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THE IMPORTANCE OF HIGHER ALCOHOLS AND ESTERS FOR SENSORY EVALUATION OF RHEINRIESLING AND CHARDONNAY WINE VARIETIES

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ABSTRACT
For a consumer, one of the first characters for evaluation of wine is its scent. A pleasant aroma of wine associated with the subsequent taste experience can be remembered by the consumer for a long time and appreciated appropriately. For this reason, the aromatic properties of wine are very important to both consumers and producers. The question, however, is to assess the evaluation of wine sensory evaluation based on a rapidly developing chemical analysis without the use of a panel of evaluators. This study has dealt with the problem of the correlation of sensory evaluation of wine with the total content of higher alcohols and esters in wine prepared from the same wine varieties (Rheinriesling and Chardonnay) on the same vineyard under the same climatic conditions and processed using the same production technology in the years 2008 - 2012. The total content of higher alcohols and esters was determined by gas chromatography with a mass spectrometer (GC/MS). The correlation between the sensory evaluation and the total content of higher alcohols has not been established. However, the direct effect of the total content of the esters on the level of the sensory analysis of the two varieties studied was demonstrated. This can be an important economic indicator for a manufacturer who can estimate the sensory quality of the wine only on the basis of chemical analysis and thus estimate the success of the wine on the consumer market.

Keywords: wine; Chardonnay; Rheinriesling; total content of higher alcohols; total ester content

INTRODUCTION
Products of grapevine are a significant source of biologically active substances with a positive effect on a human health **(Snopek et al., 2018a)**. A wine is considered as one of those products with a long tradition and popularity amongst consumers **(Soyollkham et al., 2011; Mlček et al., 2018)**. A food made from grapes of grapevine or a food where sensorial or technological attributes can be enhanced by their addition is counted between these products **(Boudová Pečivová et al., 2014)**.

The quality of grape wines and fruit spirits is assessed not only by the results of physico-chemical analyzes but also by sensory assessment of their properties (sensory analysis). From the sensory point of view, the content of flavorings in the food is important for the consumer. Aromatic substances here are all fragrances and flavors that create a complex sensory sensation called flavor (aroma) of food. Aromatic substances are either a natural ingredient of food (as primary flavorings) or are formed during food and beverage processing and storage, enzymatic and chemical reactions (as secondary or tertiary aromatics) **(Hampl, Rádl and Paleček, 2007; Patra, Kim and Baek, 2015; Zhang, 2017)**.

Perception of smell is one of the important psychological aspects in eating foods that you remember for a long time unlike other senses. This can be used in sensory evaluation, especially when evaluating foods with a wide range of aromatic substances, such as wine **(Lawless and Heymann, 2010)**.

There are many different flavors for the wine, especially the esters that are formed by the reaction of alcohols and acids. The finished wine has more than 300 different esters. Esters in wine are produced in two different ways: enzymatic esterification during fermentation and chemical esterification during long-term ripening **(Jacobson, 2006; Ribéreau-Gayon et al., 2006)**. There are several factors contributing to the formation of esters during fermentation, such as grape maturity and sugar content, yeast strains used, fermentation temperature, vinification methods, variety, pH of must and sulfur dioxide. Biochemical reactions occurring during maturation and storage may affect the aroma and quality of the wine. The fruit character of the wine can be lost very quickly depending on the storage temperature **(Pavelková, 2005)**. Yeasts, due to their esterase activity, form different esters (in a quantity of several $mg.L^{-1}$). Higher ester content is found in white wines compared to red wines, especially when a lower temperature is used during vinification **(Clarke and Bakker, 2004)**.

Chardonnay is an old grape variety for a white wine production, originating from Burgundy. This grape variety is adaptable. It is favored among winemakers because it is easier to cultivate than other varieties. This grape variety is resilient to extreme climate conditions and can adapt to various types of a soil. It ripens quite reliably and has a good yield. In comparison to other grape varieties, Chardonnay has a neutral taste. It can also retain fruitlike flavor **(Callec, Ptáček and Svobodová, 2007)**.

