EXPERIMENTAL DETERMINATION OF CORRELATION BETWEEN VISCOSITY AND SURFACE TENSION OF SOME EDIBLE OIL

ISSN: 2141 – 3290
www.wojast.com

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ABSTRACT

In this work, we present the experimental measurements of viscosities and surface tension of four edible oils namely; coconut, groundnut, olive and melon oil using stokes theorem. From Pearson correlation equation, we obtained an analytical result showing a negative correlation of - 0.4 for all the oil samples.

INTRODUCTION

Fruits are usually described as a fully grown fertilized ovary containing fully developed ovules called the seeds. The seed of some plants contain appreciable quantities of oils and fat. Oils like coconut oil, groundnut oil, olive oil are well established as both cooking and industrial oils. Olive oil is also medicinal as it contains a supplement for vitamin E while melon oil has a pigment (beta carotene) which is a provitamin of vitamin A, Mathew, (2002).

Fats are a class of material called lipids (Mathew, 2002). Lipids are biological compounds that are soluble in water. At room temperature, fats and oils are solid and liquid respectively. Fats and oils have various applications like waxes for lamps and candles. In terms of composition, the major component of fat is the Tristearin and tripalmitin while the major components of oil is the Triolein, Mathew, (2002), hence fats and oils which can normally be obtained from storage deposits in plants and animals are extracted locally, mechanically, or through solvent extraction depending on its use. Therefore measuring the viscosities and surface tension of this edible oil and checking for its correlation is very important as it helps to check and detect any adulteration which might be harmful to human health.

Melon oil has a yellow colouration and contains a pigment also found in carrot, the beta-carotene also known as the provitamin A and has 40- carbon atom per molecule, Mathew, (2002). Beta carotene obtained from melon oil is essential for vision, adequate growth and tissue differentiation. It has a good anti oxidant that helps to neutralize free radicals. Melon oil is highly recommended for consumption and used in industries; hence it is essential to determine its viscosity and surface tension.

Groundnut oil can be obtained either mechanically by pressing or through industrial solvent extraction from groundnut plant. It belongs to a family called leguminosae. Groundnut oil has a pale yellow colour and contains 24 – 35% protein with a refractive index of 1.467 – 1.478 and iodine value of 84 – 100.

Coconut oil is obtained from coconut seed which belongs to a plant family called palmae. It is a simple fruit with well developed pericarp. The coconut fibres and copra are the components of the oil with greatest significance. Coconut oil has a refractive index of 1.467 – 1.478, specific gravity of 0.917 – 0.919, a fat content of 63 – 70%. The composition of coconut oil is fatty acid called the lauric acid. It is used in the manufacture of ice cream, coconut cake, margarine as well as bakery and confectionary fillings; it is also used in the production of fatty alcohols and soaps.

Olive oil is obtained from olives. It has a pale yellow colour. Olive oil has health promoting qualities and experts have advocated the consumption of olive oil in reference to other edible

oils. It is recognised as important in maintaining body metabolism and contributes to the development of the brain and bones in children. It's a recommended source of vitamin E.

Stokes law helps to investigate the motion of an object in a fluid and its relation to frictional force. If a sphere of radius is moving with a small constant velocity v in the liquid of viscosity η, as the sphere moves in the fluid the latter offers resistance to its motion which increases with an increase in velocity; a stage is reached when the viscous resistance equals to the driving force. The resultant force at this stage becomes zero and the sphere moves with constant velocity called terminal velocity. Sir George Stokes in 1845 related the speed of the falling sphere in liquid to the viscosity (Gaur and Gupta, 2005).

Hence $$\eta = \frac{2r^2 g(\rho - \sigma)}{9v} \qquad (1)$$

ρ and σ are density of the ball bearing and oil respectively.

