INTRODUCTION

The terms antioxidant and free radical are popular expressions used by nutritionists, scientists and general public. Free radicals are chemical species, compounds and/or elements with one or two unpaired electrons in their outer layer, which can be created in a multiple ways. They can be exogenic (e.g. ultraviolet radiation, xenobiotics and infections) or endogenic (Andzi Barhé and Feuya Tchouya, 2014). A lack of antioxidant or an overproduction of free radicals can lead to an imbalance between the oxidant and antioxidant system (Guerci et al., 2001; Puita et al., 2005). Oxidative stress is involved in several illnesses, including diabetes (Huang et al., 2004), atherosclerosis, Alzheimer’s disease and Parkinson’s disease (Drobek-Słowik and Karczewicz, 2007). The provision of antioxidants through diet is a simple means to reduce the development of illnesses brought on by oxidative stress (Zafra-Stone et al., 2007).

Wine is an alcoholic fermented beverage with considerable amounts of phytochemicals (Gresèlé et al., 2011). Wine is very rich source of polyphenols, such as catechins, epicatechins, quercetin, rutin, myricetin, anthocyanins, fenolics acids (gallic acid, caffeic acid, p-coumaric acid, etc.), trans-resveratrol and many others polyphenols and compounds. Many of these compounds have been reported to have multiple biological activities, including cardioprotective, anti-carcinogenic, antiviral and antibacterial properties (King et al., 2006; Santos-Buelga and Scalbert, 2000; Špakovská et al., 2012). To date, over 3000 flavonoids have been identified. These can mainly be found in the pigments in flowers or in leaves (Marfak, 2003). Flavonoids are primarily known for their anti-oxidative (Bruneton, 1999), vasculooprotectrice (Vitor et al., 2004), anti-inflammatory (Chen et al., 2008) and anti-diabetic (Marfak, 2003) properties. Currently, chemoprevention is being used in medicine as a new strategy to prevent cancers. Natural phytochemicals, including wine and/or grape polyphenols, appear to be very promising substances to block, reverse, retard or prevent the process of carcinogenesis (Russo, 2007).

The total amount of polyphenols in wines has been estimated to range from 200 to 6000 mg.L⁻¹ (Quideau et al., 2011). The highly variable level of phenolic compounds in wine is due to differences in grape variety and source as well as processing. Wine polyphenols have been reported to be bioavailable in several studies.
These compounds are directly related to the quality of wines, so phenolic analysis can be used as an effective tool in characterizing different wines. Many factors can influence the phenolic composition if wines, including grape variety and the technology applied (Mulero et al., 2011).

The purpose of this study was to determine and evaluate chosen properties (the content of total polyphenols, content of total flavonoids and antioxidant activity) and their mutual correlations in white wines – Welschriesling (typical Central European variety) and Chardonnay (most famous world variety), originated from 3 most important Slovak vineyard areas.

MATERIAL AND METHODOLOGY

Chemicals and instruments
All analysed parameters – content of total polyphenols, content of total flavonoids and antioxidant activity in wines were analyzed using UV/VIS spectrophotometry (spectrophotometer Shimadzu UV/VIS – 1240, Shimadzu, Japan). The chemicals used for all analysis were: Folin-Ciocalteau reagent, monohydrate of gallic acid p.a., aluminium chloride p.a., sodium nitrite p.a., sodium hydroxide p.a., 35%, catechin hydrate 98%, methanol p.a., 2,2-diphenyl-1-picrylhydrazyl (DPPH) radical p.a.

Samples
Analysed, bottled, white, especially dry wines Welschriesling (WR), resp. Chardonnay (CH) and their characteristics are mentioned in Table 1 and 2. Wine samples with origin in various Slovak vineyard areas (VA) were purchased in retail network, to provide that analysed samples of wine would have the same properties as wines that are consumed by common consumers (properties of wine affected by various factors, such as period and conditions of storage or distribution of wine).