Riesling is an old grape variety with a production of high-quality white wines **(Lapčíková, 2017)**. This grape variety originates from Rhine basin area in Germany. Its flavor may vary from steel-like, in unripe vintages, through peppery, crisply spicy to maturely fresh. Peach, both green and yellow apple, orange, lemon peel, quince, and in softer wines apricot, pineapple, honey, marzipan, almonds and even raisins can be found in its flavor **(Kraus et al., 2005)**.

From the consumer's point of view, the sensory quality of the wine is very important. Sensory evaluation of wine can be subjective and influenced by many aspects. On the contrary, the rapidly developing analytical methods are objective methods under different circumstances. Based on the correlation between analytical values and sensory evaluation, the sensory quality of the product and the consumer's interest could be estimated. This could become one of the key economic indicators in introducing a given vintage wine into the consumer market.

Scientific hypothesis

Scientific hypothesis is: The overall sensory evaluation of the selected type of wine correlates with the content of aromatic substances (higher alcohols and esters) in wine. (Correlation coefficient is greater than 0.95).

The aim of the study was to find out the correlation between the total point assessment of sensory analysis and the total content of higher alcohols and esters in selected wine varieties. Wine samples were selected with respect to their comparability - they are made from the same varieties, grapes for their production come from the same vineyard and are made using the same technology.

MATERIAL AND METHODOLOGY

Wine samples

In total 10 samples of wine – 5 samples of Chardonnay (further marked as CH + respective vintage) and 5 samples of Riesling (further marked as RR + respective vintage) – was used to determine the content of individual aromatic substances. **Table 1** shows a description of individual wine samples.

Presented wine samples were of the same grape variety from the same vineyard track and made using the same technology. Grapes come from vineyard track "Horní hory – Pohany", city Bzenec, region Slovácko, area Morava. This vineyard track is one of the most suitable for cultivation of grape varieties, typical for this winemaking region.

Methodology of sensory evaluation of wine

The evaluation of the wine was performed according to the 100 points scale of the International Union of Oenologists UIOE **(Kuttelvašer, 2003)**. The evaluation was carried out by a twelve-member panel of trained assessors with practical experience of seven men and five women. The age of the evaluators ranged from 28 to 71 years. Prior to the evaluation, a short briefing was conducted by the Chair of the Panel to specify the evaluation tasks.

Table 1 Description of individual wine samples.

Sample	Date of harvest	Sugar content [°NM]	Total alcohol content [% vol.]	Reducing sugars content [g.L^{-1}]	Classes according to remaining sugar	Quality
			Riesling			
RR 2008	10.11.2008	21.6	12.78	2.2	dry	PS
RR 2009	29.10.2009	23	13.74	9.9	medium dry	PS
RR 2010	23.10.2010	22	12.31	1.5	dry	PS
RR 2011	24.10.2011	22.2	12.97	7.9	medium dry	PS
RR 2012	13.10.2012	22.2	12.94	4.1	medium dry	PS
			Chardonnay			
CH 2008	21.10.2008	22.6	13.32	4.50	dry	PS
CH 2009	23.10.2009	24.6	14.57	10.6	medium dry	VH
CH 2010	17.10.2010	22.8	12.62	2.3	dry	PS
CH 2011	05.10.2011	24	13.61	11.7	medium dry	VH
CH 2012	02.10.2012	24.2	13.7	3.6	dry	PS

Note: VH – special selection of grapes, PS – Late harvest, RR – Riesling + respective vintage, CH – Chardonnay + respective vintage.

