CHOSEN THERMOPHYSICAL AND RHEOLOGIC DEPENDENCIES OF ACIDOPHILUS MILK

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INTRODUCTION

Basic principle of Hot Wire method is that heat flux is generated for an appropriate time interval through a long thin uniform wire buried in the measured sample and the temperature response is measured by the change in resistance of the wire or by the temperature sensor. The response is analysed in accordance with a model characterised by the particular formula found by solution of the partial differential equations using boundary and initial conditions corresponding to the experimental set up (NPL, 2007). Mathematical model requires ideal, infinitely long thermal source (hot wire) surrounded with infinitely homogenous and isotropic medium with constant starting temperature T_0. If in time $t = 0$ there starts radial heat flow q in measured material, so temperature $T(r,t)$ will have during time t increasing progress in distance r measured from hot wire. This time-temperature function can be described by equation (1)

$$T(r,t) = T_0 - \frac{q}{4\pi\lambda} Ei(-u) \qquad (1)$$

Ei is exponential integral with function argument $u = \frac{r^2}{4at}$, where a is thermal diffusivity.

One of the most important rheologic parameters is dynamic viscosity, which is defined as the resistance of a fluid to flow. The unit of dynamic viscosity in SI units is Pas. Viscosity changes with temperature. The difference in the effect of temperature on viscosity of fluids and gases is related to the difference in their molecular structure. Viscosity of most of the liquids decreases with increasing temperature. Theories have been proposed regarding the effect of temperature on viscosity of liquids. According to Eyering theory molecules of liquids continuously move into the vacancies (Bird et al., 1960). This process permits flow but requires energy. Activation energy is more readily audible at higher temperatures and the fluid flows easily. The temperature effect on viscosity can be described by an Arrhenius type equation

$$\eta = \eta_0 \, e^{-\frac{E_A}{RT}} \qquad (2)$$

where η_0 is reference value of dynamic viscosity, E_A is activation energy, R is gas constant and T is absolute temperature (Figura and Teixeira, 2007).
As temperature increases, cohesive forces between the molecules decrease and flow became freer. As a result viscosities of liquids decrease as temperature increases. In liquids, the intermolecular (cohesive) forces play an important role. (Sahin and Sumnu, 2006).
Measurement of dynamic viscosity was performed by digital rotational viscometer Anton Paar DV–3P. Principle of measuring by this viscosimeter is based on dependency of sample resistance against the probe rotation. Temperature dependencies of dynamic viscosity can be described by decreasing exponential functions

$$\eta = A \, e^{-B\left(\frac{t}{t_o}\right)} \qquad (3)$$

where t is temperature, t_0 is 1 °C, A, B are constants dependent on kind of material, and on ways of processing and storing .

MATERIALS AND METHODS

Acidophilus milk is milk which has been fermented with Lactobacillus acidophilus bacteria, creating a very distinctive tangy flavour and slightly thickened texture. The process used to make acidophilus milk starts with inoculation of sterile milk with the bacteria, and then allowing the milk to sit at a warm or neutral temperature so that the bacteria can thrive. The bacteria thrive in the mildly acidic environment of milk, consuming some of the lactose in the milk in the process. Like other fermented foods, acidophilus milk should be handled with care, as it has active bacteria which can continue reproducing in the milk, changing the flavour and texture.
Measured samples of acidophilus milk were stored in special boxes in the temperature 5 °C and the air moisture content was 92 %. And measurements of thermophysical and rheologic parameters were performed after basic temperature stabilization. Samples were stored for 24 hours before the measurement and the relations of thermophysical and rheologic parameters to the temperature for acidophilus milk were measured during the temperature stabilization to approximately laboratory temperature. Method of measurement was selected according to structural characteristics of the sample which have suspenzoid structure. For thermophysical measurement of suspenzoid materials is convenient Hot Wire (HW) method and for rheologic measurement is convenient method of rotational viscometer described earlier.

RESULTS AND DISCUSSION

Graphic relations of thermal conductivity and diffusivity presented on Figure 1-2 were obtained as averages from twenty measurements for every point in graphical characteristics. Results from rheologic parameters measurements are shown on Figure 3 and coefficients of regression equation (3) and coefficients of determination are in Table 1.

