Flow Behavior of Olive Oil Grown in West of Libya

Esam A. Elhefian

Abstract—This work is focused on studying the influence of temperature and storage time on the rheological properties of some samples of virgin olive oil as a function of time. Results showed that Newtonian behavior was pronounced at temperatures from 10°C to 50°C for all types of olive oil used. Studying the effects of shearing and storage times on the apparent viscosity of all samples did not show any significant differences at all shearing times applied in this study. In addition, it was found that all types of olive oil obeyed the Arrhenius equation.

Keywords—Apparent viscosity, olive oil, rheology, shear stress

I. Introduction

OLIVE oil is a complex mixture of a number of compounds such as fatty acids, vitamins and phenolic compounds. This mixture of chemical compounds is believed to be able to provide good health benefits to the users (1). For this reason, the olive has been a significant product for people of the Mediterranean countries for a long period of time. Many studies were carried out to find how best the oil could be stored without loss of its quality. Special care should be taken into account when storing olive oil. Several methods have been suggested in order to solve the problem of storage (2-5). Among the factors that can affect the olive's shelf life are light and temperature. Heating or keeping the oil at high temperature will surely age it. This will make the oil rancid. On the other hand, storing olive oil at low temperature however, will greatly extend its shelf life (6). Thus it is recommended to store olive oil in a dark cool place in tightly closed dark glass bottles.

Rheology has been applied to study the behavior of solutions, mixtures and suspensions [7]. Among important parameters in food industry, viscosity plays an important role. It is an important factor to determine the quality and stability of a food system and to characterize the fluid texture [8,9]. As with pure olive oil, it has been observed that there is a decrease in its viscosity, hence quality after certain time of its pressing, which makes it necessary to be consumed within this certain time.

The objective of this work is to study the effects of temperature and storage time on the apparent viscosity and shear stress of olive oil.

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II. Materials and methods

A. Materials

The virgin olive oil utilized in this work was obtained from a mill located in Sabratah city, west of Libya. All samples were kept at room temperature in a dark place until analysis. Every value taken is an average of three measurements. Data points in the figures are mean ± standard deviation (SD).

B. Rheological measurements

Rheological measurements were performed on a Brookfield digital viscometer, model DV-II + Pro, with an attached UL adapter. The viscosity was determined in 20 mL of the sample in each analysis and the shearing time was 15 second. For the storage time measurements, solutions were kept at room temperature in glass bottles in a dark place until analysis. Temperature was controlled using a water bath with precision of ±1°C. Analysis was done in a temperature range of 10–50°C and measurements were done in different shear rates. Each measurement was recorded as an average value of five readings when a constant shear rate was applied.

III. Results And Discussion

In this study, the shear rate-dependent viscosity of some samples (fresh, 1 year and 2 years) of olive oil as a function of shear rate at a temperature range of 10°C to 50°C is presented in figure 1. Similar to that of many fluids, the behavior of the viscosity–temperature interrelationship for all samples of olive oil shows a decrease of viscosity with an increase of temperature. This behavior is attributed to the reduction in intermolecular forces resulting from a higher thermal movement among molecules as the temperature increases. This makes the flow among the molecules easier and therefore, reduces the viscosity [9]. Another point to note is that among all temperatures studied, the difference in viscosity between the two temperatures, 10°C and 20°C, is the largest. On the other hand, the Newtonian behavior is observed at all temperatures studied for all of the samples.

The effect of temperature on the shear stress of olive oil as a function of shear rate is also shown in Fig. 1. Shear stress increased with increasing shear rate for all types of olive oil. At the same shear rate, shear stresses were higher at lower temperatures. In addition, increases in shear stress with increasing shear rate were more remarkable at lower temperatures. From the graph it is clear that all of types of olive oil exhibit Newtonian behavior at this range of temperature.

Viscosity measurements were performed as a function of shear rate at several shearing times (15, 30, 45 and 60 seconds) at 25°C to study the shearing time effect (Fig. 2). At all shearing times applied, all samples exhibit similar behavior and no significant change was observed. In addition, when the period of storage was extended to two years at a constant shear rate, almost no change in viscosity was observed (Fig. 3).