Methods
Antioxidant activity determination
Antioxidant activity (AA) was assessed by method of Brand-Williams et al. (1995) using of DPPH (2,2-diphenyl-1-picrylhydrazyl) radical. This method is based on the reduction of DPPH in methanol solution in the presence of a hydrogen–donating antioxidant due to the formation of the nonradical form DPPH-H (Chanda and Dave, 2009). This transformation results in a color change from purple to yellow, which is measured spectrophotometrically. Briefly, 0.1 mL of white wine was added to 3.9 mL of a 6x10^{-7} mol.L^{-1} solution of DPPH in methanol. A control sample containing the same volume of water instead of extract was used to measure the maximum DPPH absorbance. After the reaction had been allowed to take place in the dark for 10 min, the absorbance at 515.6 nm was recorded to determine the concentration of remaining DPPH. The percentage inhibition of the initial concentration of DPPH radical was calculated as: % inhibition = [(ADPPH - Awine)/ADPPH] x 100. The results were also expressed as Trolox equivalent antioxidant capacity using calibration curve method.

Determination of total polyphenol content
Total polyphenol content (TFC) was determined by modified method of Singleton and Rossi (1965). 0.1 mL of wine sample was pipetted into 50 mL volumetric flask and diluted with 5 mL of distilled water. To diluted mixture 2.5 mL Folin-Ciocalteau reagent was added and after 3 minutes 7.5 mL of 20% solution of Na2CO3 was added. Then the sample was filled with distilled water to volume 50 mL and after mixing left at the laboratory temperature for 2 hours. By the same procedure the blank and calibration solutions of gallic acid were prepared. Absorbance of samples solutions was measured against blank at 765 nm. The content of total polyphenols (TP) in wines was calculated as amount of gallic acid equivalent (GAE) in mg per 1 litre of wine.

Determination total flavonoid content
Total flavonoid content (TFC) was assessed by aluminum chloride method (Chang et al., 2002). 1 mL of wine sample and 4 mL of denouised water were added to a 10 mL volumetric flask. 5 min after adding 0.3 mL of 5% sodium nitrite, 0.3 mL of 10% aluminum chloride was added. 2 mL of sodium hydroxide with concentration 1 mol.L^{-1} was added to the reaction mixture after 6 min incubation. The final volume was immediately made up to 10 mL with denouised water. The absorbance of the solution was measured at 510 nm against blank solution.

Table 1 Characteristics of analysed Welschriesling wine samples.

| Sample  | Producer                               | Vineyard area  | Vintage  | Quality |
|---------|----------------------------------------|----------------|----------|---------|
| WR-1    | Villa Vino Rača, Bratislava            | Little Carpathian | 2011     | quality |
| WR-2    | Malokarpatská vinohrad. spol., Pezinok | Little Carpathian | 10/2012d | quality |
| WR-3    | Vino Matyšák, Pezinok                 | Little Carpathian | 2011     | quality |
| WR-4    | Vino Jano, Limbach                    | Little Carpathian | 2014d    | quality |
| WR-5    | Virex, Nesvady                         | South Slovak    | 5/2011d  | quality |
| WR-6    | VVD, Dvory nad Žitavou                | South Slovak    | 2011     | quality |
| WR-7    | Vitis Pezinok / Hubert J.E. Sered'     | South Slovak    | 2012     | quality |
| WR-8    | Vino Matyšák, Pezinok                 | South Slovak    | 2013     | quality |
| WR-9    | Vino Nitra, Nitra                     | Nitra           | 2011     | quality |
| WR-10   | Vinárské závody Topoľčianky, Topoľčianky | Nitra       | 2011     | quality |
| WR-11   | Vinárstvo Šintavan, Šintava           | Nitra           | 2010     | cabinet |
| WR-12   | Vinárstvo Trimovec, Nitra             | Nitra           | 2013     | quality |

d – date of bottling (unknown vintage).
The content of total flavonoids (TF) in wine samples was calculated as amount of catechin equivalent (CE) in mg per 1 litre of wine.

Statistical analysis
Statistical analysis were performed using the software Statistica 6.0 (StatSoft) and the results were evaluated by analysis of variance ANOVA.

RESULTS AND DISCUSSION
All studied parameters – the content of total polyphenols, the content of total flavonoids, and antioxidant activity of the Slovak wines Welschriesling, resp. Chardonnay are described in Table 3 and Table 4.

