# COMPARISON OF CONTENTS OF SELECTED ESTERS, HIGHER ALCOHOLS AND TOTAL CONTENT OF POLYPHENOLIC SUBSTANCES IN WINES OF THE VARIETIES 'CHARDONNAY' AND 'RIESLING' BY VINTAGE

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The content of individual sensory active substances in wine is an important parameter of wine evaluation concerning sensory attributes of wine. This article discusses the development of aromatic substances contents in wines of 'Chardonnay' and 'Riesling' grapes in five consecutive wine vintages (2008 to 2012) from the same vineyard track and processed using the same methods. Out of biologically active substances, the total content of phenolic substances was determined in the presented samples. In the individual samples, aromatic substances were analyzed using gas chromatography with mass spectrometry (GC/MS). The concentration of 1 pentanol was the highest (82 to 292 mg/l). Isobutanol and 1 propanol followed. In 'Chardonnay', out of esters, the concentration ethyl acetate was the highest, followed by ethyl ester of caprylic acid and isoamyl acetate. 'Riesling' had characteristics of highly concentrated ethyl acetate, pentyl formate and ethyl caprylate. The total content of polyphenolic substances was in a range of 188 to 308 mg/l in 'Chardonnay' and 194 to 281 mg/l in 'Riesling'. Average values in 'Riesling' were higher than in 'Chardonnay'. The article documents that wines made from the same grape variety grown at the same vineyard track during similar climatic conditions and processed using the same techniques do not possess the same aromatic characteristics. Minor changes of individual factors may cause significant changes of a wine's sensory quality.
**Keywords:** grapevine, wine, 'Chardonnay'; 'Riesling'; polyphenols

**Vergleich der Gehalte ausgewählter Ester und höherer Alkohole sowie Gesamtgehalt polyphenolischer Substanzen in Weinen der Rebsorten 'Chardonnay' und 'Riesling' nach Jahrgang.** Der Gehalt an einzelnen sensorisch aktiven Substanzen im Wein ist ein wichtiger Parameter der Weinbewertung hinsichtlich seiner sensorischen Eigenschaften. Dieser Artikel beschreibt die Entwicklung der Gehalte von Aromastoffen in Weinen identischer Herkunft und Vinifikation der Rebsorten 'Chardonnay' und 'Riesling' in fünf aufeinanderfolgenden Jahrgängen (2008 bis 2012). Von biologisch aktiven Substanzen wurde der Gesamtgehalt an phenolischen Substanzen bestimmt. In den einzelnen Proben wurden Aromastoffe mittels Gaschromatographie mit Massenspektrometrie (GC/MS) analysiert. Die Konzentration von 1-Pentanol war die höchste (82 bis 292 mg/l). Isobutanol und 1-Propanol folgten. In 'Chardonnay' war von den Estern die Konzentration von Ethylacetat am höchsten, gefolgt von Ethylester der Caprylsäure und Isoamylacetat. 'Riesling' hatte Eigenschaften von hochkonzentriertem Ethylacetat, Pentylformiat und Ethylcaprylat. Der Gesamtgehalt an polyphenolischen Substanzen lag bei 'Chardonnay' zwischen 188 und 308 mg/l und in 'Riesling' zwischen 194 und 281 mg/l. Die Durchschnittswerte in 'Riesling' waren höher als in 'Chardonnay'. Die Untersuchung zeigt, dass Weine derselben Rebsorte, gleicher Herkunft und unter ähnlichen klimatischen Bedingungen angebaut und identisch verarbeitet, nicht die gleichen aromatischen Eigenschaften besitzen. Geringe Veränderungen bei einzelnen Faktoren können die sensorische Qualität des Weins erheblich verändern.
**Schlagwörter:** Rebe, Wein, 'Chardonnay', 'Riesling', Polyphenole

