Influence of selected factors on rheological properties of forest honey

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Abstract. According to Codex Alimentarius (2004) honey is a natural sweet substance, produced by honeybees from the nectar of plants or from secretions of living parts of plants, or excretions of plant-sucking insects on the living parts of plants, which the bees collect, transform by combining with specific substances of their own, deposit, dehydrate, store and leave in honeycombs to ripen and mature. Physical properties of honey are influenced by many factors and most important of them are temperature, time of storage, honey composition, mixture of flowers visited by bees producing the honey and it differs with locations, terms and particular colony of bees. In our research we focused on influence of temperature and time of storage to rheologic properties of forest honey.

INTRODUCTION

Honey is the primary product of bees and belongs among natural sweeteners; it is also known for its health promoting effects. The main parts of honey are nectar and honeydew. Nectar is the secretion of the plant organs and it consists of concentrated solution of sugars (glucose, fructose, sucrose, and maltose). Honeydew is plant juice, which passed through the part of the bee digestive tract. Its main ingredients are also sugars, but in more varied composition. Honey is a mixture of sugars, water, and other components. The specific composition of a honey depends mostly on the mixture of flowers visited by bees producing the honey and it is different in relation to locations, terms and particular colony of bees. Honey in general consists of fructose (approximately 38 %), glucose (about 31 %), sucrose (around 1 %), other sugars (about 9 %), water (approximately 17 %), ash (around 0.17 %), and other substances (Hlaváč – Božiková, 2012).

Some rheologic properties of honey are mentioned in literature. Bhandari et al. (1999) examined rheologic properties of Australian honeys. They found that rheologic properties of honey depend on the composition of individual sugars, and the amounts and types of colloids present in honey. Zaitoun et al. (2000) examined rheologic properties of selected light-coloured Jordanian honeys. They found that the viscosity of honey decreases with the water content. The water content is the major factor that influences the keeping quality or storability of honey. White et al. (1964) examined the effect of storage and processing temperature on the honey quality. In their investigation they found that dark-coloured types of honey tend to be affected by heat faster than the light-coloured types. It is natural for many types of honey to granulate or crystallise upon storage. Since the retail honey market largely favors liquid honey, some types of processing are necessary to maintain the liquid state. This is most commonly done by straining, heating, or filtration (White, 1999). Generally, physical properties of honey are influenced by various factors such as: the type of flowers, way of processing and most of all area of origin, etc.

MATERIALS AND METHODS

This article deals with the rheologic properties of forest honey made in Slovakia. Two series of rheologic parameters measurements were done. Firstly the sample of fresh honey was measured at the beginning of storage and then the same sample of honey was measured again after one week of storage. The measurements of dynamic viscosity were done by the viscometer Anton Paar (DV-3P) and the principle of measuring is based on the dependence of the sample resistance on the probe rotation. Density of honey sample was determined according to definition. Other rheologic parameters as kinematic viscosity (dynamic viscosity divided by density of sample at the same temperature) and fluidity (reciprocal value of dynamic viscosity), were also determined.

All honey parameters were measured during temperature stabilisation in the temperature interval from 20 °C to 43 °C. The effect of temperature on viscosity can be described by an Arrhenius type equation with decreasing exponential shape.

$$\eta = \eta_0 \, e^{-\frac{E_A}{RT}} \qquad (1)$$

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).

Temperature dependencies of dynamic and kinematic viscosity can be described by decreasing exponential functions (2, 3) and temperature dependency of fluidity by increasing exponential function (4).

$$\eta = A\, e^{-B\left(\frac{t}{t_o}\right)} \qquad (2)$$

$$\nu = C\, e^{-D\left(\frac{t}{t_o}\right)} \qquad (3)$$

$$\varphi = E\, e^{F\left(\frac{t}{t_o}\right)} \qquad (4)$$

where t is temperature, t_o is 1 °C, A, B, C, D, E, F are constants dependent on kind of material, and on ways of processing and storing. It is important to know the influence of temperature on physical properties not only for food materials, but also for technical materials (Kumbár – Dostál, 2014).

RESULTS AND DISCUSSION

Results are presented as graphic relations of rheologic properties on temperature. Temperature dependencies of dynamic and kinematic viscosity are shown on Fig. 1 and Fig. 2 and temperature dependencies of fluidity are on Fig. 3.

