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Rheology of irradiated honey from Parana region

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Abstract

Viscosity characteristics can be governed by the molecular chain length of sugars present in the honey. Honey is essentially a mixture of sugar and water. When a physical treatment, as gamma radiation, is applied to food, some changes on its viscosity may occur. Viscosity is one of the important properties of honey and depends on water and sugar quantities. The objective of this work was to verify the rheological behavior of irradiated honey from Parana region in comparison to the unirradiated one. Each rheogram was measured at different shear rates that was increased to a certain value then immediately decreased to the starting point (''up and down curves''). These measurements were made for control and irradiated samples (5 and 10 kGy) in different temperatures (30°C, 35°C and 40°C). The curves constructed with shear stress against shear rate presented linearity. Honey, irradiated and control, showed a Newtonian behavior and gamma radiation did not affect it.

Keywords: Viscometer; Honey; Gamma irradiation; Rheology

1. Introduction

Food is submitted to gamma irradiation process for different purposes. Among the several benefits, a food or an ingredient is irradiated to reduce microorganism's load. The use of honey in products that receive no or limited heat treatment may require additional tests besides total plate count (Snowdon and Cliver, 1996). Although several studies have been focusing the inhibitory activity of honeys against foodborne pathogens, recent study showed that the factors contributing to this inhibitory activity have clearly not been fully defined. Further work is needed to separate the effects of peroxide and other components in honeys on survival and growth pathogenic and non-pathogenic foodborne microorganisms. (Taormina et al., 2001). Although there is few studies in literature, gamma irradiation could seem to be a good alternative to pasteurization. This process applied on seven honey samples was found to decrease the amount of aerobic and anaerobic bacteria and fungi (Migdal et al., 2000).

However, when a physical treatment, as gamma radiation, is applied to food, some changes on its viscosity may occur. Viscosity is one of the important properties of honey and depends on water and sugar quantities. Viscosity characteristics can be governed by the molecular chain length of sugars present in the honey (Bhandari et al., 1999). Viscosity is also very dependent on temperature.

Although the exact composition of honeys depend on the region, mainly the botanicals, from which they derive, the main sugars in honey are monosaccharides—fructose and glucose—which sum 70%; dissacharides, including sacarose, are around 10% and water where sugars are dissolved is approximately 20% (Felsner, 2001). A variety of degradation products are formed in aqueous solutions of monosaccharides by the effect of ionizing radiation (International Atomic Energy Agency, 1973).

There is very little information available on the rheology of honeys submitted to gamma radiation process and for this reason the current work aimed to verify the rheological behavior of Brazilian honey when submitted to gamma irradiation.

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2. Experimental

2.1. Materials

Honey type Parana, from Parana region, was kindly supplied by MNS Própolis enterprise. The composition of a typical batch was:

Water content: 18.5%.
Saccharose content: 0.96%.
Reduced sugars: 70.62%.
HMF content: 2.7 mg/kg.

2.2. Irradiation

The samples were irradiated in closed flasks containing 1 kg each, in normal atmosphere and at room temperature. Irradiation were performed in a ^{60}Co Gammacell 220 (AECL), at a mean dose rate of 5,53 kGy/h and dose uniformity factor of 1.13, with doses of 0, 5 and 10 kGy. Dosimetry was done using Amber routine dosimeter (Harwell, United Kingdom) and dose rate was established using Fricke reference dosimeter to plot calibration curves. The whole dosimetry system is in IDAS program from International Atomic Energy Agency.

2.3. Viscosimetry

Viscosity measurements were carried out using a Brookfield viscometer, model LV-DVIII, spindle SC4-34, as described previously (Sabato et al., 2002), in different temperatures at 30°C, 35°C and 40°C (±0.1°C), employing a Neslab water bath.

Viscosity values were carried out in three replicates, in different days. The set of data from the whole experimental design was submitted to a statistical treatment, consisting of *F*-test between treatments and anova among all data (Statistica 5.1, StatSoft, 1998).