Products of grapevine are a significant source of biologically active substances with a positive effect on human health. A wine is considered as one of those products with a long tradition and popularity amongst consumers (Soyollkham et al., 2011). Addition of grapes or parts of grapes to other foods can improve sensory and/or technological characteristics. (Boudová Pečivová et al., 2014). From the sensory point of view the composition of aromatic substances in a food item is important for a consumer. Aromatic substances are odorous and gustatory substances that create complex sensory perception, the so-called flavor (aroma) of a food. These substances are either natural elements of a food (as primary aromatic substances) or can develop through enzymatic and chemical reactions during storing or processing of a food (as secondary or tertiary aromatic substances) (Hálková et al., 2001; Fic, 2015). Aromatic substances are important constituent parts of must and wine that are created in grapes of grapevine, in their skin and closely under their skin. Their concentration in a wine can be various – so far around 600 to 800 aromatic substances can be distinguished. Even though such a high number of aromatic substances is recognized, only a limited amount of these substances has a significant influence on wine aroma. The amount of these substances depends on variety, ripeness, climate and soil (Farkaš, 1957; Rapp, 1999; Steidl, 2002; Michlmayr et al., 2012). These substances of various origin – simple, such as acids and esters, or complex, as terpineols – may contribute to the spicy or floral-like scent of wine (Kraus, Foffová and Vurm, 2008). Aromatic maturity can be evaluated visually, based on the color of berry skin, and sensory, based on taste and scent of free aromatic substances in grapes. Grape color can be a significant element of grape quality assessment (Steidl, 2005). The combination of grape variety, location influence and agrotechnical interventions contributes to aromatic maturity (Iland et al., 2002). Polyphenols are one of the most important secondary metabolites in grapes and wine (Bajčan et al., 2016). Polyphenolic substances (resveratrol, quercetin, rutin, catechin, proanthocyanidins) have multiple benefits concerning human health, namely cardioprotective, antiinflammatory, anticarcinogenic, antiviral and antibacterial properties that are attributed mainly to their antioxidant and antiradical activity (Lorrain et al., 2013). Total amount of polyphenols in wine depends on cultivation locality, climate conditions and factors of used processing technology, such as temperature, $SO_2$ concentration, pH level or alcohol content (Villano et al., 2006; Lachman and Šulc, 2006). Statistics and studies from all over the world suggest that red wines contain more phenolic substances than white wines in general. This may be caused by differences in winemaking technology (Beer et al., 2006). This article is focused on the analysis of selected aromatic and polyphenolic substances in the grape varieties 'Chardonnay' and 'Riesling'. 'Chardonnay' is an old grape variety for 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 climatic 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 show fruitlike flavor (Callec et al., 2007). 'Riesling' is an old grape variety for the production of high-quality white wines. This grape variety originated from the 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). The focus of this article is on a comparison of the contents of selected aromatic substances and total polyphenol contents in consecutive vintages of the same grape variety from the same vineyard track cultivated with the same agrotechnology.

## MATERIAL AND METHODS

### WINE SAMPLES

In total 10 samples of wine – 5 samples of 'Chardonnay' (furtheron named CH + respective vintage) and 5 samples of 'Riesling' (furtheron named RR + respective vintage) – were used to determine the content of individual aromatic substances and the total content of polyphenolic substances. Table 1 shows a description of individual wine samples.

Table 1: Description of individual wine samples

| Sample | Date of harvest | Sugar content (°NM) | Total alcohol content (%vol.) | Reducing sugars content (g/l) | Class according to residual sugar | Quality |
|---|---|---|---|---|---|---|
| **Riesling** | | | | | | |
| RR 2008 | 10.11.2008 | 21.6 | 12.78 | 2.2 | dry | LH |
| RR 2009 | 29.10.2009 | 23 | 13.74 | 9.9 | medium dry | LH |
| RR 2010 | 23.10.2010 | 22 | 12.31 | 1.5 | dry | LH |
| RR 2011 | 24.10.2011 | 22.2 | 12.97 | 7.9 | medium dry | LH |
| RR 2012 | 13.10.2012 | 22.2 | 12.94 | 4.1 | medium dry | LH |
| **Chardonnay** | | | | | | |
| CH 2008 | 21.10.2008 | 22.6 | 13.32 | 4.50 | dry | LH |
| CH 2009 | 23.10.2009 | 24.6 | 14.57 | 10.6 | medium dry | SG |
| CH 2010 | 17.10.2010 | 22.8 | 12.62 | 2.3 | dry | LH |
| CH 2011 | 05.10.2011 | 24 | 13.61 | 11.7 | medium dry | SG |
| CH 2012 | 02.10.2012 | 24.2 | 13.7 | 3.6 | dry | LH |