Total polyphenol content in analysed Welschriesling wine samples was in the range from 247.5 to 388.1 mg GAE.L\(^{-1}\). Average content of TP was 303.2 mg GAE.L\(^{-1}\). The results are very similar to results reported by Slezák (2007), who found out the content of TP in wines – Welschriesling in range from 250 to 361 mg GAE.L\(^{-1}\) (average value was 304.6 GAE.L\(^{-1}\)). Other foreign scientists (Li et al., 2009; Lužar et al., 2016; Ma et al., 2014) analyzing TPC in WR wines reported also very similar results (219 – 445 mg GAE.L\(^{-1}\)). Ivanova et al. (2010) and Stratil et al. (2008) reported much lower average value of TPC (205, resp. 97 mg GAE.L\(^{-1}\)) in WR wines. On the other hand, Sato et al. (1996) found out much higher phenolic content (721 mg GAE.L\(^{-1}\)) in one wine sample of Welschriesling. According to the average value of TPC and select harvest – Welschriesling could be as following: wines from Nitra VA > wines from South Slovak VA > wines from Little Carpathian VA. Gained results did not exert statistically significant differences (at significance level p = 0.05) between TPC in wines – Welschriesling made in various vineyard areas in Slovakia.

Total polyphenol content in analysed Chardonnay wine samples was in the range from 280.2 to 475.1 mg GAE.L\(^{-1}\). Average content of TP was 355.6 mg GAE.L\(^{-1}\). Our results are very similar to results reported by Chircu Brad et al. (2012) and Ma et al. (2014), who found out the content of TP in wines – Chardonnay in range from 275 to 454 mg GAE.L\(^{-1}\). Other scientists (Frankel et al., 1995; Li et al., 2009; Minussi et al., 2003 and Stratil et al., 2008) analyzing TPC in CS wines reported much lower average.

### Table 2 Characteristics of analysed Chardonnay wine samples.

| Sample | Producer                                                                 | Vineyard area           | Vintage  | Quality    |
|--------|--------------------------------------------------------------------------|-------------------------|----------|------------|
| CH-1   | Mrva & Stanko, Trnava                                                    | Little Carpathian       | 2010     | late harvest |
| CH-2   | Villa Vino Rača, Bratislava                                             | Little Carpathian       | 2011     | quality    |
| CH-3   | Chateau Zumberg, Pezinok                                                | Little Carpathian       | 2012     | quality    |
| CH-4   | Vino Matyšák, Pezinok                                                  | Little Carpathian       | 2013     | quality    |
| CH-5   | Vitis Pezínok / Hubert J.E. Sereď                                       | South Slovak            | 2011     | quality    |
| CH-6   | Vino Nitra, Nitra                                                       | South Slovak            | 2011     | quality    |
| CH-7   | Vinárské závody Topoľčianky, Topoľčianky                                | South Slovak            | 2012     | late harvest|
| CH-8   | Chateau Modra, Modra                                                    | South Slovak            | 2011     | select harvest|
| CH-9   | Vino Velkeer 1113, Veľký Kýr                                            | South Slovak            | 2014     | late harvest|
| CH-10  | Vinársťovo Trmovec, Nitra                                               | Nitra                   | 2011     | select harvest|
| CH-11  | Vinárské závody Topoľčianky, Topoľčianky                                | Nitra                   | 2012     | quality    |
| CH-12  | Ivan Czakoš, Nit. Hrnčiarovce                                          | Nitra                   | 2011     | late harvest|
| CH-13  | Peter Belan, Mojmírovce                                                 | Nitra                   | 2013     | late harvest|
| CH-14  | PD Mojmírovce, Mojmírovce                                               | Nitra                   | 2012     | select harvest|

Note: Values with the same letters denote significant differences (p < 0.05) among vineyard areas.

