.lawal@futminna.edu.ng+2348054197676 and 07064358815

Abstract

This work focuses on the physicochemical properties of blended vegetable oil (a case study of melon seed oil and groundnut oil) and it applications as cutting fluid. The oils were blended at ratios 20:80, 40:60, 60:40, and 80:20 to obtain a suitable blending ratio. Citrullus Lanatus (melon seed) oil was blended with Arachis hypogea (groundnut) oil in different ratios stated above in order to study both the chemical and physical properties of the oil respectively. The physical properties were pour point, flash point, density, thermal stability, cloud point, specific gravity and viscosity while the chemical properties were, saponification value, acid value, iodine value and Hydrogen Peroxide value. The results obtained show that the blended vegetable oils can be used as cutting fluid in machining and other engineering operations.

Keywords: Melon seed oil, groundnut oil, Oil blends, Physiochemical, properties.

1.0 INTRODUCTION

The effectiveness of mineral oil based stock have been questioned lately due to the several negative effects they have caused in the environment and to workers' health (Norby, 2003). When inappropriately discharged, it's likely to cause damage to soil and water resources resulting to serious environmental disaster. One of the most popular vegetable crops grown in Africa is Melon botanically called Citrullus vulgaris or lanatus. It belongs to the cucumber family, from which oil can be extracted and is popularly called "Egusi" a name widely used throughout Nigeria and other West Africa. The crop grows on a sandy free draining soil and can be planted as an intercrop with maize, okra and cassava or yam because of its ability to suppress weed. It is often harvested between two and half to three months and with good management, there can be up to 350-400 kg per hectare as the seeds yielding. Analysis made on melon seed indicated that melon seed consist about 50% oil by weight, 37.4% of protein, 2.6% fibre, 3.6% ash and 6.4% moisture content of the seed, 50% is made of unsaturated fatty acids, which are Linoleic (35%) and oleic (15%) and 50% saturated fatty acids, which are stearic and palmitic acids. The presence of unsaturated fatty acid makes melon nutritionally desirable and suggests a possible hypo cholestroleric effect (lowering of blood cholesterol). Melon has an amino acid profile that compares favourably with that of soya beans as reported by Akoh and Nwosu,1920. Also melon is rich source of Sodium (Na), Iron (Fe), Manganese (Mn), Copper (cu), Zinc (Zn) and fat. The nutritional value for melon per 100g are : Carbohydrate - 7.6g, Dietary fibre - 0.4g, Fat - 0.2g, Protein - 0.6g, and Vitamin C - 8mg. The oil extracted from it can be used in manufacturing of margarine, shortening and cooking oils, while the residual cake is a useful source of protein for livestock feed. The three categories in base oils are mineral oils, synthetic oils and vegetable oils. Traditionally, it was reported by Yunus, et al, 2006 that over 85% of base oils are refined from crude petroleum.

Groundnut oil on the other hand has sweet and flavourful edible oil. It is also called peanut oil or arachis oil and is extracted from Arachis hypogea with a mild-tasting vegetable oil derived from peanuts. The oil is available with a strong groundnut flavor and aroma, analogous to sesame oil. It is often used in Chinese, South Asian and Southeast Asian cuisine, both for general cooking, and in the case of roasted oil, for added flavor. Groundnut oil has a high smoke point relative to many other cooking oils, so is commonly used for frying foods. Its major component fatty acids are oleic acid (46.8% as olein), linoleic acid (33.4% as linolein), and palmitic acid (10.0% as palmitin). The oil also contains some stearic acid, arachidic acid, behenic acid, lignoceric acid and other fatty acids. Antioxidants such as vitamin E are sometimes added to improve the shelf life of the oil.

1.1 Uses of Groundnut Oil (Arachis hypogea oil)

Groundnut oil is the oil from the seed, also called the nut, of the peanut plant. Groundnut oil is used to make medicine. It is used to make so many of everyday house-hold products that includes; cosmetics, food, medicine, fuel, and industrial products.

2.0 MATERIALS AND METHODS

The major raw material in this work is Citrullus Lanatus oil (melon seed oil) and Arachis hypogea oil (groundnut oil) which were extracted from their seeds through the use of oil extracting machine (seed oil expeller) carried out in the Agricultural and Bio-resources Engineering laboratory of the Federal University of Technology, Minna, Niger State. These oils can also be extracted through the local or traditional method of heating the grinded seed. The oils were extracted using a seed oil expeller to prevent pre-heating of the oils which they experience while making use of the local or traditional method. The seeds were purchased in a local market in Minna, Niger State. Analytically graded reagents like Sodium hydroxide and Methanol (99 % purity, 78.1 °C) was used in the study.