Method of aromatic substances content determination using GC/MS

Individual aromatic substances content in wine samples was determined using gas chromatography with a mass spectrometer (GC/MS). Used apparatus was GCMS – QP2010 Ultra (Shimadzu, Japan) with Supelco SP MTM – PUFA column sized 30 m × 0.25 mm × 0.25 µm. Each vintage was analyzed three times. The sum of all the monitored higher alcohols found in the sample was used to calculate the correlation. Higher alcohols – isobutyl alcohol, propyl alcohol, pentyl alcohol, isobornyl alcohol, phenylethyl alcohol and n-butanol were found in the samples. The sum of all observed esters that were found in the sample (19 in total) was used to calculate the correlation.

Chromatographic conditions were following:

Injector

Injection temperature	200 °C
Flow regulation	Linear flow velocity
Column flow	1.22 mL.min^{-1}
Flow velocity	39.9 cm

Column

Temperature program	40 °C – 6 min
	57 °C – 4 min
	180 °C – 0 min

Detector

Interface temperature	220 °C
Ion source temperature	200 °C
Detector voltage	0.80 kV

Statistical analysis

The data were analyzed using Excel 2013 (Microsoft Corporation, USA) and STATISTICA Cz version 12 (StatSoft, Inc., USA). Results were expressed by average ± standard deviation. The correlation between the overall score of the sensory analysis and the total content of higher alcohols and esters in selected wine varieties was determined using the Pearson correlation coefficient.

RESULTS AND DISCUSSION

Basic results

The basic results of the sensory analysis of the monitored wines samples and their total content of higher alcohols and esters are given in **Table 2**. The table shows the average number of points obtained by sensory evaluation of samples of individual wine samples and the total content of higher alcohols and the total content of esters obtained from chemical analysis of wine using gas chromatography with a mass spectrometer (GC/MS).

As reported by **Francis and Newton (2005)** and **Melherbe (2011)**, higher alcohols significantly affect the variability of wine aromas (honey, spicy, whiskey, pink and similar scents) at concentrations below 300 mg.L^{-1}. In the case of higher concentrations (above 600 mg.L^{-1}), they can cause an unpleasant aroma of wine that resembles a dissolving agent. Our measured values in our study did not exceed 600 mg.L^{-1}and are consistent with the total amount of higher alcohols in the 150 – 700 mg.L^{-1}wine reported by **Steidel (2010)**.

According to **Farkaš (1983)**, young wine ranges from 2 to 6 mg.L^{-1} and older wines around 10 mg.L^{-1}. On the other hand, **Tomanová (2015)** reports the measured content of the individual esters in wine at 10 and 100 mg.L^{-1}, so the total content of the measured esters is higher than that reported by **Farkaš (1983)**. The results measured in this study are in accordance with **Tomanová (2015)**. The reason for this wide spread may be several factors, such as grape maturity and sugar content, yeast strains used, fermentation temperature, vinification methods, variety, pH of must and sulfur dioxide. Biochemical reactions occurring during maturation and storage may affect the aroma and quality of the wine. The fruit character of the wine can be lost very quickly depending on the storage temperature **(Pavelková, 2005)**.

In spite of the effort to adhere to the strict conditions of the experiment (the same cultivation site, the same agrotechnical technology, the same technological process of production), unconscious increases in the quality of these production conditions (e.g. subconscious

Table 2 Basic results of the sensory analysis of the monitored vines samples and their total content of higher alcohols and esters.

Sample	Sensory evaluation [points]	Total content of higher alcohols [mg.L^{-1}]	Total content of esters [mg.L^{-1}]
RR 08	92	182	438
RR 09	91	162	420
RR 10	89	298	406
RR 11	73	438	310
RR 12	78	251	339
CH 08	71	183	162
CH 09	85	335	331
CH 10	93	210	438
CH 11	82	438	290
CH 12	80	162	271

Note: RR – Riesling + respective vintage, CH – Chardonnay + respective vintage.

improvements in the quality of workers who can gain more experience each year) The results of the sensory evaluation of individual samples of grape wines do not show any significant dependence according to years, which shows the independence of the wine production process in case of possible improvement of production.

