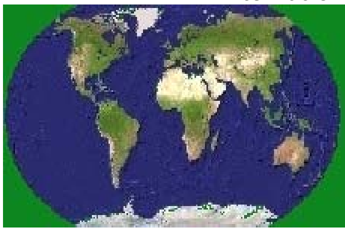

International Journal of Multidisciplinary Research and Development

IJMRD 2015; 2(1): 76-78
www.allsubjectjournal.com
Received: 10-11-2014
Accepted: 15-12-2014
e-ISSN: 2349-4182
p-ISSN: 2349-5979
Impact Factor: 3.762

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The viscosity variation of some locally produced vegetable oils with temperature

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Abstract
The viscosities of some locally produced vegetable oils; groundnut oil, cotton seed oil, soya beans oil were determined using a Temperature Control Viscometer. The viscosities of the vegetable oils decreased with increasing temperature and can be fitted with an Arrhenius type relationship. Palm oil was the most viscous while soya beans oil was the least viscous among the vegetable oils studied. This means that greater energy was needed to effect a viscosity change in the palm oil. The values of the viscosity of the vegetable oils studied were comparable to the viscosity values of other vegetable oils given in the literature.

Keywords: Vegetable Oils, Viscosity, Temperature, Liquids, Viscometer.

1. Introduction

Viscosity is the resistance of a fluid (liquid or gas) to a change in shape, or movement of neighbouring portions relative to one another. Viscosity denotes opposition to flow. The reciprocal of the viscosity is called the fluidity, a measure of the ease of flow. Molasses, for example, has a greater viscosity than water. Part of a fluid that is forced to move carries along to some extent adjacent parts of that fluid. Viscosity may be thought of as internal friction between the molecules. Such friction opposes the development of velocity differences within a fluid. Viscosity is a major factor in determining the forces that must be overcome when fluids are used in lubrication and transported in pipelines. It controls the liquid flow in such processes as spraying, injection moulding, and surface coating. For many fluids the tangential, or shearing, stress that causes flow is directly proportional to the rate of shear strain, or rate of deformation. In other words, the shear stress divided by the rate of shear strain is constant for a given fluid at a fixed temperature. This constant is called the dynamic, or absolute, viscosity and often simply the viscosity. Fluids that behave in this way are called Newtonian fluids in honour of Sir Isaac Newton, who first formulated this mathematical description of viscosity, [Encyclopaedia Britannica].

Vegetable oils and fats are very essential materials for salad oil, margarine, shortening, and other derived products, which have become significant ingredients in food preparation or processing in homes, restaurants, or food manufacturers, [Lemuel and Tianying, 2014]. There are commercial vegetable oils like olive, sunflower, canola, peanut, soya bean, and others, [Hamm and Hamilton, 2000]. There are also number of new vegetable oils such as grape seed, rice bran, macadamia nut, and many others.

It is well established that temperature has a strong influence on the viscosity of fluids with viscosity generally decreasing with increase in temperature. The Arrhenius model is commonly used to describe the relationship of the temperature dependence on vegetable oil viscosity [Sunny, 2010]. Viscosity of liquids is an important property needed in liquid flow and heat transfer unit operations, which includes pumping, flow measurement, heat exchange, sterilization, freezing, and many other operations [Lemuel and Tianying, 2014].

Many studies have already been published on the effect of temperature on the viscosities of vegetable oils. However, these studies were obtained from vegetable oils produced by standard machines. Therefore, there is a need to determine the viscosities of locally prepared vegetable oils and compare with the ones produced by modern machines under different temperatures.

2. Materials and Method

Some locally produced oils in Yola, Nigeria, like groundnut oil, palm oil, cotton seed oil, Soya beans oil were used in the study.

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A temperature controller with accuracy of ±1 K was used to increase the temperature of the oil samples from 323 K to 373 K with an increment of 10 K, and for each 10 K increment, the oil samples were left for 10 minutes until steady-state heat transfer was achieved before taking readings. The densities of the vegetable oils were determined by measuring the mass (m) of a given volume (v) of the oil and using the relation, $\rho = m/v$. Time of flow of water, t_w and t_o of oil were measured by a digital stop-watch with accuracy of ±0.01 s.