Each rheogram was measured at different shear rates that was increased to a certain value then immediately decreased to the starting point ("up and down curves").

3. Results and discussion

Viscosity values were measured in three different temperatures for unirradiated (control) and irradiated (5 and 10 kGy) samples. Gamma radiation in 5 and 10 kGy doses did not impair the viscosity significantly ($p<0.05$), as showed in Table 1. Viscosity values in 30°C were significantly different from those values in 35°C and 40°C temperature ($p<0.05$).

The shear stress was plotted against shear rate ("up and down curves") for all samples in three different temperatures. The results for unirradited sample (control) are showed in Fig. 1. Figs. 3 and 5 show these results for irradiated honey at 5 and 10 kGy, respectively. The equations of linearity were calculated considering up and down shear rates, and they are presented in Table 2. Their correlation coefficients (R^2) varied from 0.9944 to 0.9999 (Table 3), indicating Newtonian fluids. The irradiation process did not affect this behavior.

Table 1
Averages and standard deviation of viscosity values for honey-type Parana in function of irradiation doses and measured at three levels of temperature

Temperature (°C)	Viscosity (cP)		
	Irradiation doses		
	0 kGy	5 kGy	10 kGy
30	6412±510 (b)	5849±1157 (b)	6939±1815 (b)
35	3849±239 (c)	3594±397 (c)	4112±579 (c)
40	2433±211 (c)	2229±526 (c)	2530±428 (c)

Means values followed by different letters in the same column are significantly different ($p<0.05$).
Means values followed by asterisk (*) in the same row are significantly different ($p<0.05$).

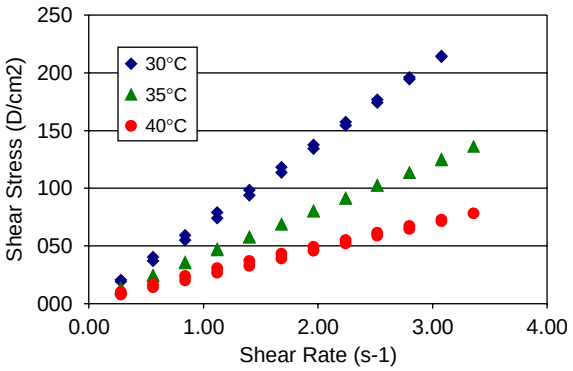

Fig. 1. Shear stress vs. shear rate for unirradiated honey (control).

Viscosity measurements were plotted against speed and they are presented in Figs. 2, 4 and 6. The viscosity values remain almost constant as the speed varied, confirming the Newtonian behavior (Figs. 2–6).

Several studies about honey rheology aim the effects due to temperature changes. Although some honeys are reported to be shear thickening, in the most of the published papers honeys are reported to be a Newtonian fluid (Bhandari et al., 1999). A Chinese study, evolving 46 varieties of natural honeys, demonstrated the same Newtonian behavior (Junzheng and Changying, 1998). This current study demonstrated Brazilian honeys treated with gamma radiation did not change their rheological behavior.

Table 2
Equations related to curves between shear stress and shear rate for irradiated samples and control

Temperature (°C)	Equations		
	0 kGy	5 kGy	10 kGy
30	$y = 69.822x - 0.7803$	$y = 51.43x + 2.0321$	$y = 65.346x + 1.2754$
35	$y = 39.833x + 1.8628$	$y = 31.094x + 1.744$	$y = 35.868x + 1.8315$
40	$y = 22.495x + 3.1913$	$y = 19.682x + 1.5001$	$y = 21.921x + 0.6642$

Table 3
Correlation coefficient between shear stress and shear rate for irradiated samples and control

Temperature (°C)	R^2 Irradiation doses (kGy)		
	0	5	10
30	0.9991	0.9975	0.9989
35	0.9999	0.9994	0.9970
40	0.9944	0.9994	0.9996

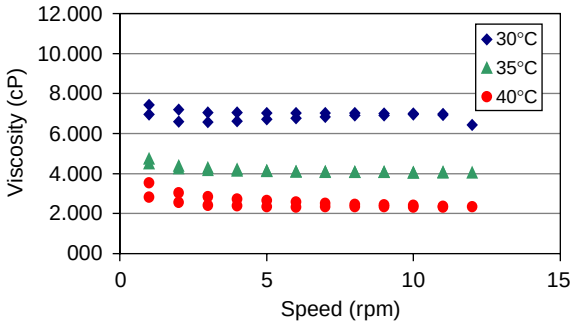

Fig. 2. Viscosity vs. speed for unirradiated honey (control).