### Table 3 The content of total polyphenols (TPC), content of total flavonoids (TFC) and antioxidant activity (AA) in analysed wines Welschriesling.

| Wine sample | TPC (mg GAE.L\(^{-1}\)±SD) | TFC (mg CE.L\(^{-1}\)±SD) | AA inhib. ±SD | AA (mmol Trolox.L\(^{-1}\)±SD) |
|-------------|-----------------------------|----------------------------|----------------|-------------------------------|
| WR-1L       | 327.2 ±2.5                  | 58.9 ±0.5                  | 33.0 ±1.0      | 0.375 ±0.012                 |
| WR-2L       | 272.3 ±9.4                  | 44.2 ±1.1                  | 28.2 ±0.7      | 0.321 ±0.009                 |
| WR-3L       | 289.6 ±2.3                  | 44.5 ±3.0                  | 29.9 ±0.7      | 0.340 ±0.009                 |
| WR-4L       | 247.5 ±6.5                  | 42.4 ±1.8                  | 44.2 ±0.5      | 0.501 ±0.006                 |
| Average LCVA| 284.2 ±38.7\(^a\)           | 47.5 ±8.0\(^a\)            | 33.8 ±7.8\(^a\) | 0.384 ±0.087\(^a\)           |
| WR-5S       | 317.6 ±4.7                  | 61.1 ±2.0                  | 35.5 ±0.5      | 0.403 ±0.006                 |
| WR-6S       | 275.0 ±14.2                 | 45.6 ±3.5                  | 29.5 ±0.7      | 0.335 ±0.009                 |
| WR-7S       | 292.7 ±2.4                  | 44.0 ±1.1                  | 30.3 ±1.1      | 0.344 ±0.014                 |
| WR-8S       | 310.7 ±6.4                  | 44.7 ±1.1                  | 33.9 ±0.7      | 0.385 ±0.009                 |
| Average SSVA| 299.0 ±20.7\(^b\)           | 48.9 ±8.3\(^b\)            | 32.3 ±2.9\(^b\) | 0.367 ±0.023\(^b\)           |
| WR-9N       | 342.3 ±9.7                  | 55.0 ±1.1                  | 32.7 ±0.9      | 0.371 ±0.011                 |
| WR-10N      | 388.1 ±11.8                 | 83.7 ±0.5                  | 42.5 ±1.6      | 0.482 ±0.020                 |
| WR-11N      | 293.7 ±3.1                  | 49.4 ±0.4                  | 41.6 ±0.8      | 0.472 ±0.010                 |
| WR-12N      | 281.2 ±8.7                  | 49.6 ±3.4                  | 38.8 ±0.5      | 0.440 ±0.006                 |
| Average NVA | 326.3 ±52.0\(^c\)           | 59.4 ±16.7\(^c\)           | 38.9 ±4.8\(^c\) | 0.441 ±0.054\(^c\)           |
| Total average| 303.2 ±37.3                 | 51.9 ±11.8                 | 35.0 ±5.5      | 0.397 ±0.062                 |

Note: Values with the same letters denote significant differences (p < 0.05) among vineyard areas.

LCVA – Little Carpathian vineyard area, SSVA – South Slovak vineyard area, NVA – Nitra vineyard area.
The content of total polyphenols (TPC), content of total flavonoids (TFC) and antioxidant activity (AA) in analysed wines Chardonnay.

