

# Modelling the Temperature Dependence of Kinematic Viscosity for Refined Canola Oil

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Viscosities of refined, bleached, deodorized (RBD) and refined, bleached, winterized (RBW) canola oils were measured at temperatures from 4 to 100°C. The viscosities of these refined canola oils were exponentially related to the oil temperature. Viscosity of the RBW oil was slightly greater than that of the RBD oil when the temperature was below 15°C. Compared to refined soybean oil, the canola oils were substantially more viscous. The viscosity of canola oil was modelled as  $\nu = \exp(C_0 + C_1T + C_2T^2)$ . The maximum predicted error was less than 1.6% over the tested temperature range.

**KEY WORDS:** Canola oil, model, viscosities.

In a project designed to determine the feasibility of using canola oil as a dust-control agent in grain handling systems, knowledge of the dependence of oil viscosity on temperature was required. Vadke *et al.* (1) proposed a viscosity model for the temperature range of 10 to 35°C for crude canola oil, which proved to be unsuitable for the refined oils used in the present study. Some of the physical properties of refined soybean oil are similar to those of refined canola oil, but viscosities of the two oils were found to be quite different. Therefore, a series of experiments was conducted to determine viscosities of two commercial grades of refined canola oil as a function of temperature within the range of 4 to 100°C.

## MATERIALS AND METHODS

Cannon-Fenske Routine Viscometers (Cannon Instrument Co., State College, PA), consisting of a series of glass tubes, as illustrated in Figure 1, were used in this experiment. A TEMPTRON viscosity bath (Precision Scientific Group, Chicago, IL) and a liquid-in-glass thermometer were used to maintain a constant oil temperature during each test run. A KKS25 cooling machine (Colora Messtechnik GMBH, Wurt, Germany) was employed to adjust the bath temperature when tests were conducted below 20°C. All temperatures were controlled within  $\pm 0.1^\circ\text{C}$  variation.

Refined, bleached, deodorized (RBD) and refined, bleached, winterized (RBW) canola oils were evaluated. Each grade was tested with two sizes of glass tubes to cover the wide range of viscosity. The reservoir, H, of the glass tubes was filled with oil and equilibrated at the desired temperature in the bath before forcing the oil to slightly above point C on the viscometer by applying compressed air from tube G (Fig. 1). Approximately 15 to 20 min were required to reach the equilibrium temperature. The efflux time for the meniscus to pass from mark C to mark E was measured. The viscosity was calculated by multiplying the efflux time by the viscometer constant.

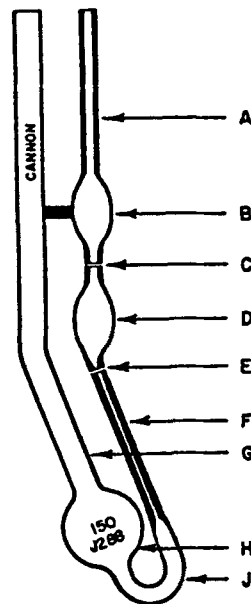


FIG. 1. Cannon-Fenske Routine Viscometer.

## RESULTS AND DISCUSSION

Preliminary tests indicated that the viscosities measured with the 200 and 350 size viscometers were almost identical, indicating that viscometer size was not critical in this study. Figure 2 illustrates the experimental results for both grades of oil and showed that viscosity was strongly influenced by temperature and was identical for both grades except at temperatures below 20°C. The

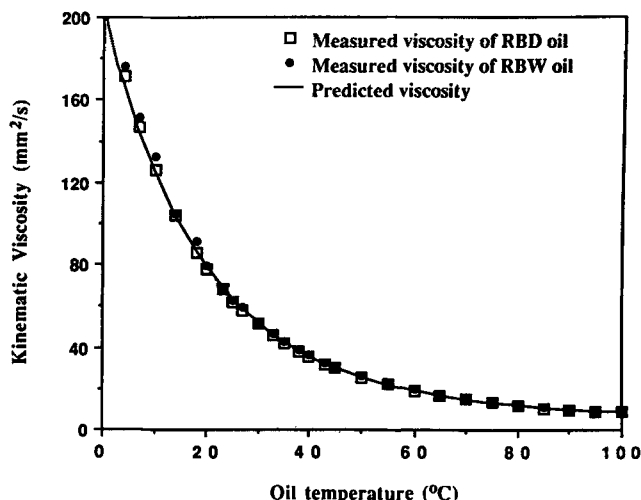


FIG. 2. Effect of temperature on viscosities of refined, deodorized, bleached and refined, bleached, winterized canola oils.

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maximum difference of 20 mm<sup>2</sup>/s was found in the range between 4 and 20°C.

Compared to values reported by Magne and Skau (2) for refined soybean oil, the refined canola oils were more viscous at each temperature (Table 1). For example, at room temperature, the viscosity of refined soybean oil was about 50 mm<sup>2</sup>/s while, for both RBD and RBW canola oils, the viscosities were over 62 mm<sup>2</sup>/s.

The Arrhenius equation has been used to describe the effect of temperature on shear viscosity of fluids (3):

$$\mu = \mu_0 \exp[E/(RT)] \quad [1]$$

where  $\mu$  is the shear viscosity; T is the absolute temperature of the fluid;  $\mu_0$  is the temperature-independent constant; E is the flow activation energy; and R is the gas constant. The kinematic viscosity,  $\nu$ , can be obtained by dividing the shear viscosity,  $\mu$ , by density of the fluid,  $\rho$ . The density of refined canola oil was essentially constant at 910 kg/m<sup>3</sup> (4).

TABLE 1

Effects of Temperature on Viscosities of Canola and Soybean Oils<sup>a</sup>

Temperature (°C)	Viscosity (mm <sup>2</sup> /s)		
	RBD oil	RBW oil	Refined soybean oil <sup>b</sup>
0	—	—	172.9
4	178.8	172.3	—
10	128.8	131.5	99.7
25	62.6	64.7	50.1
40	36.7	36.6	28.9

<sup>a</sup> Abbreviations: RBD, refined, bleached, deodorized; RBW, refined, bleached, winterized.

<sup>b</sup> Data were obtained from Magne and Skau (ref. 2).

An attempt was made to use Equation 1 to compute viscosities of the refined canola oils but the predictions were unsatisfactory when compared to measured data. Vadke *et al.* (1) used a modified form of the Arrhenius equation to estimate the shear viscosity of crude canola oil:

$$\mu = 4.6 \cdot 10^{-3} \exp[200.9/(T + 50)] \quad [2]$$

where T is the oil temperature, °C.

Equation 2 was also applied to predict the viscosities of the two refined oils. The prediction from this equation was satisfactory in the range of 10°C to 35°C, but a statistically significant difference from the present experimental data was found outside of this temperature range. Therefore, a new model for the kinematic viscosity of the refined canola oils over a temperature range of 4 to 100°C was developed:

$$\nu = \exp(C_0 + C_1 T + C_2 T^2) \quad [3]$$

where  $\nu$  is the kinematic viscosity in mm<sup>2</sup>/s; T is the oil temperature, °C; and C<sub>0</sub>, C<sub>1</sub> and C<sub>2</sub> are experimentally determined constants with values: C<sub>0</sub> = 5.3273, C<sub>1</sub> = 0.0519, C<sub>2</sub> = 0.0002. The maximum difference between predicted values from Equation 3 and experimental data was less than 1.6% over the temperature range of 4 to 100°C used in these tests, as shown in Figure 2.

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