Viscosity measures the resistance of a fluid to deform under shear stress (Yong and Freedman, 2004). It is also the measure of fluids internal friction which determines its rate of flow in application of infinitesimal shear stress (Etuk *et al.*, 2001)

Coefficient of viscosity is the ratio between the pressure exerted on the surface of a fluid in the lateral or horizontal direction, to a change in the velocity of the fluid (Essiett and Akpan, 2001). Mathematically written as

$$\eta = \frac{\tau}{(du/dy)} \qquad (2)$$

where $\tau = \frac{force}{area}$ and $\frac{du}{dy} =$ velocity gradient $= \frac{velocity}{length}$

The unit of viscosity is Nsm^{-2} or Pa.s

Surface tension is tangential force acting parallel to the surface of a liquid or the force per unit length acting parallel to the surface of the liquid. The Surface tension of most oils is mainly due to the cohesive force between the molecules.

Correlation between viscosity and surface tension

Correlation analysis is concerned with the relationship between two variables X and Y in a two dimensional random variables (Lassa and llori 1991). The correlation coefficient, r measures the interrelation between the x and y variables, and r satisfies the inequality: $-1 \le r \le 1$.

If r = +1, then the correlation is perfect and positive which means that a unit increase in variable X result in constant increase in Y. If r = -1, there is a negative correlation which means that a unit increase in X leads to a constant decrease in Y. Then if r = 0 it means there is no correlation. We will use computational analysis to determine the type of correlation existing between viscosity of oils and its surface tension, where viscosity will be Y and surface tension X. Using Pearson's correlation coefficient, Onwukwe, (2003).

$$r = \frac{n\sum XY - \sum X \sum Y}{\sqrt{\left(n\sum X^2 - \left(\sum X\right)^2\right)\left(n\sum Y^2 - \left(\sum Y\right)^2\right)}} \qquad (3)$$

Determining the correlation between surface tension and viscosity can easily enhance setting up a mathematical modelling which can help to check the rate of adulteration of the oil samples, Etuk *et al.*, (2001).

The applications of viscosity and surface tension include;

(a) evaluation of magma bt geologist to determine the occurrence of volcanic eruption (Rajput, 2007).
(b) determination of the ability of oils to lubricate engine parts to reduce friction.
(c) hospital use to test for jaundice.
(d) the Reynolds number based on viscosity is an important quantity used by engineers to determine if a flow is laminar or turbulent.
(e) improving system performance (volumetric efficiency and mechanical efficiency).

Since viscosity varies for different fluids transported in petroleum pipelines, it is widely considered that online measurement can be beneficial to pipeline operations (Ngala and Boufaida , 2004)

METHODOLOGY

Extraction of Coconut oil

Coconut oil was extracted from coconut fruit. Ten dried coconuts was broken to remove the outer shell. The whitish inner part was grated with local grater. The grated coconut was soaked in cool water and thoroughly stirred and left for about seven minutes. The mixture was then filtered and the fluid stored in a cool place for about 18 -19 hours. This was done to ensure that the fluid content separate itself from water content. After 19 hours, the oil floated on top of the fluid and we then scoped out the oil into a pot and heated for about 10 minutes to obtain the pure refined coconut oil.

Extraction of Melon oil

Melon oil was extracted from melon fruit. The melon seed was separated from the shell, it was sun dried for about 5 to 6 hours before grinding and later pounded. The pounded melon recollected oils within itself which were extracted by using a separating cloth with tiny pores to squish the oil out. The oil was heated to remove the water content in order to obtain pure refined oil.

Extraction Groundnut oil

Twelve cups of groundnut was grinded and later squeezed to remove the oil using fins separating cloths that enhance filtration. The oil was then boiled, filtered out to remove the debris and was scooped out.

Extraction of Olive oil

Olive oil extraction is an industrialized process. The pure form was obtained directly from the company. The type that was used for the experiment is called virgin oil.

Determination of Viscosity

Viscosity was determined using Stoke's theorem. 82cm of the Stoke's column and the diameters of the four ball bearings measured at $25^0 c$. The measurement was taken for four consecutive times for a particular ball bearing and the average was computed. The Stoke's column was washed with chromic (iv) acid, distilled water, ethanol and diethyl ether and dried. Two marks A and B were labelled on the column representing the upper and lower marks respectively. The oil sample was poured into the column and filled to the brim. A ball bearing was gently dropped in after 15 mins. Timing started when the ball bearing reached point A and stopped at point B. The ball was removed with a magnet and the experiment was repeated for the different ball bearings. Before another ball was dropped, about 15minutes was allowed to elapse so that the molecules of the oil get settled to enhance a uniform velocity of the ball bearing. The process was repeated for all the oil samples.

