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Rheological properties for olive oil in palestine: shear stress versus shear rate

A.M.Bahti, Sh.M.Musameh, I.R.Abdelraziq*

Physics Dept., An-Najah National University, Nablus, (PALESTINE)

ABSTRACT

In this study, olive oil samples of different storage ages and locations in Palestine were studied. The experimental result of viscosity was compared with the powerlaw equation, and the behavior of olive oil was found to be Newtonian.

INTRODUCTION

Olive oil is a fat obtained from the olive fruit by mechanical or chemical means. Olive oil is commonly used in cooking, cosmetics, pharmaceuticals, soaps, and as a fuel for traditional oil lamps. Olive oil is used throughout the world, but especially in the Mediterranean countries and, in particular, in Greece, which has the highest consumption per person[1].

Olives are very important for the Palestinian, not only because they are the biggest crop in what remains a largely agricultural economy, but also for their deep cultural significance as a symbol of traditional society and ties to the land. It is estimated that olive trees account for nearly 45 percent of cultivated land in Palestine and in good years can contribute as much as 15 - 19 percent of agriculture output. Given that agriculture accounts for nearly 25 percent of gross domestic product, olives are an important element of the Palestinian economy and estimates suggest that about 100,000 families depend to some extent upon the olive harvest for their livelihoods[2].

Vegetable oils have become increasingly important for nutritional purposes and in a wide range of industrial applications which include fuels, skin care products, high pressure lubricants and alkyd resins for paint. These applications require extensive studies on the physic - chemical properties of oils in order to ascertain their suitability as raw materials. Such properties include viscosity and acidity which are an important parameters in the design of process equipment for oils[3],[4].

Adnan and his group studied the characterization of different oils and their rheological properties. Eight different natural oils, namely olive, coconut, almond, castor, sesame, cotton seed, sunflower, and paraffin oils. All the oils investigated were found to possess Non - Newtonian behavior[5].

Stanciu proposed four relationships of dynamic viscosity temperature dependence for vegetable oils. In his studies he found a polynomial or exponential dependence between temperature and dynamic viscosity of vegetable oil using the Andrade's equation changes[6].

OBJECTIVES OF THE STUDY

Full Paper

The goal of this work is to check whether olive oil in Palestine shows Newtonian or Non - Newtonian behavior. The experimental data will be fitted by using SPSS and Excel programs.

THEORY

Newtonian fluid

Newtonian fluid means that when shear stress is plotted against shear rate at a given temperature, the plot shows a straight line with a constant slope that is independent of shear rate. (Figure 1).

The simplest constitutive equation is Newton's law of viscosity:

$$\tau = \eta\dot{\gamma} \quad (1)$$

where η is the Newtonian viscosity and $\dot{\gamma}$ is the shear rate or the rate of strain. The Newtonian fluid is the basis for classical fluid mechanics. Gases, for example, exhibit characteristics of Newtonian viscosity.

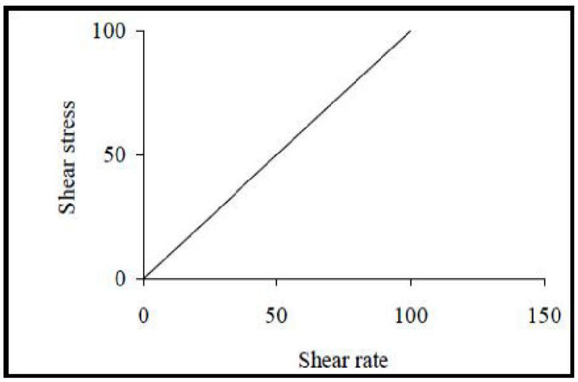

Figure 1 : Flow curve of a Newtonian fluid at power law

Non - newtonian fluid models

One of the most widely used forms of the general non - Newtonian constitutive relation is a power law model, which can be described as[7][8][9]:

$$\tau = m\dot{\gamma}^{n} \quad (2)$$

Where τ is stress and $\dot{\gamma}$ is strain rate, m and n are power–law model constants. The constant, m is a measure of the consistency of the fluid with dimensions of cP.(s)$^{n-1}$, the higher the *m* is, the more viscous the fluid is.*n*is a measure of the degree of non - Newtonian behavior. The greater the departure from the unity, the more pronounced the non - Newtonian properties of the fluid are.

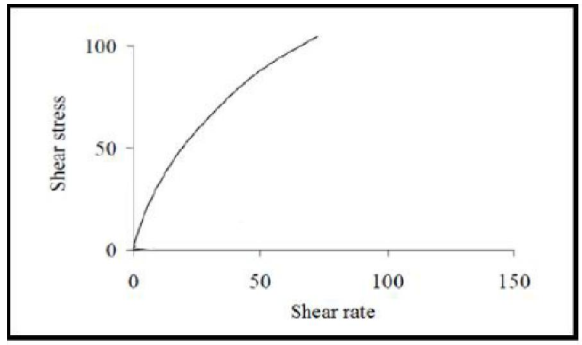

Figure 2 : Flow curve of a Non - Newtonian fluid at power law

The viscosity for the power - law fluid can be expressed as[7][8][9]:

$$\eta = m\dot{\gamma}^{n-1} \quad (3)$$

Where η is non - Newtonian apparent viscosity, if *n* = 1, a Newtonian fluid is obtained. If n deviates from 1, a non - Newtonian fluid is obtained. (Figure 2).

