ORIGINAL PAPER

STUDY CONCERNING THE RHEOLOGICAL BEHAVIOR OF SUNFLOWER OIL

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Abstract *In this work it was proposed a study concerning the rheological behavior of sunflower oil. This oil has a pseudoplastic behavior at studied temperatures. The equations of dynamic viscosity depending on shear rate between 40$^{\circ C}$ and 100$^{\circ C}$ for sunflower oil were used. The A, B, and C constants were obtained using the Origin 6.0 software by fitting exponential curves obtained from experimental data. The proposed equations showed correlation coefficients close to one.*

Keywords*: rheological behavior, sunflower oil, viscosity.*

1. INTRODUCTION

Sunflower oil is the non-volatile oil compressed from sunflower (*Helianthus annuus*) seeds. This oil contains predominantly linoleic (48–7%), oleic (14–40%), palmitic (4–9%) and stearic (1–7%) acids [1, 2]. The rheology role is very important in the cosmetic field, especially in the field of emulsions and lotions preparation [3, 4]. It is well known that the different creams have various consistencies and from this reason can be used for a long periods. In this respect, for well understanding the performance of the system, the effects of different rheological parameters of oils are studied [5]. Two principal models of rheology, which are Newtonian and Non-Newtonian systems, are used to explain the rheological behavior of oils. Newtonian material and products are those in which viscosity remains constant by varying shear stresses. This type of flow is influenced by the variation of temperature. Viscosity, shear stress, shear rate, yield value, plastic, pseudoplastic and thixotropic models, viscometer and rheometer types are the major issues discussed in rheology [6]. By definition rheology is a simple analysis that is being more and applied to determine the physical behavior of solutions, suspensions and mixtures. The basic parameter, obtained in the rheological study of liquid foods, is viscosity, which is used to characterize the fluid texture [7]. Rheology is concerned with how materials respond to applied forces and deformations. Basic parameters of stress (force per area) and strain (deformation per length) are the key to all rheological evaluations [8]. The sunflower oil was found to be more sensitive to thermal treatment, undergoing greater changes in its properties, especially in viscosity, which may increase considerably [9].

In this paper the sunflower oil rheological analysis of dynamic viscosity - shear rate relationship of the sunflower obtained from good sunflower by mechanical was carried out at gradient temperatures, providing scientific foundation for the rheological application of sunflower oil industry [10].

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2. MATERIALS AND METHOD

The dynamic viscosity for sunflower oils have investigated using a Haake VT 550 Viscometer developing shear rates ranging between 3 and 120 s^{-1} and measuring viscosities from 10^4 to 10^6 mPa·s, temperature ranged between 40 and 100 °C, when the HV_1 viscosity sensor is used.

3. RESULTS AND DISCUSSION

The dependence of dynamic viscosity on the shear rate for sunflower oil at temperature (the black curves from Figs. 1 - 7) was first order exponential decay as shown in Figs 1 - 7. The sunflower oil shows an exponential decrease of viscosity with shear rate (Fig. 1). The parameter values are given inside the figure, and the correlation coefficient is 0.98973 at 40°C sunflower oil has a pseudoplastic fluid behavior. The exponential dependence of dynamic viscosity on the shear rate for sunflower oil at 40^0 C is described by equation (1):

$$\eta = 20.85272 + 24.99034 \exp(-\dot{\gamma} / 4.56207) \quad (1)$$

The values are: A=20.85272, B=24.99034 and C=4.56207

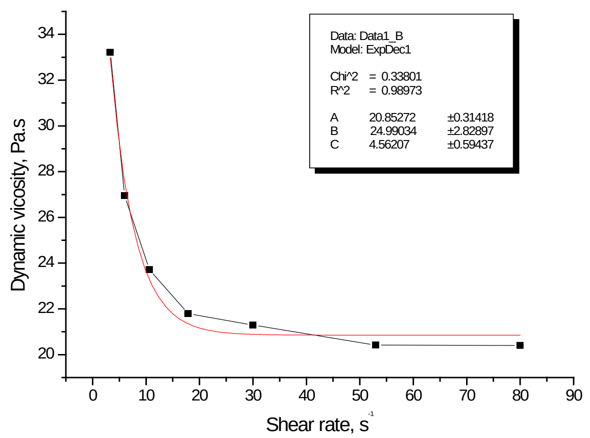

Fig. 1. The dependence of dynamic viscosity on shear rate at 40°C; 1_B represents the fitting exponential to B.