2.1 Determination of Acidic value

A neutral solvent was prepared by mixing petroleum ether and methanol. A quantity of about 1grams of the oil was measured and placed in a beaker on which 5ml of the neutral solvent was added. The mixture was thoroughly stirred for about 30 minutes while 0.56grams of sodium hydroxide pellet was measured and used to prepare 0.1M NaOH. Some 4 drops of Phenolphthalein indicator was added to the oil/neutral solvent in the beaker and titrated against 0.1 M NaOH until end point was reached (ASTM D 664). The acid value was calculated from the relation:

$$\text{Acid value (mgNaOH/g)} = \frac{56.11 \times V \times N}{W} \qquad 1$$

Where V is volume of standard alkali (NaOH) in ml, N is normality of standard alkali used and W is weight of oil used in grams.

2.2 Determination of Free Fatty Acid (FFA) value

According to Gregory (2005), the acid value obtained was subsequently used to determine the free fatty acid and this was defined as:

$$\text{Acid value} = \text{free fatty acid}/\ 2 \quad (2)$$

Therefore,

$$\text{Free Fatty Acid value}\left(\frac{\text{mgNaOH}}{\text{g}}\right)\ \text{Acid value} \times 2 \quad (3)$$

2.3 Determination of Specific gravity

Following the ASTM D1298 method, Volume of oil is assumed to be 25ml.Weight of empty bottle is 22.712 and weight of bottle + water is 43.485. The empty calibrated bottle was filled with blended vegetable oil and reweighed; Specific gravity was calculated using the relation:

$$\text{Specific Gravity} = \frac{\text{Weight of Xml of Oil}}{\text{Weight of Xml of Water}} \quad (4)$$

2.4 Determination of Density

The density of a substance is defined as the ratio of the mass of the substance to unit volume of that substance. Density could also be described as volumetric weight of a substance and it describes the weight of the substance as given below.

$$\text{Density} = \frac{\text{Weight of substance}}{\text{Volume of substance}}\ (\text{g/ml}) \quad (5)$$

2.5 Determination of Viscosity at 40 ^{0}C to 120 °C

The viscosity of the blended oil sample was determined using an empty bottle on a viscometer. The samples of the blended oil as carried out by Giwa et al, 2013 were raised to a temperature of 40 °C and 120 ^{0}C respectively. The viscometer was calibrated 1cm apart while the oil sample was then poured into the viscometer. At the time which the oil starts dropping into the beaker or conical flask the stop watch is started. The time, at which a specific distance of about 1cm is attained, the stop watch is stop and the time interval is taken or recorded. The procedure was repeated for about two to three times and the average value was taken (ASTM D-445).

The Kinematic viscosity was calculated from this relation:

$$V = C \times t \quad (6)$$

Where V is Kinematic viscosity (mm^2/s), t is Mean flow time (s) and C is Calibration constant of the viscosity (mm^2/s)/s.

2.6 Iodine value Determination:

The Blended oil sample was poured into beaker along with 1grams of the oil poured into a glass-stopper bottle of about 250ml capacities. A sample Carbon tetrachloride (10ml) was then added to the oil to dissolve. Subsequently, 20ml of solution was added and allowed to stay in the dark for 30 minutes. Nearly 15 ml of potassium iodide solution (KI) with 10 percentage by Weight and 100 ml of water was introduced and the mixture thoroughly mixed. The mixture was titrated with 0.1 M sodium thiosulphate solution (Na_2SO_3) using starch as indicator .A blank is carried out at the same time starting with 10 ml of carbon tetrachloride.

$$\text{Iodine value} = \frac{(Vb-Va) \times 1.269}{\text{Weight of egusi melon oil sample}} \qquad 7$$

2.7 Determination of Pour point:

The pour point is a main feature of low-temperature interactions. It is a pointer of the fluid's capability to flow at colder operational temperature. Pour point is the lowest temperature at which fluid will flow when damped below approved conditions. This temperature is known as pour point (PP) and is described as the lowest temperature at which progress of the specimen is observed. Pour point values have conventionally been determined when the sample no longer shifts on tilting the tube enclosing the sample (pour point). Pour point less than 0^0C are regarded to below (Arbain and Salimon 2009).

2.8 Determination of Flash point:

The flash point is the lowest temperature at which a liquid generates adequate concentration of vapour beyond where it will develop a flammable mixture with air. Most vegetable oils with a low flash point are greater fire hazard. The flash point is adequately great to tolerate reliable process and lower volatilization at the highest operating temperature. For the highly challenging operations, which include aviation jet engine fuel, an efficient liquid extent greater than 300°C might be essential (Gerpen and Shanks, 2004). The lesser the flash point, the comfortable it is to kindle the material. It is very important to test the flash point of the oil to be used as fuel.