A temperature control capillary viscometer type, [Dikko, 2014], the design shown in Figure 1, was used to study the viscosity of the oils at various temperatures,

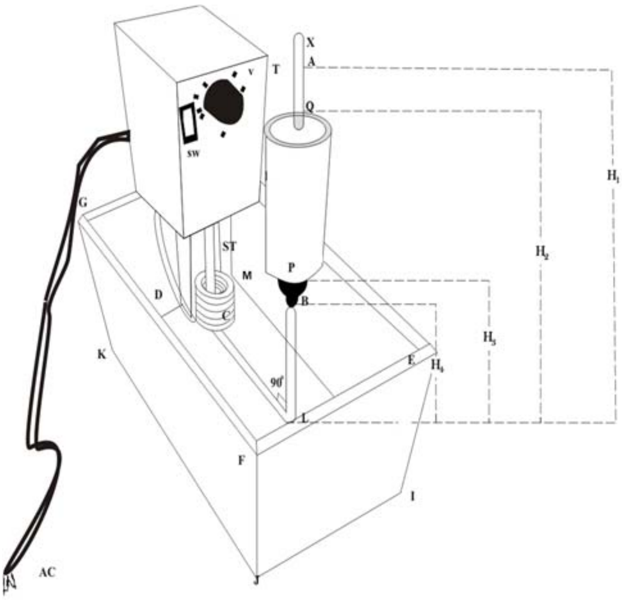

Fig 1: Design of the Temperature Control Viscometer

To determine the viscosity coefficient of a given oil, we need the absolute value of density, ρ_w and viscosity, μ_w of water at various temperatures from Hand book of Physical Constants, (Cutnell and Johnson, 1995). The viscosity coefficient μ_o of the oils were then calculated using the equation (1), (De and Dikko).

$$\mu_s = \frac{\mu_w \rho_s t_s}{\rho_w t_w} \quad (1)$$

3. Results and Discussion

The viscosity values of the vegetable oils studied are presented in Table (1). The viscosity of all of the oils decreased with the temperature increase. This could be due to the energy obtained to overcome the resistance to flow, which may be due to the attractive forces among the oil molecules, (Sunny, 2010). A similar behaviour is also observed for various fluids, such as alcohol mixtures, salt-sugar solution, milk-water mixtures (Dikko, 2014). From Figure (2), one can see that the reduction of the viscosity is greater at the initial stage of the temperature increment. Subsequent increases in the temperature during the latter part had less influence on reducing the viscosity, as was observed for all of the vegetable oils studied.

Palm and soya beans oil is the most and least viscous, respectively, from all four vegetable oils studied. The other oils, groundnut and cotton seed, are ranged between these two viscous limits. The high oil viscosity could be attributed to the stronger attraction force between oil molecules, (Sunny, 2010). Therefore, soya beans oil is the liquid with the weakest in terms of its resistance to flow in relative comparison to the other three oils.

Table 1: Variation of viscosity of some oils with absolute temperature

T (K)	μ-gnut (Pa-sec)	μ-palm (Pa-sec)	μ-cott (Pa-sec)	μ-soya (Pa-sec)
323	0.0175	0.0195	0.017	0.0161
333	0.0125	0.0143	0.0121	0.0117
343	0.0085	0.0095	0.0079	0.0074
353	0.0054	0.0066	0.0048	0.0043
363	0.003	0.0047	0.0025	0.0019
373	0.0021	0.0046	0.0016	0.0012

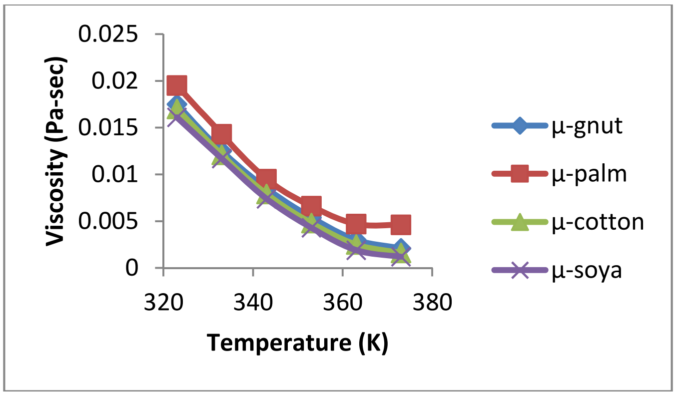

Fig 2: Viscosity variation of some vegetable oils with temperature

The viscosity of the vegetable oils studied fall between 0.0161 Pa-sec and 0.0195 Pa-sec, within temperature range of 323 K to 373 K, which are comparable to the ones in literature [Lemuel and Tianying, 2014], [Nwokolo and Smartt, 1996], [O'Brien, 2009], [Hamm and Hamilton, 2000].

4. Conclusion

The viscosities of the vegetable oils decrease with increasing temperature and can be fitted with an Arrhenius type relationship. Palm oil was the most viscous followed closely by groundnut oil, while soya beans oil was the least viscous and followed by cotton seed oil among the oils studied. The values of the viscosities of the oils determined in this study, locally produced, are comparable to those produced by modern equipments.

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