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BIOLOGICAL EFFECT OF MAGNETIC FIELD ON THE FERMENTATION OF WINE

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ABSTRACT

During the transformation process of matter is produced energy, which afterwards interacts with matter itself, and other forms of energy. Energy induced electromagnetic appliances may affect the processes occurring in biological systems. In our study we have evaluated the wine fermentation process of the magnetic field with different amplitudes of electromagnetic induction, the constant exposure of 30 minutes a day for 10 days. The device for inducing magnetism was constructed at the Department of Fruit Growing, Viticulture and Enology at Slovak University of Agriculture in Nitra for research purposes. Essence of the device lies in the way of the management of direct current, which flows through the coil. Volume of direct current is regulated by network auto-transformer. Output of network autotransformer is rectified by two-way bridge rectifier. The coil is powered by a direct current voltage pulse. This device has a maximum value of the magnetic induction at 150 mT. At full power it must be supplied from three-phase socket with a rated current of 32 A. For our experiment, we chose wine grape variety of Hibernal, from Nitra wine region. The magnetic field induced by the electromagnetic device has an impact on the process of fermentation and sensory characteristics of a young wine. As part of the sensory profile, we noticed higher levels of residual sugar and speed up of the fermentation process and the process of purifying of the young wine. The influence of magnetic field on grape juice during the entire fermentation process and production of wine is a convenient way to improve the quality of wine without side effects or any chemical additives.

Keywords: wine; *Saccharomyces cerevisiae*; fermentation; magnetic field

INTRODUCTION

The low frequency magnetic field without thermal effect with a field strength of less than 0.1 mT induces a number of effects in cells and tissues **(Blank, 1995; Goodman et al., 1995; Hong, 1995)**. Such effects include increased activity of the enzyme ornithine decarboxylase, Na, K-ATPase and cytochrome oxidase **(Byus et al., 1988; Blank, 1995; Blank and Soo, 1998)**. Enhanced expression of genes which were exposed to the magnetic field indicates that the cells respond to the magnetism as the environmental stress **(Goodman and Blank, 1995)**.

Non-thermal effects are given to do to long term treatment with weak fields. It is explain by the electromagnetic induction, with initiates formation of ion current in irradiated tissue. Biological properties of cell membranes (their permeability) and excitability are changing by influence of this ion current **(Cabanová, 2004)**.

It is assumed, magnetic field at first induces the interaction with the cell membrane, which activates signalising pathways leading to the core, resulting in the synthesis of stress proteins. However, the cell membrane is the place of interaction with the magnetic field of the cell. The increase in receptor binding and activation was established as well as the increased activity of membrane enzymes **(Blank, 1995)**.

Other studies of cells and organisms interact with the magnetic field show the effect of the magnetic field on the cell metabolism. **(Belyavskaya et al., 1992; Dardeniz et al., 2006)**. **Anton-Leberre et al. (2009)** prove no effect of magnetic field to yeast *Saccharomyces cerevisiae*, because of using strong static (up to 16 T for 8 h) and pulsed (up to 55 T single-shot and 4 x 20 T repeated shots) magnetic fields with are different conditions in experiment than we created.

MATERIAL AND METHODOLOGY

In the experiment, we focused on studying the influence of magnetic field on the fermentation of wine varieties Hibernal, from the harvest which was performed in 2016, by the yeast *Saccharomyces cerevisiae*. The grape juice, which was made out of this harvest contains 20.4 kg of sugar per one hectoliter. Grapes which have been used for this purpose came from Nitra wine region, directly from the botanical garden Slovak University of Agriculture. For the production of research sample were used healthy crops,

free from mold and other undesirable effects, so there was only minimal need for usage of sulfur.

Hibernal is an interspecific white wine grape variety, which was created by breeding varieties Seibel 7053 (Chancellor) x Riesling. The visual characteristics of this variety is defined as follows: medium-sized berry, yellow-red, medium length stems. The variety is very resistant to winter and spring frosts. From a sensory perspective, the wine from this variety has Riesling character, accompanied by subtle notes of savignon and pleasant acidity. Variety is suitable for the production of organic wine and aging in oak barrels. Character has taste characteristics of peach, grapefruit and citrus, also spicy notes.