Results of sensory evaluation of grape wines in context to the total content of higher alcohols

In the fermentation process, ethanol, carboxylic acids and higher alcohols (the so-called "blooms") are formed in the third phase. Higher alcohols significantly contribute to the bouquet of mature wine. The total content is from 150 to 700 mg.L^{-1} **(Steidl, 2010)**.

The correlation between the sensory evaluation of samples and the total content of higher alcohols was analyzed for the Rheinriesling variety and the Pearson correlation coefficient was determined. The Pearson correlation coefficient was r = -0.8052 and the correlation equation:

Sensory evaluation [points] = 101.23 – (0.0625 × Total content of higher alcohols [mg.L^{-1}])

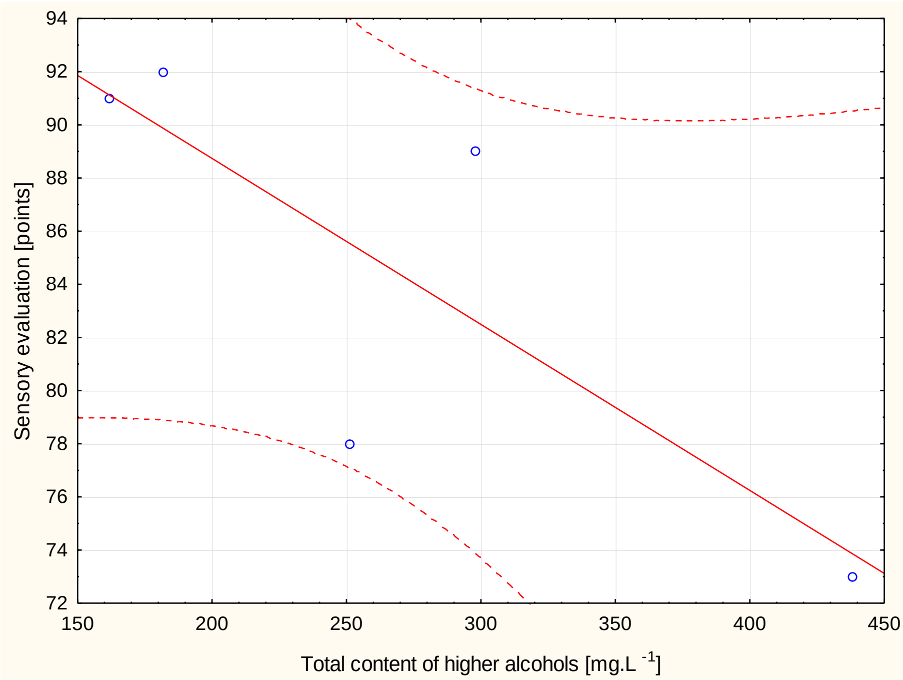

Figure 1 Graph of the correlation between the total content of higher alcohols [mg.L^{-1}] and the sensory evaluation [point] of the Rheinriesling.