Note: SG – special selection of grapes, LH – late harvest, RR – Riesling + respective vintage, CH – Chardonnay + respective vintage

* °NM = 1 g of sugar in 100 ml of must (°KMW = 0,732 × °NM + 3,2)

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

## CHEMICALS

Following chemicals were used for analysis:

- Folin-Ciocalteau solution (Penta, Praha, CZ)
- $Na_2CO_3$, p. a. – Mr. 105.99, CAS No.: (497-19-8) (Penta, Praha, CZ)
- Tannin, p. a. - CAS No.: (1401-55-4) (Lach-Ner, s.r.o., Neratovice, CZ)
- distilled water

All chemicals were of analytical reagent grade or equivalent analytical purity.

## 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, Nakagyo-ku, Japan) with Supelco SP MTM – PUFA column sized 30 m × 0.25 mm × 0.25 μm. Each vintage was analyzed three times.

Chromatographic conditions were:

| | | |
|---|---|---|
| Injector | Injection temperature | 200 °C |
| | Flow regulation | linear flow velocity |
| | Column flow | 1.22ml/min |
| | 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 |

### METHOD OF TOTAL POLYPHENOL CONTENT DETERMINATION USING FOLIN-CIOCALTEU AGENT

Standard tannin solution was pipetted into three 50 ml measuring flasks in volumes 0.4, 0.6 and 0.8 ml of solution. At the same time, 1 ml of clear wine sample was pipetted into the fourth measuring flask. The sample was diluted with distilled water in ratio 1:4 beforehand.
20 ml of distilled water and 1 ml of Folin-Ciocalteu agent were added next. The contents of the flask were mixed thoroughly. After 3 minutes 5 ml of 20 % $Na_2CO_3$ solution (40 g of sodium carbonate in 160 g of distilled water) were added, contents of the flask were mixed again and the rest of the flask was filled with distilled water.
After 30 minutes color intensity of sample was measured using spectrophotometer UV/VIS – LAMBDA 25 (PerkinElmer Inc., Waltham, USA) at 700 nm against blank experiment. Samples were in a 10 mm cuvette. Individual results were used to draw calibration curves and to determine the total amount of polyphenols.

## RESULTS AND DISCUSSION

### AROMATIC SUBSTANCES

Through a process of a chemical analysis the amounts of aromatic substances were observed in various vintages of 'Chardonnay' and 'Riesling' wines. Concerning higher alcohols, a significant amount of 1-pentanol was found in both grape varieties. 1-Propanol and isobutanol were also detected. In 'Chardonnay' isobornyl alcohol and phenethyl alcohol were found. In 2011 and 2012 vintages of 'Riesling' n-butanol was detected as well. Determined values are shown in Table 2.