The experiment was conducted in the laboratory, there were used three samples of the volume of 1.1 litres of fermentation wine, which were in the beginning of the fermentation exposed to electromagnetic field (EMF). Grape wine in the control sample for comparison of results was not exposed to EMF.

Electromagnetic induction coil used in our experiment was constructed by co-author of this research J. Jedlička. Induction coil internal diameter 2R = 55 cm (Figure 1) generated the magnetic field by proposal of **Horák and Krupka (1976)** with relation to the solenoid.

Description of electromagnetic inductor

Electromagnetic inductor (coil), which we used in our experiments consists of the following components:

- Supply Network Driver,
- voltage transducer,
- The measurement of magnetic induction,
- leads with an induction coil,
- cylindrical induction coil.

The line voltage 230V ---Voltage Inverter --- magnetic induction meter --- Inductor

$$B = \frac{\mu_0 \mu_r I z}{\sqrt{l^2 + (2R)^2}}$$

Figure1 Block diagram of the device

In which:

$\mu 0$ = the permeability of free space $4\pi.10^{-7}$ [m.kg. $p^{-2}.A^{-2}$],

μr = the relative permeability of the medium [-],

I = the electric current [A],

z = the number of turns of coil [-],

l = the length of coil [m],

R = the radius of the coil [m].

Experimental samples were magnetized by the aforementioned electromagnetic induction coil in the volume of the induction 10 mT, 40 mT, 100 mT and exposure for 30 minutes, five times a week for a total duration of 10 days. All options for the final fermentation and purification were bottled and stored in premises with a temperature of 13 °C.

Analysis of wines

The analysis was performed on the unit specialized for the analysis of wines FT / NIR spectrometer from Bruker Optics alpha wine analyser. Before analysing each variant was centrifuged to avoid measurement inaccuracies due to random impurities. The analysis of each variant was performed after completion of fermentation, individually for each sample, and the final value is the average of three single measurements.

Sensory evaluation

Sensory evaluation was performed by qualified and professional wine judges in accordance to the 100-point system of the International Union of Enologists (I.U.E.), in the total number of five persons. Lowest and highest value for each sample assessment were eliminated. Average values obtained from three evaluators were rounded to total numbers.

Statistical analysis

The data collected from the experiment was evaluated by our statistical method ANOVA (analysis of variance between groups).

RESULTS AND DISCUSSION

Analysis of the wine did not prove statistically significant differences in different versions in the amount of all acids or glycerol. The highest amount of alcohol was observed in the control sample – 10.93%, the other three variants had lower levels of alcohol what can be the result of increased value of the stress caused by the magnetic field. The lowest value of alcohol was recorded in experimental variant no. two (40 mT) – 10.5%. The most significant difference among the magnatized samples was noticed in sample no. two, which was exposed to the influence of the EMF of 40 mT strength. Fermentation stopped two days earlier, than in the other variants and began final

Table 1 The results of sensory analysis.

		1. variant 100 mT	2. variant 40 mT	3. variant 10 mT	4. control variant
Appearance	**Clarity**	5	5	5	5
	Colour	10	10	10	10
Fragrance	**Intensity**	7	6	7	7
	Softness	5	3	4	4
	Quality	12	11	12	12
Taste	**Intensity**	7	7	7	7
	Softness	5	4	5	4
	Quality	16	16	16	16
	Persistence	7	7	7	7
general impression		10	9	10	10
total points		84	79	83	82

Table 2 Analysis of the ingredients.