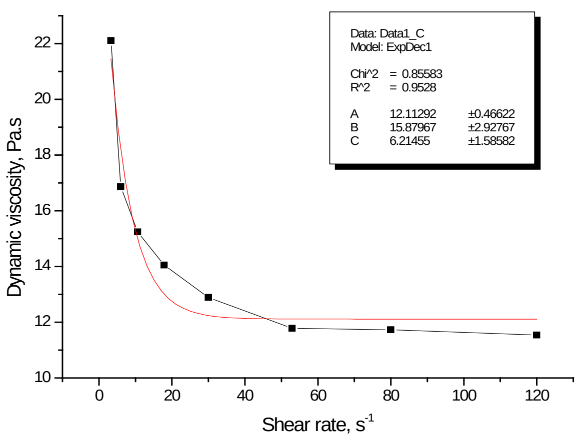

Fig. 2. The dependence of dynamic viscosity on shear rate at 50°C; 1_C represents the fitting exponential to C.

The raising sunflower oil temperature by 10^0 C dynamic viscosity decreases with shear rate (Fig. 2). Parameter values are given inside the figure, the correlation coefficient is 0.9528 at $50^{°C}$ sunflower oil has a pseudoplastic fluid behavior. The exponential dependence of dynamic viscosity on the shear rate for sunflower oil at 50^0 C is described by equation (2):

$$\eta = 12.11292 + 15.87967 \exp(-\dot{\gamma} / 6.21455) \quad (2)$$

From Fig. 2 it can see that at 50 °C the parameter A decreased with 8.7398 units, the parameter B decreased with 9.11067 units and the parameter C increased with 1.65248 units, comparative with the initial values of parameters A, B and C form Fig. 1.

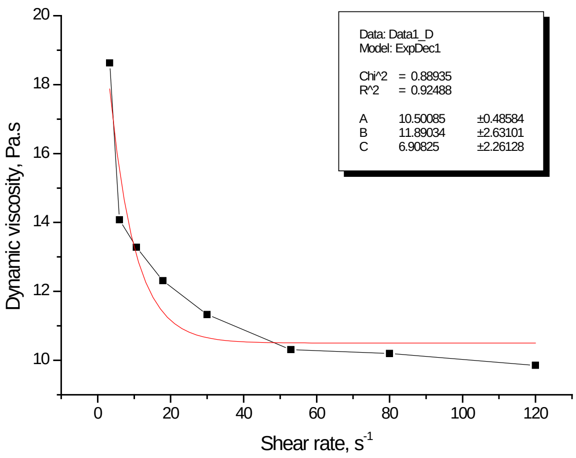

Fig. 3. The dependence of dynamic viscosity on shear rate at 60°C; 1_D represents the fitting exponential to D.

At temperature 60°C sunflower oil shows an exponential decrease of viscosity with shear rate (Fig. 3). Parameter values are given inside the figure, the correlation coefficient is 0.92488 at 60°C sunflower oil has a pseudoplastic fluid behavior. The exponential dependence of dynamic viscosity on the shear rate for sunflower oil at 60 °C is described by equation (3):

$$\eta = 10.50085 + 11.89034 exp\,(-\dot{\gamma}/6.90825) \qquad (3)$$

Increasing the temperature with 20 °C, the parameter A decreased with 10.35187 units, the parameter B decreased with 13.10006 units and the parameter C increased with 2.34618 units (Fig. 3).

