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Theoretical rheological models for olive oil

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Introduction

Rheology is the science of deformation when used for food that paves the way for a better understanding of structural changes during the processing of these products. An important rheological parameter needed in selecting pumps and pipes for handling vegetable oils is viscosity. Despite the abundance of studies on the microstructure of olive oils, their rheology has been rarely researched. Among the very few articles however, rather historically, studies on the rheology of liquid foods by Rao [1, 13] should be mentioned. Some physical properties of edible oils, such as the dynamic viscosity of triglycerides [2,13] as well as the rheology of vegetable oils [3,13] are also reported.
Research on edible oils also covers more detailed topics such as elasticity and extensive viscosity [4,13]. Viscosity is a measure of the resistance of fluid layers to slip when subjected to shear stress. More microscopically speaking, therefore, is related to the size and orientation of molecules. It is well known that the viscosity of vegetable oils increases with the length of the chain of fatty acid triglycerides and decreases with unsaturation, in other words, increases with hydrogenation [5,13]. Changes in rheological properties are also attributed to physico-chemical changes in edible oils. Therefore, the change in the viscosity of the oils may be indicative of a possible degradation, which is the subject of this study. Viscosity can also be a determining parameter for heat transfer [6,13].Vegetable oils have been proposed several empirical relationships describing the temperature dependent dynamic viscosity. The more important of these is the Andrade equation (1). Andrade [14] equations are modified versions of equations (2) and (3) [15-19]:

$$\eta = A \cdot 10^{B/T} \quad (1)$$

$$\ln \eta = A + B/T + C/T^2 \quad (2)$$

and

$$\ln \eta = A + B/T + CT \quad (3)$$

where T is the temperature absolute and A, B and C in the equations (1) to (3) are correlation constants.

Experimental

Types of oilve oil used in this paper are produced in Romania. The oilve oil have investigated using a Haake VT 550 Viscotester developing shear rates ranging between 3 and 120 s-1 and measuring viscosities from 104 to 106 mPa·s when the HV1 viscosity sensor is used. The temperature ranged between 40 and 90oC and the measurements were made from 10 to 10oC. The accuracy of the temperature was 0.1oC.

Results and discussion

Figure 1 shows dependency of the ln dynamic viscosity on the T for studied olive oil at shear rate 3.3s-1, 6s-1, 10.6s-1, 17.87s-1, 30s-1, 52.95s-1, 80s-1 and 120s-1.
This article proposes one correlations (Eq.4) ln dynamic viscosity according to the temperature absolute for olive oil. We used the computer program Origin 6.0 to determine the constants lnη0 , A1 and t1 and the correlation coefficients, R2. The values of constants lnη0, A1 and t1 were determined by fitting exponential curves obtained for olive oil.

$$\ln \eta = \ln\eta_0 + A_1 \exp(T/t_1) \quad (4)$$

The dependency of ln dynamic viscosity on the absolute temperature for olive oil at shear rate 3.3s-1 , 6s-1, 10.6s-1 17.87s-1and 30s-1 (the black curves from Fig. 2, 3, 4,5 and 6) was fitting exponential as shown in figures 2, 3, 4, 5 and 6. The exponential dependence of ln dynamic viscosity on the absolute temperature for oilve oil at 3.3s-1 is described for equation (5):

$$\eta = 2.73206+1.20222E12\exp(T/ 11.13042) \quad (5)$$

where lnη0 =2.73206 , t1 = 11.13042 and A1 = *1.20222E12*. The correlation coefficient is R2 = 0.96973.
The exponential dependence of ln dynamic viscosity on the temperature for olive oil at 30s-1 is described for equation (6):

$$\eta = 2.2195+4.1979E8 \exp(-T/15.5549) \quad (6)$$

The value of the parameter lnη0 drops very little by main taining around 2 and the values of the parameters A1 and t1 vary within wide limits.
In table 2 we see that the empirical relations who give the best results in this study the temperature dependence of oil ln dynamic viscosity is described by equations (4), where the correlation coefficient values are close by 1.00. Equation (4) is not suitable to describe the temperature dependence of oil viscosity, because the values of correlation coefficients are less than 1.

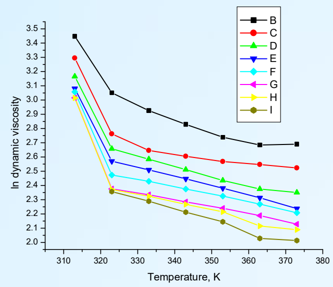

Fig.1. The correlation ln dynamic viscosity on the absolute temperature fro olive oil at: B – 3.3s-1, C – 6s-1, D – 10.6s-1, E – 17.87s-1, F – 30s-1, G – 52.95s-1, H – 80s-1 and I – 120s-1

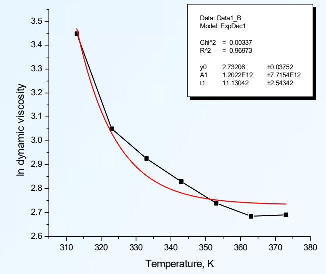

Fig. 2 . The correlation ln dynamic viscosity on the absolute temperature at 3.3s-1

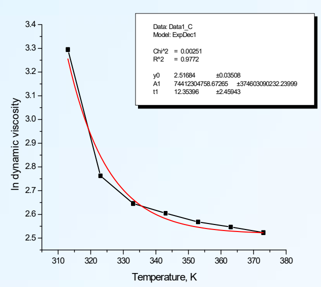

Fig. 3. The correlation ln dynamic viscosity on the absolute temperature at 6s-1

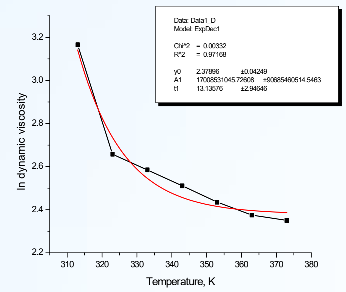

Fig. 4. The correlation ln dynamic viscosity on the absolute temperature at 10.6s-1

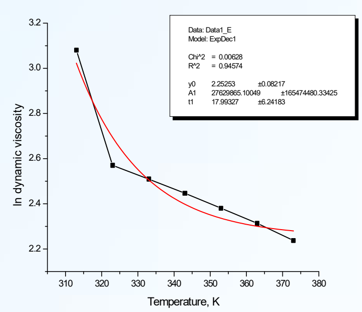

Fig. 5. The correlation ln dynamic viscosity on the absolute temperature at 17.87s-1

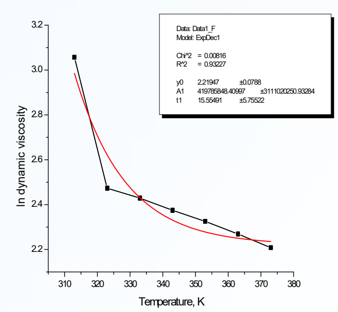

Fig. 6. The correlation ln dynamic viscosity on the absolute temperature at 30s-1

Conclusion

The equations that best describe the temperature dependent ln dynamic viscosity of oilve oil studied are (4) for which correlation coefficients have values close to one. Olive oil ln dynamic viscosity decreases with increasing temperature at constant shear rate. Plotting the ln dynamic viscosity depending on temperature shows an exponential decline.