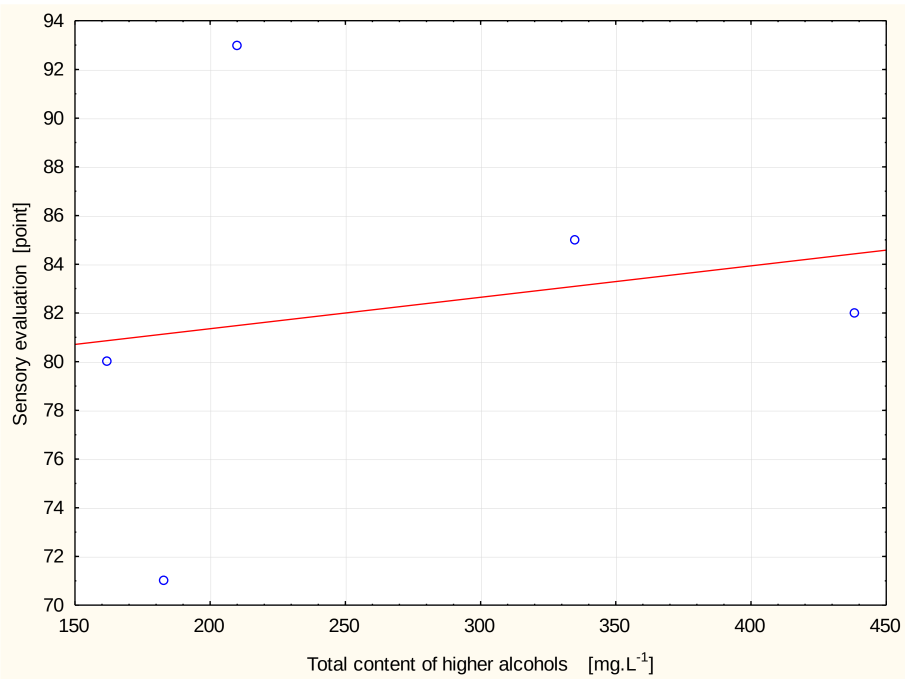

Figure 2 Graph of the correlation between the total content of higher alcohols [mg.L^{-1}] and the sensory evaluation [point] of the Chardonnay variety.

The results show a intermediate correlation of the total score of sensory analysis with the total content of higher alcohols in the sample of wine.

This fact is confirmed by the graph in **Figure 1**.

For the Chardonnay variety, the Pearson correlation coefficient was determined by r = 0.18998 and the correlation equation:

Sensory evaluation [points] = 78.771 + (0.01291 × Total content of higher alcohols [mg.L^{-1}])

The results for the Chardonnay variety show that the total score of sensory analysis does not correlate with the total content of higher alcohols in the sample of wine.

This fact is again confirmed by the graph in **Figure 2**.

Results of sensory evaluation of grape wines in context to the total content of esters

Esters are one of the most important categories of volatile substances in wine and they represent the primary source of wine fruity aroma, namely attributed to derivatives of esters **(Pavelková, 2005)**. Esters are therefore of great

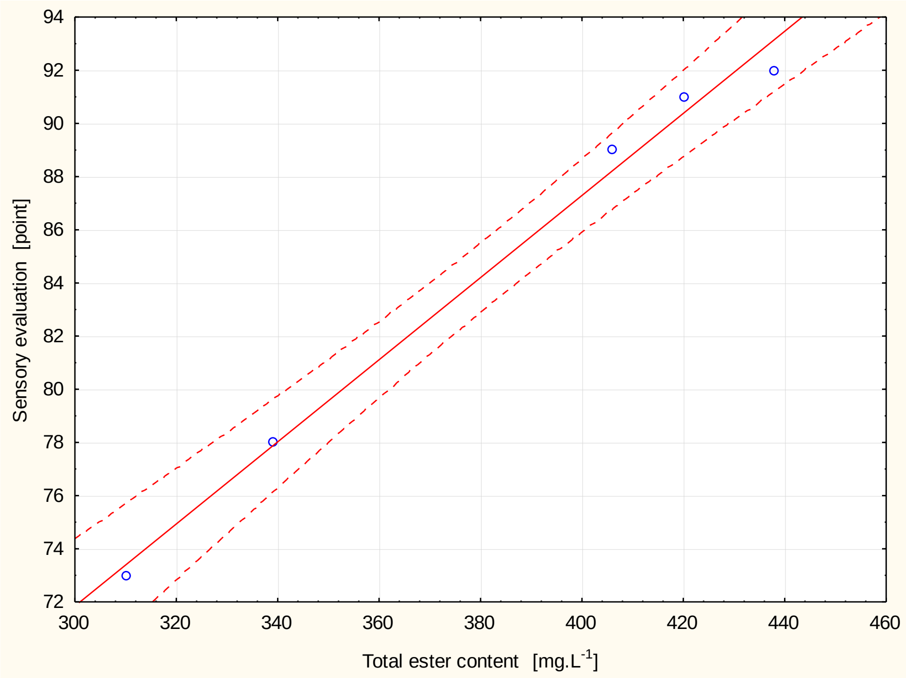

Figure 3 Graph of the correlation between the total ester content [mg.L^{-1}] and the sensory evaluation [point] of the Rheinriesling.