Table 2: Higher alcohols composition in individual samples of 'Chardonnay' and 'Riesling' wines (mg/l)

| Chardonnay | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Sample | CH 08 | | CH 09 | | CH 10 | | CH 11 | | CH 12 | |
| | M | SD | M | SD | M | SD | M | SD | M | SD |
| Isobutanol | 9.9 | ± 0.7 | 26.1 | ± 1.8 | 53.9 | ± 3.2 | 105.0 | ± 7.3 | 38.9 | ± 0.7 |
| 1-Propanol | 15.7 | ± 0.6 | 17.1 | ± 0.6 | 26.3 | ± 1.5 | 42.6 | ± 1.8 | 7.9 | ± 0.4 |
| 1-Pentanol | 157.4 | ± 8.4 | 291.8 | ± 9.0 | 129.8 | ± 3.8 | 289.0 | ± 6.2 | 107.4 | ± 8.1 |
| Isobornyl alcohol | ND | | ND | | ND | | 1.4 | ± 0.1 | ND | |
| Phenethyl alcohol | ND | | ND | | ND | | ND | | 7.8 | ± 0.3 |
| Σ | 183.0 | | 335.0 | | 210.0 | | 438.0 | | 162.0 | |
| Riesling | | | | | | | | | | |
| Sample | RR 08 | | RR 09 | | RR 10 | | RR 11 | | RR 12 | |
| | M | SD | M | SD | M | SD | M | SD | M | SD |
| Isobutanol | 56.6 | ± 1.7 | 23.0 | ± 2.0 | 27.1 | ± 1.4 | 69.2 | ± 3.1 | 40.9 | ± 1.8 |
| 1-Propanol | 42.6 | ± 2.5 | 28.2 | ± 1.0 | 36.4 | ± 1.3 | 22.3 | ± 1.6 | 20.8 | ± 0.8 |
| 1-Pentanol | 82.8 | ± 6.1 | 110.8 | ± 8.5 | 234.5 | ± 16.0 | 261.9 | ± 16.5 | 135.6 | ± 8.1 |
| n-Butanol | ND | | ND | | ND | | 84.6 | ± 4.5 | 53.7 | ± 3.6 |
| Σ | 182.0 | | 162.0 | | 298.0 | | 438.0 | | 251.0 | |

Note: RR – Riesling + respective vintage, CH – Chardonnay + respective vintage, ND – not detected

Results were evaluated using Kruskal-Wallis nonparametric test that proved a statistically significant difference in the composition of alcohols between vintages. As for 'Riesling', isobutanol levels show the statistically significant difference between vintages 2009 and 2011. Statistically significant differences were also found in 1-propanol levels of 2008 and 2012 vintages as well as in 1-pentanol levels of 2008 and 2011 vintages. Concerning 'Chardonnay' wine samples, statistically significant differences were found in the amount of isobutanol in 2008 and 2011 vintages, 1-propanol in 2011 and 2012 vintages, and 1-pentanol in 2012 vintage and both 2009 and 2011 vintages. No statistically significant differences were proven between other vintages ($p > 0.05$).

In wine, most of the higher alcohols are produced during fermentation processes as a result of amino acids biosynthesis. In concentrations lower than 300 mg/l these alcohols can contribute to aroma variability (honey, spicy, whiskey, rose and similar scents) but in concentrations over 600 mg/l, these alcohols can spoil the aroma of wine with chemical-like scents reminiscent of solvent (Francis and Newton, 2005; Melherbe, 2011). Even though higher alcohols are present in small volumes (yet bigger volumes than methanol), they greatly contribute to a bouquet of a mature wine. The total amount is in a range from 150 to 700 mg/l (Steidl, 2010). These listed values are consistent with values presented in this article. By reaction with organic acids, higher alcohols increase the total amount of esters in wine.

Esters are one of the most important categories of volatile substances in wine and they represent the primary source of fruity aroma, namely attributed to derivatives of esters.