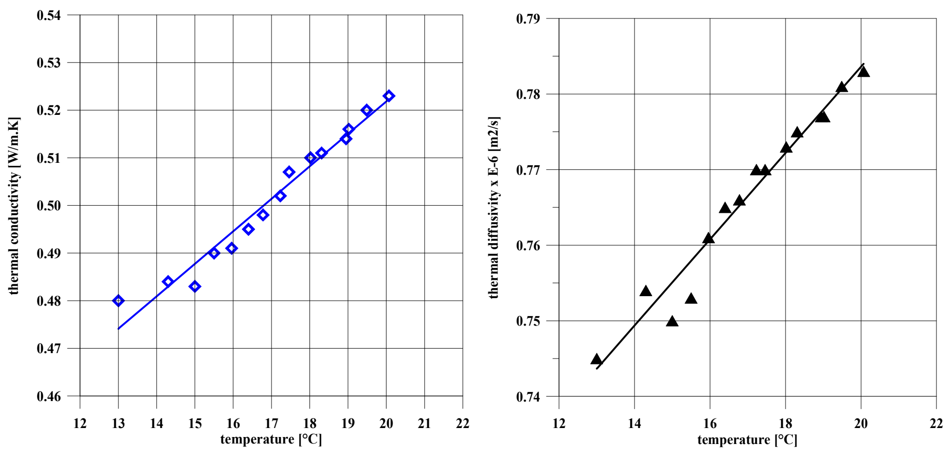

Figure 1-2
Relation of thermal conductivity and diffusivity to temperature in temperature range (13 – 20) °C for sample Acidko

$$\lambda = 0{,}00682162t + 0{,}385418, a = 0{,}003570485t + 0{,}669498 \quad (4)$$

Table 1: Coefficients A, B of regression equation (3) and coefficients of determination

Measurement	Exponential function (3)		
	Coefficients		
	A	B	R^2
First	686.263	0.034 015 3	0.949 287
Second	572.061	0.032 938 2	0.984 487
Third	416.074	0.022 282 0	0.988 512

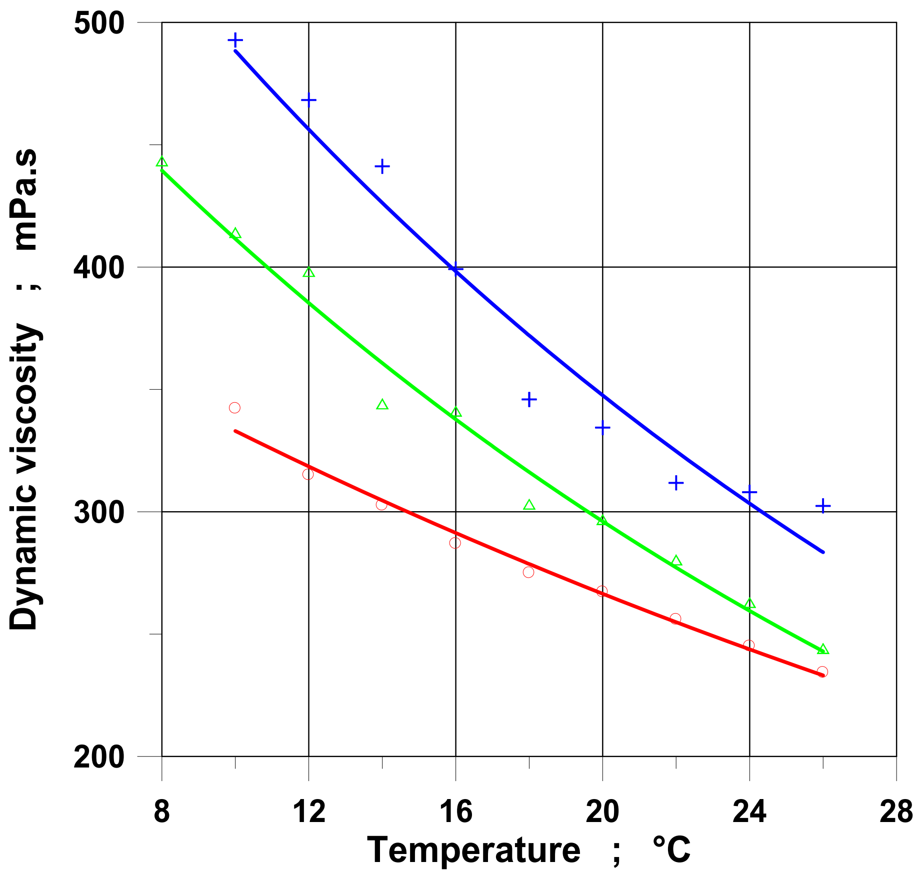

Fig. 3 Dependencies of Acidko dynamic viscosity on temperature in different time of storage: First measurement – at the beginning of storage **(+)**, Second measurement – after five days of storage **(Δ)**, Third measurement – after one week of storage **(o)**

CONCLUSION

Progress of temperature dependency of Acidko dynamic viscosity has decreasing shape which is in accordance with Arrhenius equation (2) and values are lower after storage that can be caused by structural changes in the sample during the storage. Thermophysical parameters of Acidko have increasing progress (4). From presented results is clear that thermophysical and rheologic parameters can determine status of food materials and it can be included between significant characteristics of materials.

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ACKNOWLEDGEMENT

This work was supported by research projects VEGA 1/0643/09 and 1/0708/09 of Slovak Grant Agency for Science.