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INFLUENCE OF STORAGE TEMPERATURE ON THE VISCOUS BEHAVIOUR OF PARTIALLY FERMENTED WINE MUST (*PINOT GRIS*)

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Abstract

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The main goal of this article deals with effect of storage temperature on the partially fermented wine must viscosity. Four samples of partially femrented wine must (Pinot Gris) wre observed. Two samples were stored in cold temperature 5 °C and another two samples were stored at the room temperature ~20 °C. The kinematic viscosity has measured for 132 hours from start of stormy fermetation (in the interval about 16 hours). Rotary viscometer with standard spinde and low-volume adapter was used to experimental measured. Results of kinematic viscosity process were mathematically modelled using logarithms function. Created mathematical models were precision because correlation coefficients and values of significance achieved very high values. Results and trends form this article can be used to the partially fermented wine must viscosity process prediction.

Keywords: partially fermented wine must, viscosity, storage temperature, modelling

INTRODUCTION

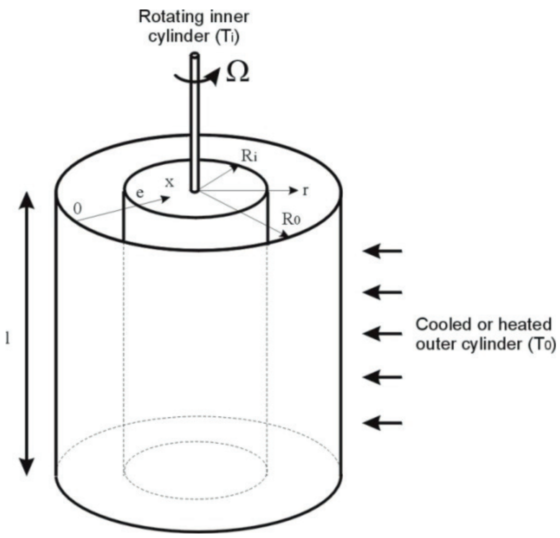
From the point of view of viticultural law the partially fermented wine must can be classified as a partially fermented must coming from exclusively from wine grapes which were harvested and processed in the land of Czech Republic. Term of partially fermented wine are defined by EU regulations as a product obtained by fermented wine must with a real amount of alcohol higher than 1% and lower than 3/5 of all amount of alcohol. According to viticultural law (Česko, 2004) the partially fermented wine must can be offered to straight consumption between the 1st of August and 30th of November of calendar year.

The partially fermented wine must is a semi-finished product during production of wine, it is a speciality of Bohemia and Moravia, alternatively of bordering Austria where it holds Sturm trademark. In other countries it is rarely consumed. Grapes variety and ripeness is determinative for quality of both partially fermented wine must and wine. High-quality partially fermented wine must in the best phase of high fermentation contains (4–6) volume % of alcohol and it is characterized by harmonical relation of sugar and acids, contains great amount of vitamins (complex of vitamins B – thiamin, nicotinic acid, nicotinamide, pantothenic acid) and other ingredients. The partially fermented wine must is made of must created during grapes pressing and its fermentation which has several phases. Yeasts cause fermentation of wine must – the process of fermentation itself disperse sugar and glucose when alcohol and carbon dioxide arise. The partially fermented wine must arises in stormy phase of fermentation (Burčákomat, 2014).

Several publications deal with the kinematic viscosity of certain wines (Košmerl *et al.*, 2000; Havlíček *et al.*, 2007). Only one publication has been found for partially fermented wine must (López *et al.*, 1989). As it is a little researched topic, every publication which deals with this issue is very beneficial.

MATERIAL AND METHODOLOGY

Samples of partially fermented wine must from fruits of grapevine variety of Pinot Gris were



1: *Scheme of device measuring geometry (Kumbár and Sabaliauskas, 2013)*

prepared and studied. Taking of partially fermented wine must were realized during stormy phase fermentation consequently to divide into four same samples at volume of 100 ml each. Two of the samples were storaged for the duration of 132 hours in a cold environment at temperature 5 °C and other two samples were storaged for the same duration at room temperature ~20 °C.

The samples from the cold environment were marked as a cold_1 and cold_2, samples storaged at room environment were marked as temp_3 and temp_4.

Experimental measuring of viscosity were made on a rotary viscometer Anton Paar DV-3P (Graz, Austria) fixed with standardized spindle TR8. Adapter using to measure small samples showing low viscosity as it was used in a publication (Kumbár and Dostál, 2014) as well. Spindle revolution were set on 100 RPM (shear rate 93 s^{-1}) and 200 RPM (shear rate 186 s^{-1}), frequency of sampling on 1 Hz. The scheme which measuring geometry of device is displayed on the Fig. 1.