		1. variant 100 mT	2. variant 40 mT	3. variant 10 mT	4. control variant
Acetic acid	**[g.L^{-1}]**	0.48	0.48	0.49	0.48
Citric acid	**[g.L^{-1}]**	0.05	0.23	0.11	0.02
Malic acid	**[g.L^{-1}]**	2.7	2.73	2.83	2.87
Tartaric acid	**[g.L^{-1}]**	3.78	3.61	3.67	3.47
Lactic acid	**[g.L^{-1}]**	0.71	0.57	0.66	0.74
Total acid	**[g.L^{-1}]**	0.77	7.6	7.57	7.4
Density		0.995	0.996	0.995	0.995
Fructose	**[g.L^{-1}]**	0.67	2.47	0.7	1.13
Glucose	**[g.L^{-1}]**	1.3	1.13	1.4	1.2
Saccharose	**[g.L^{-1}]**	0.5	0.6	0.3	0.4
Total sugar	**[g.L^{-1}]**	1.43	3.17	1.4	1.77
Alcohol	**[%]**	10.67	10.5	10.77	10.93
Glycerol	**[g.L^{-1}]**	5.93	5.87	5.93	5.7
pH		3.36	3.32	3.36	3.37

purification. Variant no. two (40 mT) was the purest of all samples, and by sensory analysis contained also the most of sugar. This argument was proved by the analysis of wine. Fructose content in variant no. two (40 mT) is 2.47 g.L^{-1}, which is the highest value. The lowest value of fructose was recorded in variant no. one (100 mT), 0.67 g.L^{-1}. Variant no. one (100 mT) completed its fermentation as the second, one day earlier than the control variant. As it is mentioned the total sugar content was highest in the variant no. two (40 mT) – 3.17 g.L^{-1}.

The best organoleptic characteristics of wine had the first experimental variant (100 mT), which was valued at an average of 84 points in total. The variant no. two was rated the lowest (40 mT), it received an average of 79 points.

The results of the experiment indicates, that the stress in a magnetic field of 40 mT, frequency of 50 Hz, and 30 minutes exposure for 10 days on the fermentation wine, induced change in the yeast *Saccharomyces cerevisiae* of their enzymatic activity in the processing of sugars into alcohol. Increased metabolism of yeast in the variant no.