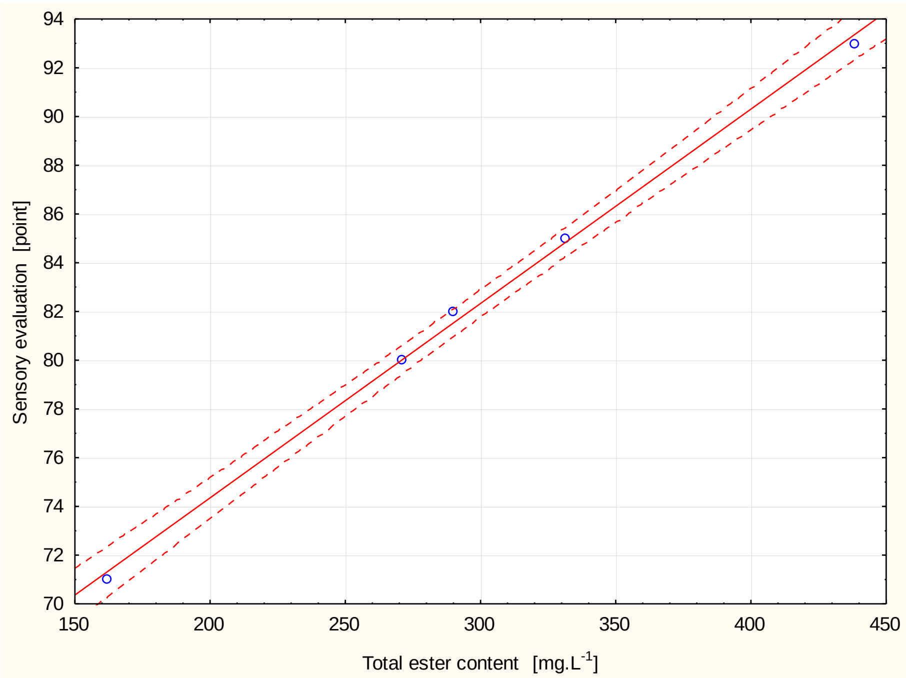

Figure 4 Graph of the correlation between the total ester content [mg.L^{-1}] and the sensory score [point] of the Chardonnay variety.

importance for sensory evaluation of wine properties. Sensory evaluation of wine has been dealt with by **Fikselova et al. (2018)** and **Snopek (2018b)**, who emphasizes the importance of flavorings at the first contact of wine with the consumer. Esters are produced in wine in two ways. They can be formed by enzymatic esterification during alcohol fermentation or during malolactic fermentation by yeast and bacteria or by chemical esterification by aging **(Ribéreau-Gayon et al., 2006)**. The most important esters of higher alcohols with acetic acid are isoamylaceate with banana flavor and phenylethyl acetate having rose aroma **(Ribéreau-Gayon et al., 2006)**. **Francis and Newton (2005)** report the concentration of 118 – 4300 $\mu g.L^{-1}$ in the case of isoamylacetate in young wine and248 - 3300 $\mu g.L^{-1}$ in the old wine with a perception threshold of 30 $\mu g.L^{-1}$. Similarly, apple flavor ethyl butyrate has a perception threshold of 20 $\mu g.L^{-1}$ and a young wine concentration of69 – 371 $\mu g.L^{-1}$ and of old wine of20 – 1118 $\mu g.L^{-1}$. In addition, ethyl acetate, which, when exceeding the limit of 150 – 200 $mg.L^{-1}$ causes a wine defect, which is characterized by an acetic odor **(Pavelková, 2005)**. This ester is undesirable in the wine **(Jacobson, 2006)**.