Relation for calculation of kinematic viscosity is demonstrated by ratio of absolute or dynamic viscosity and density at the same temperature (Kumbár *et al.*, 2015):

$$\nu = \frac{\eta}{\rho}, \quad (1)$$

where
ν .... kinematic viscosity [$m^2.s^{-1}$],
η .... absolute or dynamic viscosity [Pa.s],
ρ .... density [$kg.m^{-3}$].

RESULTS AND DISCUSSION

Measurement was performed first, which predictably (Pickering *et al.*, 1998; Yanniotis *et al.*, 2007) confirmed that partially fermented wine must shows features of Newton fluid. Time optionality of viscosity was proved as well. The results of individual samples of kinematic viscosity are displayed in the Tab. I. These results are graphically processed in graphs on the Fig. 2 samples storaged in a cold environment 5 °C, on the Fig. 3 there are samples storaged at room temperature ~20 °C.

Various trends are obvious from measured values and graphical processing. Kinematic viscosity of samples which were storaged at temperature 5 °C firstly increased then it remained on a stabilized value. Vice versa samples storaged at room temperature ~20 °C firstly showed decrease of kinematics viscosity and then remained on a stabilized value.

In accordance with discovered trends of viscosity behaviour of individual samples of partially fermented wine must was chosen to consequent mathematical simulation (aproximation) suitable logarithmic function as per general form.

$$y(x) = a_1 \ln(x) + a_0. \quad (2)$$

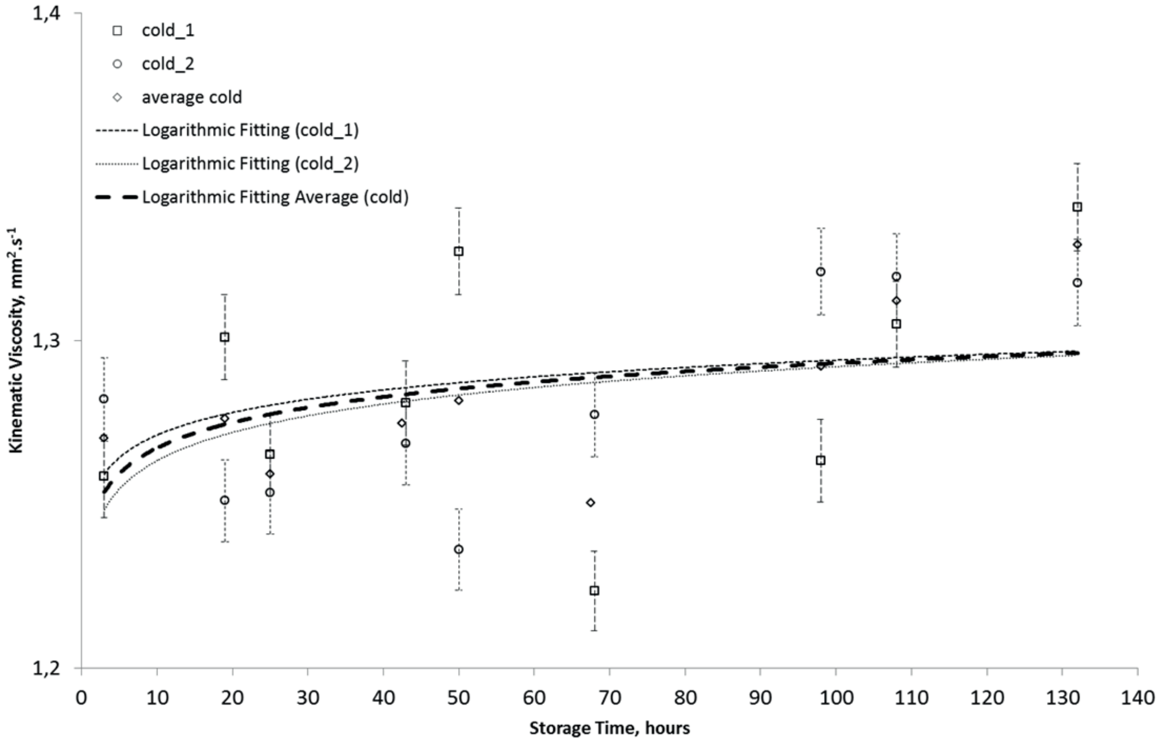
For calculation of kinematic viscosity at known time (in hours) at certain interval stands relation:

$$\nu(t) = a_1 \ln(t) + a_0, \quad (3)$$

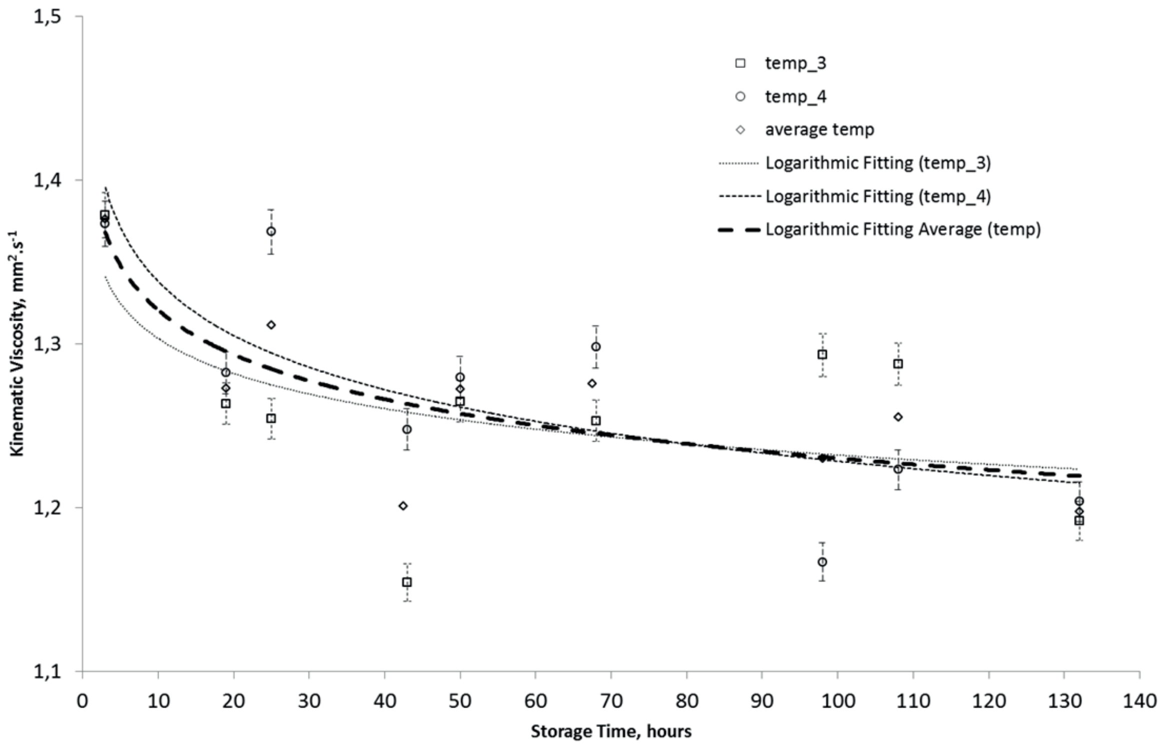
where
ν .... kinematic viscosity [$mm^2.s^{-1}$],
t ..... time [hour],
a .... coefficients.

I: *Values of samples kinematics viscosities (data are displayed as measured value ± 1% error of a measuring device) during fermentation*

hours	cold_1 ν, $mm^2.s^{-1}$	cold_2 ν, $mm^2.s^{-1}$	temp_3 ν, $mm^2.s^{-1}$	temp_4 ν, $mm^2.s^{-1}$
3	1.258 ± 0.013	1.282 ± 0.013	1.378 ± 0.014	1.373 ± 0.014
19	1.301 ± 0.013	1.251 ± 0.013	1.263 ± 0.013	1.282 ± 0.013
25	1.265 ± 0.013	1.254 ± 0.013	1.254 ± 0.013	1.368 ± 0.014
43	1.281 ± 0.013	1.268 ± 0.013	1.154 ± 0.012	1.248 ± 0.012
50	1.327 ± 0.013	1.236 ± 0.012	1.265 ± 0.013	1.280 ± 0.013
68	1.224 ± 0.012	1.277 ± 0.013	1.253 ± 0.013	1.298 ± 0.013
98	1.263 ± 0.013	1.321 ± 0.013	1.293 ± 0.013	1.167 ± 0.012
108	1.305 ± 0.013	1.319 ± 0.013	1.288 ± 0.013	1.223 ± 0.012
132	1.341 ± 0.013	1.318 ± 0.013	1.192 ± 0.012	1.203 ± 0.012



2: *Changes of samples kinematic viscosity stored at temperature 5 °C during fermentation*