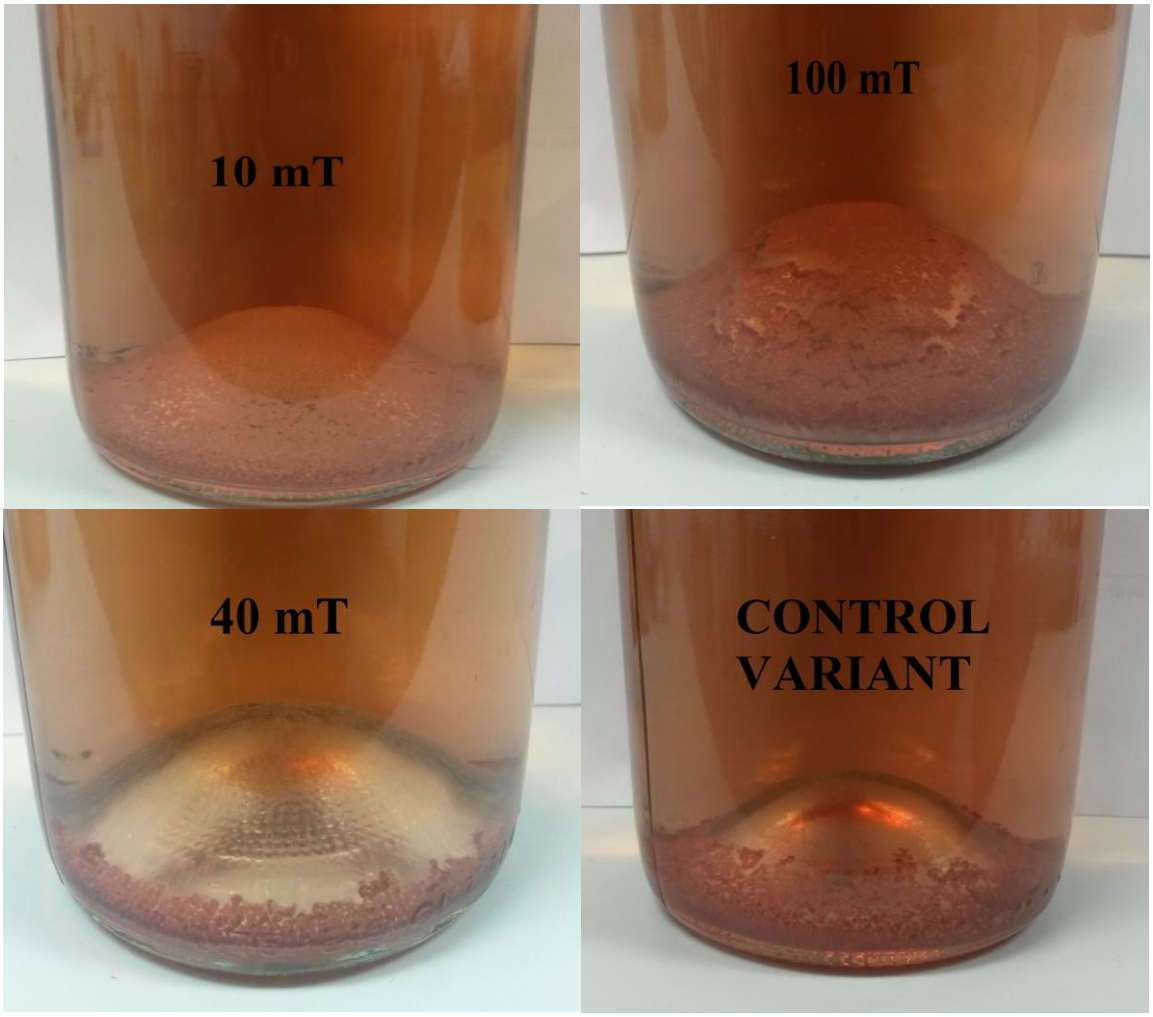

Figure 2 Differences in quantitiesoftartariccrystalsatthebottomofbottles.

two (40 mT) and the change in the amount of each enzyme secreted led to increased metabolization of simple sugars and preferation glucose. It is necessary in the wine making process for the used yeast to prefer glucose over fructose, because fructose is for our palates sweeter. Accelerated metabolism caused a more rapid completion of the fermentation process by two days, in comparison to the other three variants, purification of the variant no. two (40 mT) was the fastest.

Rakoczy et al. (2016) exhibited yeast *Saccharomyces cerevisiae* to rotating magnetic field.The results of this study demonstrated change dynamic of growth, reducing the number of cells and cell metabolic activity of analyse yeast strains by the rotating magnetic field.

Low-frequency electromagnetic fields significantly affect the rate of biochemical oxidation – reduction reactions in used medium. Our research confirmed its positive impact on the relevant constituents and also on the sensory characteristics of the wine **(Ailer et al., 2013)**.

Redox potential reflects the effect of different redox reactions in some point. Experiments have shown that the magnetic field can change the activity of certain enzymes, such as katalase, superoxidedismutase, glutationreductase, glutationtransferase, peroxidase, ascobtát peroxidase or polyfenoloxidase. Experiments were conducted on cells of several plant species. Authors of this experiments are **Xia and Guo, 2000; Baby et al., 2011; Bhardwaj et al., 2012; Jouni et al., 2012; Radhakrishnan and Kumari, 2012; Radhakrishnan and Kumari, 2013; Shine et al., 2012; Serdyukov and Novitskii, 2013**. Results indicate that exposure of plants to magnetic field causes a change in enzymatic activities.

The magnetic field of 10 mT and the frequency of 50 Hz, influencing the yeast *Saccharomyces cerevisiae* for 24 min, reduces the yeast number in the colonies in and also slows their growth. Similar results were observed with *Escherichia coli*, *Stafilococcus aureus* and *Leclercia decarboxylata* **(Novak et al., 2005)**.

The characteristic taste of wine is influenced by numerous factors. The most important of these factors is the grape variety and quality. Among other substantive additional factors, indicating the quality of crops, belong: the composition of soil, tillage, and the most important part is the way of processing of grapes and wine production techniques. During the aging of wine are made esters that contribute to the characteristic fruity odor of wine. Sensory characteristics of wine are significantly influenced by polyphenols. The final taste and aroma of the wine, is not relying only on the quantitative representation of individual substances, but also on their combination and interaction **(Harmatha, 2009)**.