The viscosity values obtained at a constant shear rate (6.15 s^{-1}) can be correlated with temperature according to the Arrhenius equation:

$$\eta = A \cdot e^{-Ea/RT} \quad (1)$$

where A is a constant related to molecular motion, E_a is the activation energy for viscous flow at a constant shear rate, R is the gas constant and T is the absolute temperature in K. A plot of ln viscosity as a function of $1/T$ should produce a straight line and from its slope the E_a can be calculated. Fig. 4 presents an Arrhenius plot for the three olive oil samples. These graphs show linear relationships.

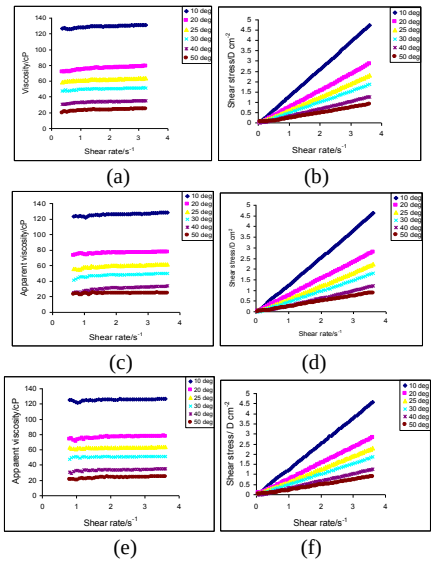

Fig.1 The influence of the shear rate and temperature on the rheological curves of (a,b) fresh , (c,d) 1 year and (e,f) 2 years olive oils.

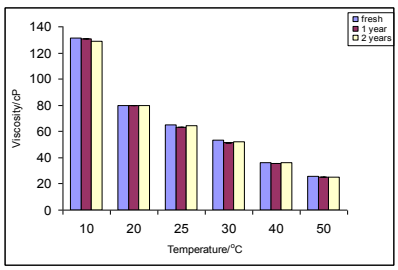

Fig. 3:The effect of storage time on the apparent viscosity determined at a constant shear rate

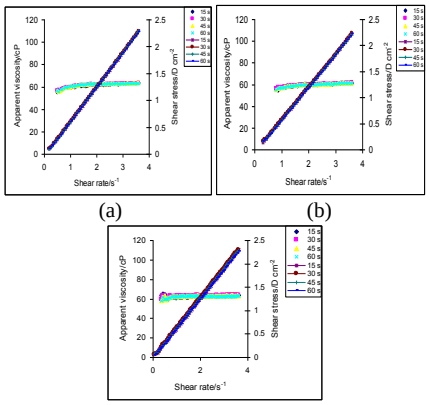

Fig. 2 The influence of shearing time on the rheological curves of (a) fresh, (b) 1 year and (c) 2 years olive oil.

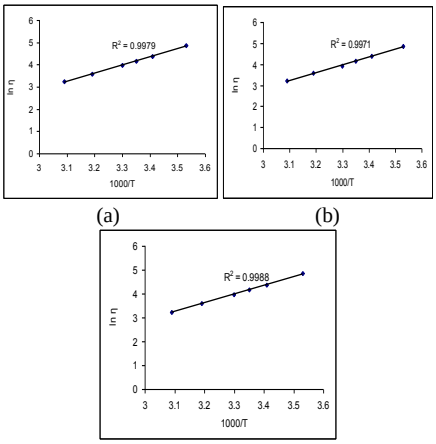

Fig.4 The Arrhenius plot of ln η versus 1/T for (a) fresh, (b) 1 year and (c) 2 years olive oil (at 6.15 s^{-1})

IV. Conclusion

This study has shown that Newtonian behavior was observed at temperatures from 10°C to 50°C for all types of olive oil used. Almost no change was observed when the effect of shearing time and storage time (until 2 years) was studied. Finally, all types of olive oil used were found to obey the Arrhenius equation.

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