The Pearson correlation coefficient between the sensory evaluation and the total content of the esters r = 0.99571 was found in the Rheinriesling species. From the observed value it is clear that the sensory evaluation of the wine is dependent on the total content of the esters in the samples. This is documented by the graph in **Figure 3**. Corresponding equation was determined for this variety:

Sensory evaluation [points] = 25.511 + (0.15444 × Total ester content [$mg.L^{-1}$])

Similarly to the Rheinriesling variety, the Chardonnay variety was found to depend on sensory evaluation of wine on the total content of esters in the samples. Given the Pearson correlation coefficient r = 0.99907, this dependence is even more pronounced than for the Rheinriesling variety. This fact is confirmed by the graph in **Figure 4**. The correlation equation was determined as:

Sensory evaluation [points] = 58.399 + (0.07976 × Total ester content [$mg.L^{-1}$])

CONCLUSION

This study has dealt with the problem of the correlation of wine sensory evaluation with the total content of higher alcohols and esters in wine prepared from the same wine varieties (Rheinriesling and Chardonnay) on the same vineyard under the same climatic conditions and processed using the same production technology in the years 2008 – 2012. The correlation of the sensory evaluation with the total content of higher alcohols has not been demonstrated, as opposed to the direct dependence of the height of the sensory analysis point score on the total ester content. This can be an important economic indicator for a manufacturer who can estimate the sensory quality of the wine only on the basis of chemical analysis and thus estimate the success of the wine on the consumer market.

REFERENCES

Boudová Pečivová, P., Kráčmar, S., Kubáň, V., Mlček, J., Juríková, T., Sochor, J. 2014. Effect of Addition of Grape Seed Flour on Chemical, Textural and Sensory Properties of Bread Dough. *Mitteilungen Klosterneuburg*, vol. 64, no. 3, p. 114-119.

Callec, Ch., Ptáček, L., Svobodová, L. 2007. *Víno: velký obrazový lexikon (Wine: a large image lexicon.)*. Čestlice, Czech Republic: Rebo. 528 p. ISBN-13: 978-80-7234-889-3 (In Czech)

Clarke, R. J., Bakker, J. 2004. *Wine flavour chemistry*. Oxford, UK: Blackwell Publishing Ltd., 324 p. ISBN 1-4051-0530-5.

Farkaš, J. 1983. *Biotechnológia vína* (*Biotechnology of Wine)*. 2nd ed. Bratislava, Slovak Republic: Alfa. 984 p. ISBN 63-076-83. (In Slovak)

Fikselova, M., Czako, P., Gažo, J., Mendelová, A., Mellen, M. 2018. Sauvignon wine quality as affected by its processing and storage. *Potravinarstvo Slovak Journal of Food Sciences*, vol. 12, no. 1, p. 299-303. https://doi.org/10.5219/885

Francis, I., Newton, J. 2005. Determining wine aroma from compositional data. *Australian Journal of Grape and Wine Research*, vol. 11, no. 2, p. 114-126. https://doi.org/10.1111/j.1755-0238.2005.tb00283.x

Hampl, F., Rádl, S., Paleček, J. 2007. *Farmakochemie (Farmakochemistry)*. 2nd ed. Prahague, Czech Republic: VŠCHT Praha, 450 p. ISBN-13: 978-80-7080-639-5 (In Czech)

Jacobson, J. L. 2006. *Introduction to wine laboratory practices and procedures*. New York, USA: Springer Science+Business media, LLC., 375 p. ISBN-13: 978-0387-24377-1.

Kraus, V., Foffová, Z., Vurm, B., Krausová, D. 2005. *Nová encyklopedie českého a moravského vína* (*New Encyclopedia of Czech and Moravian Wines)*. 1st ed. Praha, Czech Republic: Praga Mystica. 304 p. ISBN-13: 978-8086-76700-0 (In Czech)

Kuttelvašer, Z.. 2003. *Abeceda vína (Alphabet of wine)*. 2nd ed. Praha, Czech Republic: Radix, 279 p. ISBN-13: 978-80-86031-43-9 (In Czech)

Lapčíková, B., Lapčík, L., Hupková, J. 2017. Physico-chemical characterisation of Slovak wines. *Potravinarstvo Slovak Journal of Food Sciences*, vol. 11, no. 1, p. 216-222. https://dx.doi.org/10.5219/727

Lawless, H. T., Heymann, H. 2010. *Sensory Evaluation of Food. Principles and Practices*. New york, USA: Springer Science+Business media, LLC. 596 p. ISBN-13: 978-1-4419-6488-5.