Determination of Density

The density bottle was thoroughly washed with chromic (iv) acid, distilled water, ethanol and diethyl ether and kept for some minutes to dry. The mass of the density bottle was measured.

The density bottle was then filled with water and stopper corked appropriately. The mass of the density bottle with water and stopper was measured from the formula

Density = $\frac{mass}{volume}$

Determination of Surface Tension

The force that act on the oil samples, divided by the length of the Stoke's column gives surface tension. That is

Force $F = 6\pi\eta vr$

Surface tension

$$T = \frac{F}{L} = \frac{6\pi\eta vr}{L} \qquad (4)$$

Where π = constant =3.142

V = velocity of the ball bearing

r = radius of the ball bearing

η = viscosity of the oil samples

L = 0.82m (The length of the stoke column).

RESULT AND DISCUSSION

Tables 1 and 2 show the summary of the experimental results of viscosity and surface tension of edible oil samples at the temperature of $28^0 c$. Details of the experimental data and calculations shows that olive oil has the lowest viscosity of 0.083Ns/ m^2, then melon oil with viscosity of 0.113Ns/ m^2, coconut oil with the value 0.147 Ns/ m^2 in decreasing order. The highest value was groundnut oil with the viscosity 0.162 Ns/ m^2. It was also observed that melon and groundnut oils had the same value of surface tension 0.00817N/m. On using Pearson's correlation formula to compute the correlation coefficient of edible oil samples, we obtained the value as -0.4 showing that correlation between viscosity and surface tension of edible the oils is perfectly inversely correlated. It has been shown from research that if the correlation coefficient r = +1 then the variables are said to be perfectly positively correlate (Kreszig, 2004). If r = -1, then the variables are said to be perfectly inversely or negatively correlated. If r = 0 , then variables are uncorrelated (Lassa and Ilori, 1991).

Table 1: Surface Tension And Viscosity of oil Samples

S/N	OIL SAMPLES	SURFACE TENSION(N/m)	VISCOSITY (NS/ m^2)
1	Olive oil	0.0179	0.083
2	Coconut oil	0.00817	0.147
3	Melon oil	0.0178	0.113
4	Groundnut oil	0.0178	0.162

Table 2: Correlation Between Surface Tension And Viscosity for oil Samples

T	η	T^2	η^2	$T\eta$
0.0179	0.083	0.00032041	0.006889	0.0014857
0.00817	0.147	0.00006675	0.021609	0.0012009
0.0178	0.113	0.00031684	0.021609	0.0020114
0.0178	0.162	0.00031684	0.026244	0.0028836
0.06167	0.505	0.00102084	0.076351	0.0075816

$\sum T$ =0.06167, $\sum\eta$=0.505, $\sum T^2$ = 0.00102084 , $\sum\eta^2$ =0.076351 , $\sum T\eta$ = 0.0075816

Viscosity of liquid decreases with increase in temperature (Ngala and Boufaida , 2004) but the reverse is for gas. Surface tension is affected by disinfectant like soap and it responsible for the reason why insect can work on water.

Olive, groundnut and coconut oils are essentials for human body. Some serve as a source of vitamin E, adequate growth and tissue differentiation. Melon oil stimulates vision as such measuring viscosity and surface tension enhances checking for any adulteration presence.

CONCLUSION

We discovered that there is a weak correlation between viscosity and surface tension of the edible oil samples which was the main aim of our work. Also for the correlation between edible oil samples to be -0.4 which indicates inverse correlation actually shows that these oils perform different functions and each oil used for different purposes which shows that one cannot be interchangeably used in place of the other

ACKNOWLEDGEMENT

The authors are indebted to the Chief laboratory technologist of Department of Physics and Chemistry, University of Uyo, Mr. Sunday Etuk and Mr Udosen Ibanga for their assistance during the practical sessions.

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