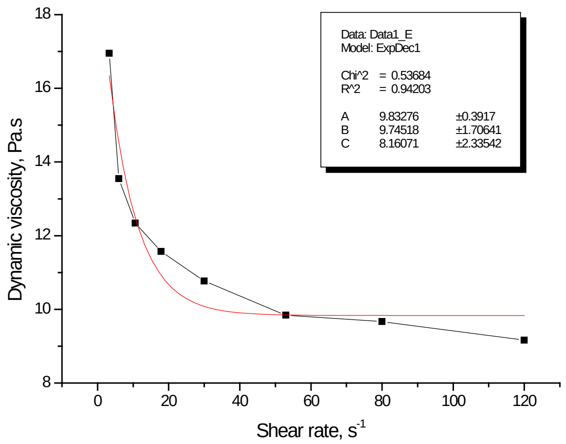

Fig. 4. The dependence of dynamic viscosity on shear rate at 70°C; 1_E represents the fitting exponential to E.

The temperature 70°C of sunflower oil shows an exponential decrease of viscosity with shear rate (Fig. 4). Parameter values are given inside the figure, the correlation coefficient is 0.94203 at 70°C sunflower oil has a pseudoplastic fluid behavior. The exponential dependence of dynamic viscosity on the shear rate for sunflower oil at 70 °C is described by equation (4):

$$\eta = 9.83276 + 9.74518 \exp(-\dot{\gamma} / 8.16071) \tag{4}$$

At 70 °C the parameter A decreased with 11.01996 units, the parameter B decreased with 15.24524 units and the parameter C increased with 3.59864 units (Fig. 4).

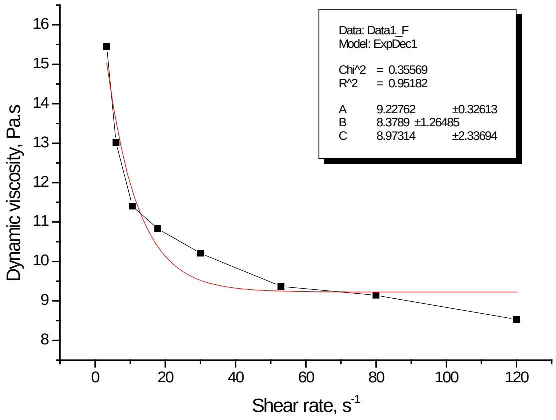

Fig. 5. The dependence of dynamic viscosity on shear rate at 80°C; 1_F represents the fitting exponential to F.

The dynamic viscosity of the sunflower oil shows an exponential decrease with shear rate (Fig. 5). Parameter values are given inside the figure, the correlation coefficient is 0.95182 at 80°C sunflower oil has a pseudoplastic fluid behavior. The exponential dependence of dynamic viscosity on the shear rate for sunflower oil at 80 °C is described by equation (5) as well:

$$\eta = 9.22762 + 8.3789 \exp(-\dot{\gamma} /8.97314) \tag{5}$$

Increasing the temperature with 40 °C, the parameter A decrease with 11.6251 units, the parameter B decrease with 16.61144 units and the parameter C increase with 4.41107 units.

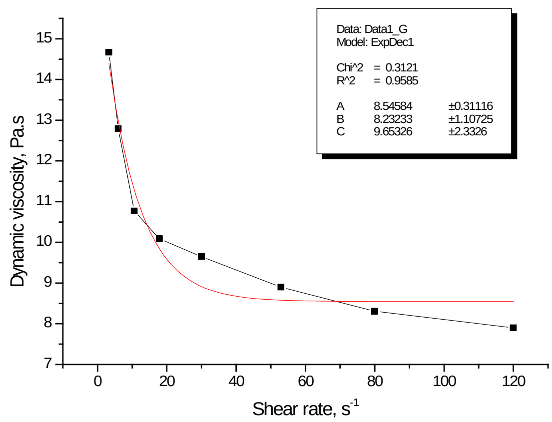

Fig. 6. The dependence of dynamic viscosity on shear rate at 90°C; 1_G represents the fitting exponential to G.