| Wine sample | TPC (mg GAEL.\(^{-1}\)±SD) | TFC (mg CE.L.\(^{-1}\)±SD) | AA (% inhib. ±SD) | AA (mmol Troloxl.\(^{-1}\)±SD) |
|-------------|-----------------|-----------------|-----------------|-----------------|
| CH-1L       | 376.7 ±2.5      | 57.3 ±0.8       | 42.1 ±1.1       | 0.477 ±0.014    |
| CH-2L       | 314.9 ±4.7      | 42.3 ±0.5       | 34.5 ±0.9       | 0.391 ±0.011    |
| CH-3L       | 321.2 ±5.2      | 67.5 ±3.3       | 47.3 ±0.5       | 0.537 ±0.006    |
| CH-4L       | 324.8 ±6.2      | 65.2 ±3.4       | 44.0 ±0.3       | 0.499 ±0.004    |
| **Average LCVA** | **334.4 ±30.0^a** | **58.1 ±12.2^a** | **42.0 ±6.2^a** | **0.476 ±0.071^a** |
| CH-5S       | 288.0 ±4.6      | 47.9 ±1.6       | 31.9 ±0.8       | 0.362 ±0.010    |
| CH-6S       | 357.4 ±2.5      | 50.9 ±0.5       | 32.5 ±1.5       | 0.369 ±0.019    |
| CH-7S       | 475.1 ±4.8      | 92.5 ±0.5       | 76.3 ±1.9       | 0.924 ±0.023    |
| CH-8S       | 389.3 ±5.3      | 92.3 ±1.3       | 47.5 ±0.8       | 0.540 ±0.010    |
| CH-9S       | 377.9 ±5.0      | 64.4 ±1.4       | 39.4 ±0.7       | 0.447 ±0.009    |
| **Average SSVa** | **377.5 ±76.2^b** | **69.6 ±19.2^b** | **45.5 ±19.1^b** | **0.528 ±0.242^b** |
| CH-10N      | 371.2 ±4.7      | 52.5 ±1.2       | 40.3 ±0.5       | 0.457 ±0.006    |
| CH-11N      | 435.4 ±2.5      | 82.3 ±1.1       | 48.4 ±3.2       | 0.550 ±0.040    |
| CH-12N      | 280.2 ±4.8      | 35.9 ±0.5       | 32.8 ±1.8       | 0.372 ±0.022    |
| CH-13N      | 353.3 ±9.6      | 47.4 ±1.0       | 45.3 ±0.8       | 0.514 ±0.010    |
| CH-14N      | 313.2 ±3.7      | 43.2 ±1.9       | 44.1 ±0.4       | 0.500 ±0.005    |
| **Average NVA** | **350.7 ±66.7^c** | **52.3 ±20.0^c** | **42.2 ±6.7^c** | **0.479 ±0.077^c** |
| **Total average** | **355.6 ±54.6** | **60.1 ±18.2** | **43.3 ±11.1** | **0.496 ±0.140** |

Note: **^a^** Values with the same letters denote significant differences (p < 0.05) among vineyard areas.

LCVA – Little Carpathian vineyard area, SSVa – South Slovak vineyard area, NVA – Nitra vineyard area.

The value of TPC (119 – 258 mg GAEL.\(^{-1}\)) in CH wines.

According to the average value of TPC an order for wines – Chardonnay could be as following: wines from South Slovak VA > wines from Nitra VA > wines from Little Carpathian VA. Gained results also did not exert statistically significant differences (at significance level p = 0.05) between TPC in wines – Chardonnay made in various vineyard areas in Slovakia.

Total flavonoid content in analysed Welschriesling wine samples varied from 42.4 to 83.7 mg CE.L.\(^{-1}\). Average content of TF was 51.9 mg CE.L.\(^{-1}\). Similar results (42.5 – 89.7 mg CE.L.\(^{-1}\)) were reported by Ivanova et al. (2010), Li et al. (2009) and Ma et al. (2014). According to the average value of TFC an order for wines – Welschriesling could be as following: wines from Nitra VA > wines from South Slovak VA > wines from Little Carpathian VA. Gained results did not exert statistically significant differences (at significance level p = 0.05) between TFC in wines – Welschriesling made in various vineyard areas in Slovakia.

Total flavonoid content in analysed Chardonnay wine samples was in the range from 35.9 to 92.5 mg CE.L.\(^{-1}\). Average content of TF was 60.1 mg CE.L.\(^{-1}\). Our results are in agreement with the data of Li et al. (2009), Ma et al. (2014) and Mitic et al. (2010) who found out TFC in range 31.0 – 94.2 mg CE.L.\(^{-1}\). Chircu Brad et al. (2012) determined lower values of total flavonoid content in Chardonnay wines which varied from 16.7 to 63.7 mg CE.L.\(^{-1}\). On the other hand, Lee and Rennaker (2007) found out much higher TFC (85.5 – 249 mg CE.L.\(^{-1}\)) in Chardonnay wine samples. According to the average value of TFC an order for wines – Chardonnay could be as following: wines from South Slovak VA > wines from Little Carpathian VA > wines from Nitra VA. Gained results also did not exert statistically significant differences (at significance level p = 0.05) between TFC in wines – Chardonnay made in various vineyard areas in Slovakia.