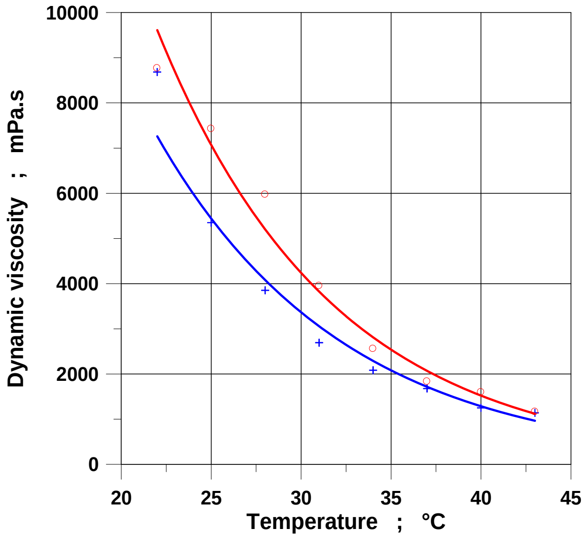

Figure 1
Temperature dependencies of forest honey dynamic viscosity
(first measurement +, after one week of storing ○)

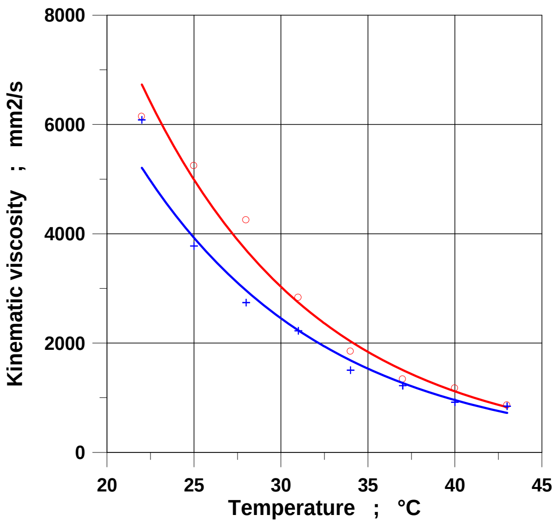

Figure 2
Temperature dependencies of forest honey kinematic viscosity
(first measurement +, after one week of storing ○)

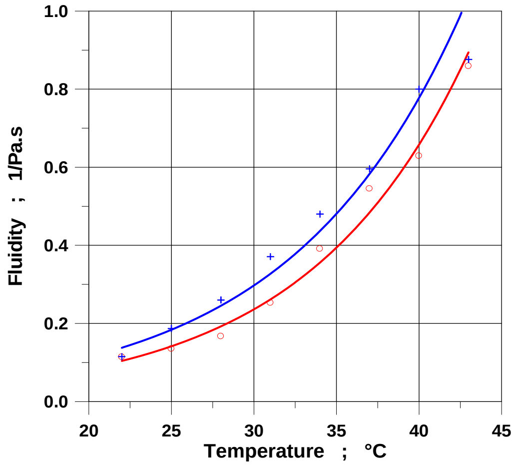

Figure 3
Temperature dependencies of forest honey fluidity
(first measurement +, after one week of storing ○)

Table 1: Coefficients A, B, C, D, E, F of regression equations (2, 3, 4) and coefficients of determinations (R^2)

	Regression equations (2, 3, 4)		
	Coefficients		
Forest honey	**A [mPa.s]**	**B [1]**	**R^2**
First measurement	60 147.9	0.096 11	0.974 692
Next measurement	91 376.4	0.102 37	0.984 745
Forest honey	**C [$mm^2.s^{-1}$]**	**D [1]**	**R^2**
First measurement	41 287.8	0.094 12	0.978 836
Next measurement	60 520.7	0.099 83	0.984 745
Forest honey	**E [$Pa^{-1}.s^{-1}$]**	**F [1]**	**R^2**
First measurement	0.016 612	0.096 14	0.974 640
Next measurement	0.010 924	0.102 44	0.985 470

It can be seen from Fig. 1 that dynamic viscosity of forest honey in both measurements is decreasing with temperature. The progress can be described by decreasing exponential function, which is in accordance with Arrhenius equation (1). Kinematic viscosity of forest honey is decreasing exponentially with temperature (Fig. 2). Dependency of forest honey fluidity on temperature is on Fig. 3. It is evident that fluidity of sample is increasing exponentially with temperature. All regression coefficients and coefficients of determination are shown in Tab.1. In all cases were the coefficients of determination very high.

From presented results is clear that dynamic and kinematic viscosity values were a bit higher after storing due to loosening of the water during storage. Values of fluidity were a bit smaller after storing, which is caused by loosening of the water respectively by crystallization during the storage.

CONCLUSION

Rheological properties of forest honey at the beginning of storage and after one week of storing were compared in this paper. Also the influence of temperature on rheological properties of honey was analyzed. Exponential functions were obtained for temperature dependencies of rheological parameters. In case of dynamic and kinematic viscosity it has decreasing shape which is in accordance with Arrhenius equation. In case of fluidity was used increasing exponential function. Similar results were obtained for other types of honey (Hlaváč – Božiková, 2012; Bhandari et al., 1999; White et al., 1964).From the presented results is clear that viscosity values were a bit higher after storage due to the loosening of water during the storage. The values of fluidity were a bit smaller after storage, which was caused by the loosening of water respectively by crystallization during the storage. Similar results were obtained by authors Sahin and Sumnu (2006), Figura and Teixeira (2007), and Cohen and Weihs (2010). Results showed that temperature has significant influence on thermal and rheologic parameters. Knowledge about physical properties of food products can be used at determination of their quality.

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