During the determination of esters content in samples of 'Chardonnay' and 'Riesling' ethyl acetate was detected in the highest quantities. Usually, it accounted for more than 70 % of detected substances in total. As can be seen in Table 3 the amount of other individual aromatic substances was not stable through vintages of 'Chardonnay'. For example, butyl isocyanate acetate was the second

Table 3: Ester content in individual 'Chardonnay' wine samples (mg/l)

| Sample | CH 08 | | CH 09 | | CH 10 | | CH 11 | | CH 12 | |
|---|---|---|---|---|---|---|---|---|---|---|
| | M | SD | M | SD | M | SD | M | SD | M | SD |
| (2-ethoxyethoxy) acetatic acid | ND | | ND | | 2.2 | ± 0.2 | ND | | ND | |
| 2-Propenoic acid, 1,7,7-* | 0.5 | ± 0.0 | 0.3 | ± 0.0 | 0.4 | ± 00 | ND | | 1.1 | ± 0.1 |
| Butyl isocyanate acetate | 11.8 | ± 0.8 | 6.6 | ± 0.4 | 7.9 | ± 0.6 | ND | | ND | |
| Diethyl acetyl | ND | | 1.7 | ± 0.1 | ND | | 2.3 | ± 0.1 | 0.5 | ± 0.0 |
| Diethyl succinate | 0.2 | ± 0.0 | 0.3 | ± 0.0 | ND | | ND | | ND | |
| Isobutyl acetate | 1.3 | ± 0.1 | 1.3 | ± 0.1 | 1.3 | ± 0.1 | 09 | ± 0.0 | ND | |
| Ethyl caprylate | 7.8 | ± 0.2 | 7.0 | ± 0.5 | 12.3 | ± 0.3 | 9.0 | ± 0.6 | 7.0 | ± 0.5 |
| Ethyl decanoate | 1.1 | ± 0.1 | 1.7 | ± 0.1 | 3.6 | ± 0.2 | 2.3 | ± 0.1 | 2.7 | ± 0.2 |
| Ethyl caproate | 3.9 | ± 0.4 | 3.0 | ± 0.1 | 5.7 | ± 0.4 | 4.0 | ± 0.2 | 4.1 | ± 0.2 |
| Ethyl butyrate | 1.5 | ± 0.1 | 1.7 | ± 0.1 | 2.2 | ± 0.1 | 1.8 | ± 0.1 | 0.3 | ± 0.0 |
| Ethyl lactate | ND | | ND | | 6.1 | ± 0.5 | ND | | ND | |
| Ethyl acetate | 131.2 | ± 6.8 | 300.2 | ± 9.4 | 385.9 | ± 20.7 | 256.7 | 13,2 | 151.8 | ± 5.0 |
| Ethyl propionate | 0.7 | ± 0.0 | ND | | 0.4 | ± 0.0 | 0.3 | ± 0.0 | ND | |
| Hexyl acetate | ND | | ND | | ND | | 0.3 | ± 0.0 | 0.3 | ± 0.0 |
| Isoamyl acetate | 2.1 | ± 0.2 | 7.3 | ± 0.3 | 10.0 | ± 0.2 | 12.2 | ± 0.7 | 10.0 | ± 0.1 |
| Pentyl formate | ND | | ND | | ND | | ND | | 93.2 | ± 5.6 |
| Σ | 162 | | 331 | | 438 | | 290 | | 271 | |

Note: CH – Chardonnay grape variety + respective vintage, ND – not detected, *2-Propenoic acid, 1,7,7-trimethylbicyclo(2.2.1) hept-2-yl ester, exomost concentrated aromatic substance (11.8 mg/l) in 2008 vintage, but in 2011 vintage it was not detected at all and isoamyl acetate was the second most concentrated aromatic substance (12.2 mg/l). The similar content structure through the vintages was observed for ethyl acetate of caprylic, decanoic, hexanoic and butyric acid as well as isoamyl acetate. Pentyl formate was also detected in a significant amount in the last examined vintage.

In 'Riesling' wine samples there was the biggest content of ethyl acetate followed by pentyl formate and ethyl caprylate. Through the examined vintages there were similar concentrations of ethyl 3-methyl valerate. The amounts of other detected substances were unstable through individual vintages as can be seen in Table 4.