2.9 Determination of saponification value

A gram of the oil was weighed into a flask. Twenty five cm^3 of 0.1M alcoholic sodium hydroxide solution was added into the flask. A reflux condenser was attached and the flask was heated on a water bath for one hour while constantly shaking it. At the end of 1 hour,the flask was removed from the water bath and 1 cm^3 of about 1% phenolphthalein indicator was added. It was then titrated with the standard 0.5M hydrochloric acid.

$$\text{Saponification value} = \frac{(Vb-Va) \times 26.05}{\text{Weight of oil}} (mgKOH/g) \qquad 8$$

8

Where Va is sample titre value (cm^3), and Vb is blank titre value (cm^3), AOAC, (1990).

2.10 Determination of Peroxide Value

About a gram of the oil was weighed into a clean dry boiling tube and 1g of powdered potassium iodide and 10cm^3 of the solvent mixture were added. The mixture was allowed to boil vigorously for 30 seconds. The tube was washed twice with 25cm^3 portions of water and the washings were added to the titration flask. With 0.002M sodium thiosulphate using starch indicator, the mixture was titrated.

The relation for peroxide value is given as;

$$\text{Peroxide value} = \frac{(\text{Vb}-\text{Va}) \times \text{molarity of titrant}}{\text{Weight of oil}} (\text{mgKOH/g}) \qquad 9$$

Where;
Va = sample titre value (cm^3),
Vb = blank titre value (cm^3)

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2.11 Cloud Point

Cloud Point of oil is the temperature at which the oil begins to cloud and no longer gets completely soluble so as to determine its physical resistance towards lower temperature. Cloud point is very useful in identifying the minimum temperature of oil storage (Roiaini et al,2014).

2.12 Determination of thermal stability:

The thermal stability of the blended oil was determined in accordance to the American Society of Testing Materials (ASTM).The thermal stability was determined by dipping 40ml stainless steel viscometer rotor in a beaker containing the heated blend oil and the rotor was set to a revolution of 60rpm.

3.0 Results and Discussion

3.1 Presentation of Results

Table 1: The table below shows the properties obtained for the various percentage oil blends

PROPERTIES PERCENTAGE OIL BLENDS				
	20:80	**40:60**	**60:40**	**80:20**
Acid value (mgNaOH/g)	1.122	2.244	2.806	3.367
Free Fatty Acid (mgNaOH/g)	2.244	4.488	5.612	6.734
Specific gravity(g)	41.150	41.376	41.438	41.575
Density (g/mL)	1.646	1.655	1.658	1.663

Viscosity 40⁰C	23.30	21.40	18.40	16.30
Viscosity 120⁰C	5.30	4.50	3.90	3.60
Iodine value (mgKOH/g)	192	119	139	117
Pour point (⁰C)	-1	-2	-3	-4
Cloud point (⁰C)	14	13	13	9
Flash point (⁰C)	174	168	192	204
Saponification value(mgKOH/g)	121	107	118	177
Hydrogen peroxide (mgKOH/g)	3.98	4.29	4.17	4.49

3.2 Discussion

Based on the analysis obtained, the physiochemical properties of oil 60%:40% provides a suitable results for use as a cutting fluid in machining operations with the following results: acidic value (2.806mgNaOH/g), free acid value (5.612mgNaOH/g), specific gravity (41.438g), density (1.658g/mL), viscosity at 40⁰C (18.40pa.s), viscosity at 120⁰C (3.90pa.s), iodine value (139 mgKOH/g), pour point (–3⁰), flash point (192⁰C), saponification value (118 mgKOH/g), Hydrogen peroxide value (4.17 mgKOH/g) and cloud point (13⁰C). The thermal stability of this ratio is also appreciable for cutting fluid. The blends also correspond with the physicochemical properties of SAE 35. The physicochemical properties also confirmed the quality of the extracted oil for cooking and industrial potentials such as cutting fluid and lubricating fluid. Hence blending is a good choice for manufacturing oils of good quality and characteristics for the various applications. The physical, chemical, and functional properties of groundnut that relate to specific end products have to been determined and refined to facilitate screening breeding material for such properties. With these desirable physicochemical properties, blending of traditional oils with this nonconventional oil is a good choice by manufacturers. The food value of the oils and blends can also be predetermined to provide the safest food for consumers.

4.0 Conclusion

The oil samples have been investigated and physicochemical properties of this oil suggest they are within the requirements of cutting fluids as well as any other oil. It impact on the environment and health of those who handle them all along the production chain, until their final disposal makes it appreciable for machines operations. They safe safety handling while used as lubricant, non-toxic nature to human population and in the event of oil spills do not put at risk the environment like forest, water bodies and areas of agricultural activities. These reason, influenced the demand to development of novel formulation of blends with significantly increased biodegrading rate compared to those obtained from mineral source is necessary as this study have shown.

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