Malherbe, S. 2011. *Investigation of the impact of commercial malolactic fermentation starter cultures on red wine aroma compounds, sensory properties and consumer preference* : dissertation theses. Stellenbosch, South Africa: University of Stellenbosch. 121 p.

Mlček, J., Trágeová, S., Adámková, A., Adámek, M., Bednářová, M., Škrovánková, S., Sedláčková, E. 2018. Comparison of the content of selected mineral substances in Czech liturgical and common wines. *Potravinarstvo Slovak Journal of Food Sciences*, vol. 12, no. 1, p. 150-156. https://doi.org/10.5219/901

Patra, J. K., Kim, S. H., Baek, K.-H. 2015. Antioxidant and free radical-scavenging potential of essential oil from Enteromorpha linza L. Prepared by Microwave-Assisted Hydrodistillation. *Journal of Food Biochemistry*, vol. 39, no. 1, p. 80-90. https://doi.org/10.1111/jfbc.12110

Pavelková, I. 2005. Kvasinky a aroma vína (Yeasts and wine aroma). *Vinařský obzor*, vol. 98, no. 11, p. 557-559. (In Czech)

Ribéreau-Gayon, P., Dubourdieu, D., Donèche, B., Lonvaud, A. 2006. *Handbook of enology*. 2nd ed. Hoboken, NJ, USA : John Wiley and Sons. 512 p. ISBN-13: 978-0470-01034-1.

Snopek, L., Mlcek, J., Sochorova, L., Baron, M., Hlavacova, I., Jurikova, T., Kizek, R., Sedlackova, E., Sochor, J. 2018a. Contribution of red wine consumption to human health protection. *Molecules*, vol. 23, no. 7, p. 1-16. https://doi.org/10.3390/molecules23071684

Snopek, L., Mlček, J., Fic, V., Hlaváčová, I., Škrovánková, S., Fišera, , M., Velichová, H., Ondrášová, M. 2018b. Interaction of polyphenols and wine antioxidants with its sulfur dioxide preservative. *Potravinarstvo Slovak Journal of Food Sciences*, vol. 12, no. 1, p. 180-185. https://doi.org/10.5219/899

Soyollkham, B., Valášek, P., Fišera, M., Fic, V., Kubáň, V., Hoza, I. 2011. Total polyphenolic compounds contents (TPC), total antioxidant activities (TAA) and HPLC determination of individual polyphenolic compounds in selected Moravian and Austrian wines. *Central European Journal of Chemistry*, vol. 9, no. 4, p. 677-687. https://doi.org/10.2478/s11532-011-0045-3

Steidl, R. 2010. *Sklepní hospodářství*. (*Cellar Management*). 2nd ed. Valtice, Czech Republic : Národní vinařské centrum. 309 p. ISBN: 978-80-903201-9-2 (In Czech)

Tomanová, B. 2015. *Aromatický profil mladých vín (Aromatic profile of young wines*) : diploma theses. Lednice, Czech Republic : Mendel University in Brno. 74 p.

Zhang, W., Si, G., Ye, M., Feng, S., Cheng, F., Li, J., Mei, J., Zong, S., Wang, J., Zhou, P. 2017. An Efficient Assay for Simultaneous Quantification of Ethyl Carbamate and Phthalate Esters in Chinese Liquor by Gas Chromatography-Mass Spectrometry. *Food Analytical Methods*, vol. 10, no. 11, p. 3487–3495. https://doi.org/10.1007/s12161-017-0906-2

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