Table 4: Ester contents in individual 'Riesling' wine samples (mg/l)

| Sample | RR 08 | | RR 09 | | RR 10 | | RR 11 | | RR 12 | |
|---|---|---|---|---|---|---|---|---|---|---|
| 2-Propenoic acid, 1,7,7-* | 0.4 | ± 0.0 | 0.4 | ± 0.0 | ND | | 3.0 | ± 0.2 | 0.3 | ± 0.0 |
| Dibutyl sulfate | 8.3 | ± 0.4 | ND | | ND | | 14.3 | ± 0.8 | ND | |
| Diethyl acetyl | ND | | ND | | ND | | 3.0 | ± 0.2 | ND | |
| Ethyl 3-methyl valerate | 6.1 | ± 0.4 | 5.5 | ± 0.4 | 6.1 | ± 0,4 | 3.1 | ± 0.2 | 4.4 | ± 0.1 |
| Ethylester isobutyrate | 1.8 | ± 0.1 | 0.8 | ± 0.0 | ND | | 1.6 | ± 0.1 | ND | |
| Ethylester caprylate | 14.9 | ± 0.3 | 15.1 | ± 0.2 | 15.0 | ± 1,1 | 8.4 | ± 0.5 | 11.9 | ± 0.5 |
| Ethyl decanoate | 2.2 | ± 0.1 | 3.4 | ± 0.3 | 4.5 | ± 0,3 | 3.1 | ± 0.2 | 6.1 | ± 0.4 |
| Ethyl butyrate | 1.8 | ± 0.1 | 1.3 | ± 0.1 | 1.2 | ± 0,1 | 0.9 | ± 0.1 | 1.0 | ± 0.0 |
| Ethyl lactate | ND | | ND | | 14.2 | ± 0,8 | 4.3 | ± 0.3 | ND | |
| Ethyl acetate | 359.6 | ± 21.2 | 355.3 | ± 22.1 | 361.2 | ± 8,0 | 218.9 | ± 13.2 | 254.6 | ± 17.6 |
| Ethyl propionate | ND | | ND | | ND | | 3.0 | ± 0.1 | ND | |
| Isoamyl acetate | 3.1 | ± 0.2 | 1.7 | ± 0.1 | 3.3 | ± 0,3 | 2.1 | ± 0.1 | 4.1 | ± 0.3 |
| Pentylester formate | 39.9 | ± 2.9 | 36.5 | ± 0.6 | ND | | 52.4 | ± 2.4 | ND | |
| Σ | 438 | | 420 | | 406 | | 310 | | 339 | |

Note: RR – Riesling grape variety + respective vintage, ND – not detected, *2-Propenoic acid, 1,7,7-trimethylbicyclo(2.2.1) hept-2-yl ester, exo-

In a way similar to the analysis of higher alcohols values of individual ethyl esters levels were evaluated using Kruskal-Wallis nonparametric test followed by multiple comparisons of p values. These results suggest variability of ethyl esters content despite samples shared an origin in grape variety, vineyard track and winemaking processes ($p < 0.05$). In 'Chardonnay' statistically significant differences were found in ethyl ester of decanoic acid levels between 2008 and 2010 vintages, ethyl ester of caprylic acid levels between 2009 and 2010 vintages, ethyl ester of hexanoic acid levels between 2009 and 2010 vintages, and ethyl ester of butyric acid levels between 2011 and 2012 vintages. Other statistically significant differences were found between 2010 and 2008 vintages in the levels of ethyl acetate, and between 2008 and 2011 vintages in the levels of isoamyl acetate.

In a case of 'Riesling' statistically significant differences were found between 2009 and 2011 vintages in the ethyl ester of caprylic acid levels, between 2008 and 2009 in the ethyl ester of decanoic acid levels, between 2008 and 2011 vintages in the ethyl ester of butyric acid levels, and between 2009 and 2012 in the levels of isoamyl acetate. Even though Kruskal-Wallis nonparametric test and median test suggest a possible statistically significant difference in ethyl acetate and ethyl esters of 3-methyl valeric acid levels between samples ($p < 0.05$), multiple p parameter comparisons do not prove this conclusion ($p > 0.05$). Other substances were not detected in all vintages.