Measured differences in the content of certain substances in wine have repercussions on the overall taste profile of wine and were also encountered in sensory analysis. The observed differences in colour and clarity were among the only slight variants. The alcohol was in all variations in between 10% and 11%, and was not significant in the taste of the wine. Residual sugar, which was highest in variant no. two (40 mT), affects the taste of wine. After the final fermentation of residual sugar was evaluated positively, after one month aging at 13 °C the wine was warm and the smell less pronounced as confirmed by sensory analysis. Before sensory evaluation was recorded wine tartar at the bottom of the bottles, in variants one and three (100 mT and 10 mT) was coated across the base of the bottle and in variant two and four (40 mT and the control variant) was tartaric less than half as much.

CONCLUSION

Low-frequency electromagnetic fields significantly affect the rate of alcoholic fermentation of yeast *Saccharomyces cerevisiae*, presumably by varying the amount of secreted enzymes to convert sugars into alcohol.

We achieved improvement in sensory characteristics of the wine. As the most suitable was manifested the magnetic field of 100 mT. Wine with influence of magnetic induction of 40 mT stopped fermentation earlier, but it is necessary to choose a more suitable way for preserving positive taste qualities. Application of a magnetic field in the fermentation of wine seems to be an appropriate mean to achieve a higher quality in young wines already, with this technology without any residues and adverse effects. Changes in content substances and positive impact on the organoleptic characteristics should not be reversible and short-term and therefore it is necessary to continue research and continuously monitor parameters of wine during its regular wine life. The need to continue in the research is not urged only because of the fermented wine, but also because of the behaviour of yeast in a magnetic field. For a better understanding of the effects of magnetic fields on the yeast we will continue its examination, especially on pure culture yeast in bigger number of samples.

REFERENCES

Ailer, Š., Jedlička, J., Paulen, O. 2013. Biological effects of magnetic field on sensory profile and wine content (Biologické účinky magnetického poľa na senzorický profil a obsahové látky vína). *Potravinarstvo*, vol. 7, special no., p. 138-145. Available at: http://www.potravinarstvo.com/dokumenty/mc_march_2013/bezpecnost_potravin_rastlinneho_povodu/ailer.pdf

Anton-Leberre, V., Haanappel, E., Marsaud, N., Trouilh, L., Benbadis, L., Boucherie, H., Massou, S., François, J. M. 2009. Exposure to high static or pulsed magnetic fields does not affect cellular processes in the yeast Saccharomyces cerevisiae. *Bioelectromagnetics*, vol. 31, no. 1, p. 28-38.

Baby, S. M., Narayanaswamy, G. K., Anand, A. 2011. Superoxide radical production and performance index of Photosystem II in leaves from magnetoprimed soy bean seeds. *Plant Signaling and Behavior*, vol. 6, no. 11, p. 1635-1637. https://doi.org/10.4161/psb.6.11.17720

Belyavskaya, N. A. 2004. Biological effects due to weak magnetic field on plants. *Advances in Space Research*, vol. 34, no. 7, p. 1566-1574. https://doi.org/10.1016/j.asr.2004.01.021

Bhardwaj, J., Anand, A., Nagarajan, S. 2012. Biochemical and biophysical changes associated with magnetopriming in germinating cucumber seeds. *Plant Physiology and Biochemistry*, no. 57, p. 67-73. https://doi.org/10.1016/j.plaphy.2012.05.008

Blank, M. 1995. Na/K-Adenosine-Triphosphatase. *Advances in Chemistry*, vol. 250, p. 339-348. https://doi.org/10.1021/ba-1995-0250.ch019

Blank, M., Soo, I. 1998. Enhancement of cytochrome oxidase activity in 60 Hz magnetic fields. *Bioelectrochemistry*

and Bioenergetics, vol. 45, no. 2, 1998, p. 253-259. https://doi.org/10.1016/S0302-4598(98)00086-5

Byus, C. V., Kartun, K., Pieper, S., Adey, W. R. 1998. Increased omithine decarboxylase activity in Cultured cells exposed to low energy modulated microwave fields and phorbol ester tumor promoters. *Cancer Research*, vol 48, no. 15, p. 4222-4226.