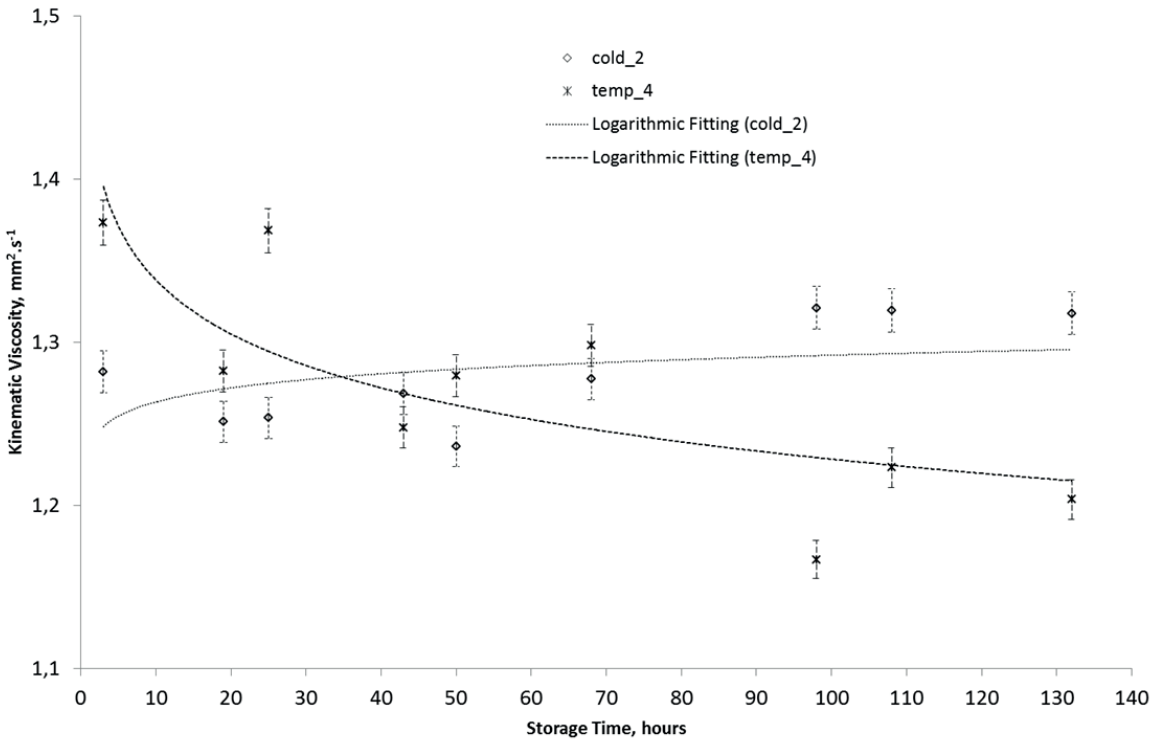
3: *Changes of samples kinematics viscosity stored at room temperature ~20 °C during fermentation*

In Tab. II there are displayed values of coefficients a, correlative coefficients R, significance levels p and coefficients of determination R^2 for logarithmic function of individual samples of partially fermented wine must.

To asses the statistical indicator in Tab. II it is obvious that for more suitable prediction of viscosity behaviour is spacing logarithmical function at samples of partially fermented wine must cold_2 and temp_4. This is demonstrated mainly by high

II: *Values of coefficients*

sample	a_0	a_1	R	p	R^2
cold_1	1.2483	0.0099	0.38	0.318	0.10
cold_2	1.2346	0.0125	0.77	0.014	0.21
temp_3	1.3744	–0.031	–0.33	0.392	0.33
temp_4	1.4479	–0.048	–0.82	0.006	0.64



4: *Changes of samples kinematic viscosity cold_2 (5 °C) and temp_4 (20 °C) during fermentation*

absolute correlational coefficient values R = 0.77 a R = 0.82, also by low values of significance level p = 0.014 and p = 0.006. The processes of kinematic viscosity are comparatively pictured in graph on the Fig. 4.

CONCLUSION

In this article there was studied process of kinematic viscosity of four samples partially fermented wine must from grapevine variety Pinot Gris. Partially fermented wine must was taken during stormy fermentation. Two of the samples were storaged in a cold environment 5 °C and other two samples were storaged at room temperature ~20 °C. The kinematic viscosity were measured in a process of 132 hours from the beginning of stormy fermentation, always after approximatly 16 hours. The rotary viscometer with standartized spindle was used for experiments along with the adapter using for measuring of small samples showing low viscosity. Samples which were storaged in a cold environment had increased kinematic viscosity and then remained on a stabilized value. Vice versa samples storaged in the room temperature showed firstly decrease of kinematic viscosity and then als remained on the stabilized value. The process of kinematic viscosity was also processed and mathematically modelled by using logarithmical function. The proposed mathematical models were of high quality accuracy which were proved by correlation coefficients levels and significance levels. After assessment of statistical data it is obvious that spacing by logarithmical function at partially fermented wine must samples cold_2 and temp_4 is better for prediction of viscosity behaviour. It is caused mainly with both high absolute levels of correlation coefficient R = 0.77, R = 0.82 and low significant levels p = 0.014, p = 0.006. Several publications deal with the kinematic viscosity of certain wines. There was no describtion found for partially fermented wine must and that is why it can be said that this can be original article dealing with this problematic. Results which are contained in this article can serve as an example for prediction behaviour of partially fermented wine must of grapevine's fruit.

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