In a case of secondary aromatic substances produced by yeasts during fermentation it is possible for their content to vary through vintages (Kumšta, 2010). It can occur due to chemical esterification by aging as well (Ribéreau-Gayon et al., 2006). Differences between vintages can also be caused by climate changes between individual years, possible minor differences in grapevine cultivation processes and age of the wine. In a general comparison Francis and Newton (2005) state, that content of some esters increases with the age of the wine. They present a four-time increase in the ethyl ester of butyric acid amount detected in aged wine (1.118 mg/l) compared to detected quantities in young wine (0.371 mg/l). This statement is consistent with results of 'Chardonnay' wine samples. The last examined vintage 2012 contained 0.3 mg/l of the ethyl ester of butyric acid compared to previous vintages with levels from 1.5 to 2.2 mg/l. On average the detected values were six times lower in 2012 vintage when compared to previous vintages. According to Farkaš (1983) total content of esters in wine is between 2 and 6 mg/l for a young wine, and around 10 mg/l for an aged wine. Detected higher levels of esters presented in this article could have been caused by these stated facts.

## TOTAL POLYPHENOL CONTENT

The total content of polyphenols was determined using Folin-Ciocalteu method. In 'Chardonnay' this amount was between 188 mg/l and 308 mg/l of tannin through examined vintages. Measured values are presented in Table 5. Individual samples were very similar through the vintages. 2011 vintage is an exception. The total content of polyphenols was considerably higher. Because the climate conditions were stable through the years the increased level of polyphenols may have other causes, for example, premature fermentation of wine mash.
'Riesling' wines have a total content of polyphenols between 194 mg/l and 281 mg/l of tannin. The highest detected value is from the 2008 vintage. The lowest detected value is from the following vintage, 2009.
When comparing both grape varieties we can see that 'Riesling' has higher average values. It was not possible to prove the statistically significant difference between individual grape varieties due to high detected contents in vintage 2011 of 'Chardonnay' (the highest detected content of all the samples).

Table 5: Total content of polyphenols in individual vintages of 'Chardonnay' and 'Riesling' (mg/l)

| Vintage | Chardonnay | | Riesling | |
|---|---|---|---|---|
| | M | SD | M | SD |
| **2008** | 188.4 | ± 4.5 | 280.8 | ± 15.3 |
| **2009** | 191.7 | ± 9.7 | 194.5 | ± 16.6 |
| **2010** | 191.8 | ± 7.7 | 214.3 | ± 13.9 |
| **2011** | 307.9 | ± 10.6 | 216.8 | ± 10.2 |
| **2012** | 191.2 | ± 11.0 | 246.1 | ± 17.1 |

Jančářová et al. (2013) state that unlike esters total amount of phenolic substances decreases with the age of wine. In addition, Faitová et al. (2004) claim that total content of polyphenols (TPC) could be influenced by wine transportation and storing conditions as well as, for example, the location of an individual bottle on a shelf of a market destination, improper packaging and light exposure leading to decrease in polyphenol levels (mainly anthocyanins).

With an exception of 'Riesling' 2008 vintage and 'Chardonnay' 2011 vintage, this slow decrease can be observed in all of the samples investigated. However, it cannot be considered a statistical evidence ($p > 0.05$). Variations may be caused by many factors similar to those concerning esters and higher alcohols (premature fermentation of wine mash, minor schedule changes during winemaking etc.).
This article documents that wine made from the same

grape variety grown at the same vineyard track under similar climatic conditions and processed using the same winemaking technology does not have the same aromatic characteristics. Variation of these attributes depends on a minor, yet in many cases significant, variation of mentioned factors. Minor changes in winemaking technology (e.g. procedure and attributes of the fermentation process), the age of wine (influence on the total content of acids, ethyl esters and polyphenols), wine archivation (storage, the influence of light, …) and climate conditions can significantly contribute to the overall sensory quality of wine.

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