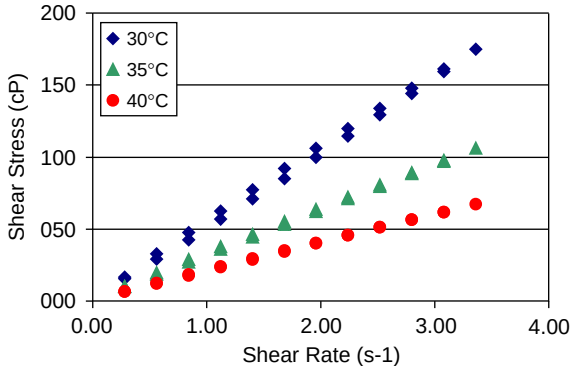

Fig. 3. Shear stress vs. shear rate for 5 kGy irradiated honey.

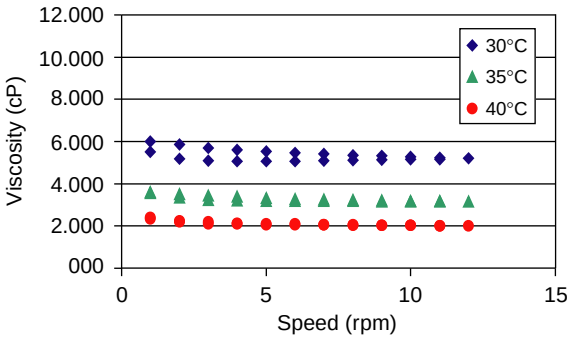

Fig. 4. Viscosity vs. speed for 5 kGy irradiated honey.

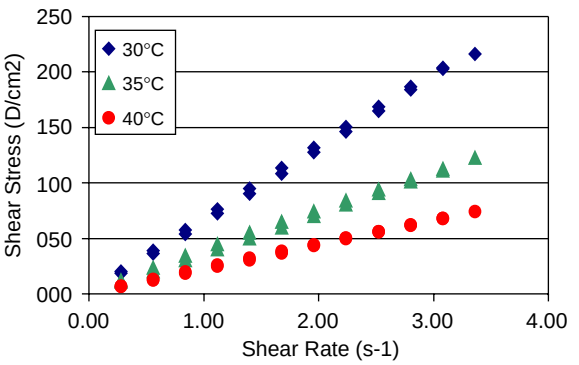

Fig. 5. Shear stress vs. shear rate for 10 kGy irradiated honey.

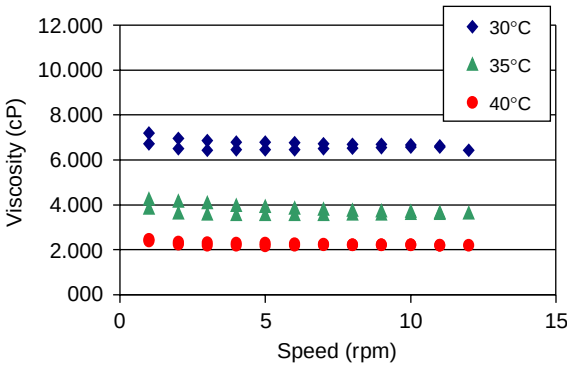

Fig. 6. Viscosity vs. speed for 10 kGy irradiated honey.

4. Conclusion

Gamma irradiation in the studied doses did not affect the viscosity of honey and its rheological behavior. Control and irradiated honeys (5 and 10 kGy) showed a Newtonian behavior.

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