At 90°C it can see that the dynamic viscosity of the sunflower oil has an exponential decrease with shear rate (Fig. 6). Parameter values are given inside the figure, the correlation coefficient is 0.9585 at 90°C and it can conclude that sunflower oil has a pseudoplastic fluid behavior. The exponential dependence of dynamic viscosity on the shear rate for sunflower oil at 90 °C is described by equation (6):

$$\eta = 8.54584 + 8.23233 exp\,(-\dot{\gamma}/9.65326) \quad (6)$$

By increasing the temperature with 50 °C, it can see that the parameter A decrease with 12.30688 units, the parameter B decrease with 16.75801 units and the parameter C increase with 5.09119 units (Fig.7).

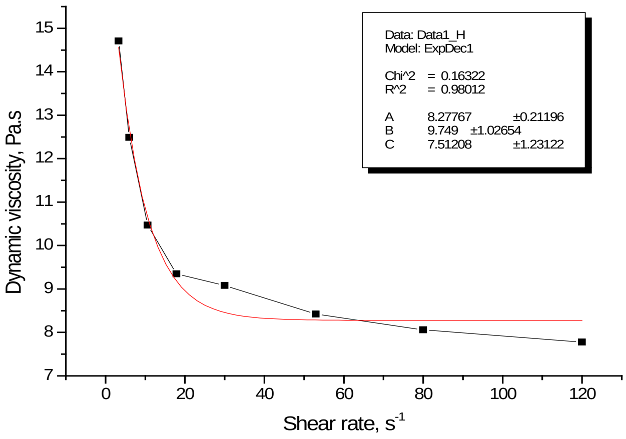

Fig. 7. The dependence dynamic viscosity on shear rate of at 100°C and 1 H represents the fitting exponential to H.

At 100 °C the sunflower oil shows an exponential decrease of viscosity with shear rate as shown in Fig. 7. Parameter values are given inside the figure, the correlation coefficient is 0.98012 at 100°C sunflower oil has a pseudoplastic fluid behavior. The exponential dependence of dynamic viscosity on the shear rate for sunflower oil at 100 °C is described by equation (7):

$$\eta = 8.27767 + 9.749 exp\,(-\dot{\gamma}/7.51208) \quad (7)$$

Increasing the temperature by 60 °C the parameter A decreased with 12.57505 units, the parameter B decreased with 15.24134 units and the parameter C increased with 2.95001 units.

From this study it can observe that with the temperature increasing the viscosity of sunflower oil decrease at each constant shear rate (Fig. 8). However, the oil viscosity at 80°C and 90°C are fairly close. These results reveals that viscosity of sunflower oil is not correlated with the variation of shear rate at a special constant temperature, but is negatively correlated with temperature at a special constant shear rate. Therefore, when sunflower oil is used as the raw of edible oils and industries, the working procedures at high temperature will not influence its rheological characteristic distinctly, and the temperature of 80°C and 90°C should be priory used.

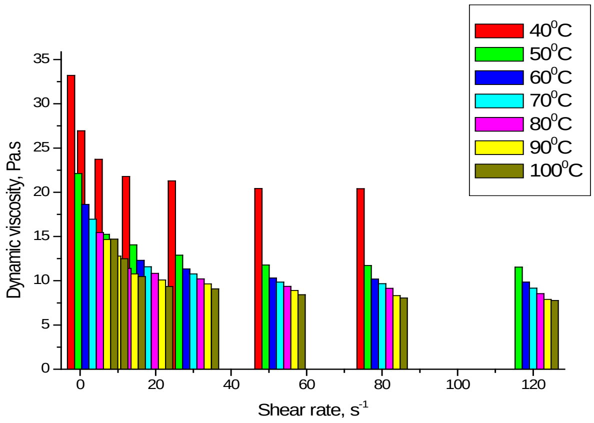

Fig. 8. The dependence dynamic viscosity on shear rate for sunflower oil.

4. CONCLUSIONS

The sunflower oil is pseudoplastic behavior at studied temperatures. The graphic representation of dynamic viscosity dependence on shear rate shows a decreasing exponential constant temperature in which correlation coefficients have values between 0.92488 and 0.98973. This result reveals that the viscosity of sunflower oil is not correlated with the variation of shear rate at a special constant temperature, but is negatively correlated with temperature at a special constant shear rate.

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