Cabanová, Z. 2004. Biological effects of electromagnetic field (Biologické účinky elektromagnetického poľa). *Advances in Electrical and Electronic Engineering*, vol. 3, no. 1, p. 24-29.

Dardeníz, A., Tayyar, S., Yalcin, S. 2006. Influence of low frequency electromagnetic field on the vegetative growth of grape. *Journal Central European Agriculture*, vol. 7, no. 3, p. 389.

Rakoczy, R., Konopacki, M., Fijalkowski, K. 2016. The influence of a ferrofluid in the presence of an external rotating magnetic field on the growth rate and cell metabolic activity of a wine yeast strain. *Biochemical Engineering Journal*, vol. 109, p. 43-50. https://doi.org/10.1016/j.bej.2016.01.002

Goodman, R., Blank, M. 1995. Biosynthetic stress response in cell sex posed to electromagnetic fields. *Advances in Chemistry*, vol. 250, p. 423-436. https://doi.org/10.1021/ba-1995-0250.ch023

Goodman, E. M., Greenebaum, B., Marron, M. T. 1995. Effects of electromagnetic fields on molecules and cells. *International Review of Cytology*, vol. 158, p. 238-279. https://doi.org/10.1016/S0074-7696(08)62489-4

Harmatha, J. 2009. The quality of wine from the aspect of a chemist and sommelier (Kvalitavína z pohledu chemika a sommeliéra). In *Proceedings – Wine as a multicultural phenomenon (Víno jako multikulturní fenomén)*. Olomouc : Palacký University, Department of Philosophy, pp. 69-75.

Hong, F. T. 1995. Magnetic field effects on biomolecules, cells and living organisms. *Biosystems*, vol. 36, no. 3, p. 187-229. https://doi.org/10.1016/0303-2647(95)01555-Y

Horák, Z., Krupka, F. 1976. *Fyzika. Příručka pro vysoké školy technického směru*. 2nd ed. PRAHA : SNTL/ALFA. ISBN 04-011-76.

Jouni, F. J., Abdolmaleki, P., Ghanati, F. 2012. Oxidative stress in broad bean (*Vicia faba* L.) induced by static magnetic field undernatural radioactivity. *Mutatation Research*, vol. 741, no. 1-2, p. 116-121. https://doi.org/10.1016/j.mrgentox.2011.11.003

Novák, J., Strašák, L., Fojt, L., Slaninová, I., Vetterl, V. 2005. Effects of low-frequency magnetic fields on the viability of yeast *Saccharomyces cerevisiae*. *Bioelectrochemistry*, vol. 70, no. 1, p. 115-121. https://doi.org/10.1016/j.bioelechem.2006.03.029

Radhakrishnan, R., Kumari, B. D. R. 2012. Pulsed magnetic field: a contemporary approach offers to enhance plant growth and yield of soy bean. *Plant Physiology and Biochemistry*, vol. 51, p. 139-144. https://doi.org/10.1016/j.plaphy.2011.10.017

Radhakrishnan, R., Kumari, B. D. R. 2013. Influence of pulsed magnetic field on soy bean (*Glycine max* L.) seed germination, seed ling growth and soil microbial population. *Indian Journal of Biochemistry and Biophysics*, vol. 50, no. 4, p. 312-317.

Serdyukov, Y., Novitskii, Y. I. 2013. Impact of weak permanent magnetic field on antioxidant enzyme activities in radish seed lings. *Russian Journal of Plant Physiology*, vol. 60, no. 1, p. 69-76. https://doi.org/10.1134/S1021443713010068

Shine, M., Guruprasad, K., Anand, A. 2012. Effect of stationary magnetic field strengths of 150 and 200 mT on reactive oxygen species production in soybean. *Bioelectromagnetics*, vol. 33, no. 5, p. 428-437. https://doi.org/10.1002/bem.21702 PMid:22253132

Xia, L., Guo, J. 2000. Effect of magnetic field on peroxidase activation and isozyme in *Leymus chinensis*. Ying Yong Sheng Tai Xue Bao, no. 11, no. 5, p. 699-702.

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