METHODOLOGY

Olive oil samples were collected from different region in Palestine, they were all produced by Palestinian industrial olive oil mills, from the crop of 1994 until the crop of 2012 at least four samples were collected from each region representing different olive oil ages.

The samples were collected from different regions, these are:L_1, L_2, L_3, L_4, L_5, L_6, L_7, L_8, L_9, L_{10}, L_{11}, L_{12}, and L_{13}. The samples were kept in closed glass bottles in dark place at 25°C. The viscosity was measured using the ND - 1 rotational viscometer, while temperature of the samples was measured by using Digital Prima Long Thermometer.

RESULTS AND DATA

The power law model is used to check whether the behavior of the olive oil samples is Newtonian or Non - Newtonian. A linear fit was done to the experimental results by the power law equation ($\tau = \eta\dot{\gamma}^{n}$) to find the value of the exponent n. The results of two samples from L_1 and L_8 are given in

TABLE 1: The results of power law fit to experimental data from L_1 and L_8

T (°C)	L_1						L_8					
	Storage age: 2 year		Storage age: 5 years		Storage age: 13 years		Storage age: 3 years		Storage age: 6 years		Storage age: 10 years	
	n	Error	*n*	Error	*n*	Error	*n*	Error	*n*	Error	*n*	Error
8	1.00	0.006	1.01	0.008	1.03	0.021	1.01	0.008	1.01	0.010	1.01	0.004
18	1.00	0.006	1.01	0.008	1.00	0.006	1.00	0.006	1.00	0.008	1.00	0.006
28	0.99	0.016	1.00	0.000	0.99	0.010	1.00	0.008	1.00	0.008	1.00	0.000
40	1.01	0.014	1.01	0.006	0.99	0.006	1.02	0.002	1.02	0.002	1.01	0.006
47	0.98	0.012	1.01	0.006	0.98	0.011	1.01	0.010	1.02	0.009	1.00	0.000
58	1.02	0.014	1.05	0.004	1.00	0.003	1.01	0.006	1.04	0.002	1.00	0.004
70	1.02	0.006	1.00	0.000	0.98	0.006	1.05	0.004	1.00	0.004	1.02	0.008

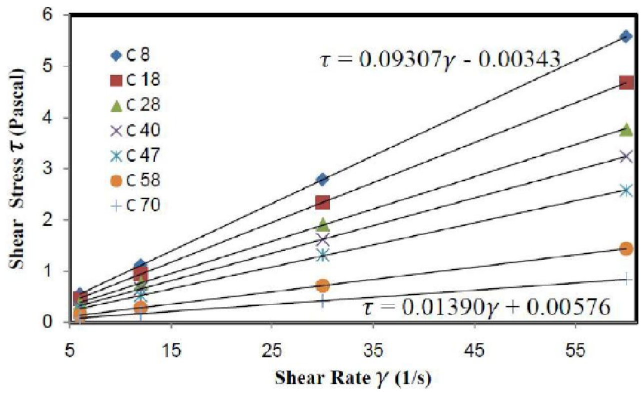

Figure 3 : Relationship between shear stress and shear rate for olive oil sample from L_1 (2 year storage age) at different temperatures.

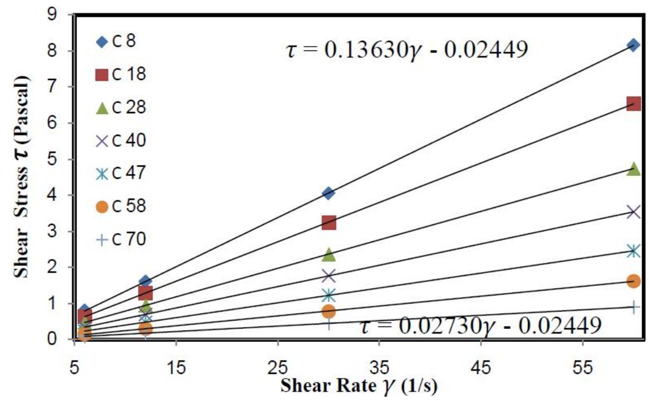

Figure 3 : Relationship between shear stress and shear rate for olive oil sample from L_1 (2 year storage age) at different temperatures

TABLE 1.

The relationships between shear stress and shear rate for L_1 (2 and 13 years storage age) for different temperatures are shown in Figures 3 and 4 respectively.

TABLE 1 shows the value of *n* is closed to one within an accepted error bars. This means that the olive oil samples are Newtonian fluid.

Figures 3 and 4 show that the relationship between shear stress and shear rate for olive oil is always linear at all temperatures. This is another indication of the Newtonian behavior of the olive oil samples as indicated by the simplest equation of Newton's law of viscosity.

DISCUSSION AND CONCLUSION

Eight samples from L1 and five samples from L8are selected to be analyzed. The reasons of choosing these two regions are:

Firstly: they are far enough from each others.

Secondly: the altitude are different, it is 350 m for L1, and 890 m for L8.

Thirdly: the quantities of rain are different for both regions, since we have different crops.

The results of viscosity measurements showed that the behavior of olive oil is Newtonian since the value of the flow indices (*n*) is very close to one.

Our work is not consistent with the work of Adnan and his group who found the flow index of olive oil to be 0.84, and so olive oil was considered Non - Newtonian[5].

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