Antioxidant activity in analysed Welschriesling wine samples was in range 28.2 – 44.2% inhibition of DPPH (0.321 – 0.501 mmol Troloxl.\(^{-1}\)). Average value of AA was 35.0% inhibition of DPPH (0.397 mmol Troloxl.\(^{-1}\)). Our data are in agreement with the results published by Li et al. (2009) and Ma et al. (2014) who determined values of AA in the range 0.26 – 0.602 mmol Trolox/L. Slightly lower values of AA reported Slezáková (2007), who found out AA in Slovak wines – Welschriesling in the range from 20.11 to 41.95% inhibition of DPPH (average value was 30.9% inhibition of DPPH). On the basis of value of AA for wines – Welschriesling an order could be as following: wines from Nitra VA > wines from Little Carpathian VA > wines from South Slovak VA. Gained results exert statistically significant differences between values of antioxidant activity in wines made in South Slovak VA and AA in wines made in Nitra VA.

Antioxidant activity in analysed Chardonnay wine samples was in range 31.9 – 76.3% inhibition of DPPH (0.362 – 0.924 mmol Troloxl.\(^{-1}\)). Average value of AA was 43.3% inhibition of DPPH (0.496 mmol Troloxl.\(^{-1}\)). Similar data (49.1 – 74.7% inhibition of DPPH, resp. 0.082 – 0.87 mmol Troloxl.\(^{-1}\)) were reported by Chircu Brad et al. (2012), Li et al. (2009), Ma et al. (2014) and Stratil et al., 2008. On the basis of value of AA for wines – Chardonnay an order could be as following: wines from South Slovak VA > wines from Nitra VA > wines from Little Carpathian VA. Gained results also did not exert statistically significant differences (at significance level P = 0.05) between values of AA in wines – Chardonnay made in various vineyard areas in Slovakia.

The results showed that both types of Slovak white wines were high in polyphenols and flavonoids, as well as a high antioxidant activity, comparable to the wines produced in other regions in the world. Similar conclusions were
CONCLUSION

The phenolic, resp. flavonoid content and antioxidant properties of white wines (Welschriesling and Chardonnay) made in 3 most important Slovak vineyard areas was evaluated in the present study. All 3 studied parameters of analysed Slovak wines – total polyphenol content, total flavonoid content and antioxidant activity are comparable to the wines produced in other regions in the world. Slovak white wines – Welschriesling and Chardonnay have high content of healthy useful phenolic compounds and high antioxidant activity. The results didn’t showed statistically significant differences for all 3 studied parameters (except AA in Welschriesling) in wines made in different vineyard areas in Slovakia. On the basis of statistical evaluation of our results we can state that statistically very highly significant correlations were demonstrated between all 3 parameters (TPC, TFC and AA).

REFERENCES

Barhé, T. A, Feuya Tchouya, G. R. 2016. Comparative study of the anti-oxidant activity of the total polyphenols extracted from Hibiscus Sabdariffa L., Glycine max L. Merr., yellow tea and red wine through reaction with DPPH free radicals. Arabian Journal of Chemistry, vol. 9, no. 1, p. 1-8. http://dx.doi.org/10.1016/j.arabjc.2014.11.048

Brand-Williams, W., Cuvelier, M. E., Berse, C. 1995. Use of a free radical method to evaluate antioxidant activity. Lebensmittel Wissenschaft und Technologie – Food Science and Technology, vol. 28, no. 1, p. 25-30. http://dx.doi.org/10.1016/s0026-6445(95)80008-5

Bruneton, J. 1999. Pharmacognosie, phytochimie et plantes médicales. 5th ed. Paris : La Viosier TEC et DOC. p. 250-270. ISBN 2743011882.

Chanda, S., Dave, R. 2009. In vitro models for antioxidant activity evaluation and some medicinal plants possessing antioxidiant properties: An overview. African Journal of Microbiology Research, vol. 3, no. 13, p. 981-996.

Chang, C. C., Yang, M. H., Wen, H. M., Chern, J. C. 2002. Estimation of total flavonoid content in propolis by two complementary colometric methods. Journal of Food and Drug Analysis, vol. 10, no. 3, p. 178-182.

Chen, H. Q., Jin, Z. Y., Wang, X. J., Xu, X. M., Deng, L., Zhao, J. W., 2008. Luteolin protects dopaminergic neurons from inflammationinduced injury through inhibition of microglial activation. Neuroscience Letters, vol. 448, no. 2, p. 175-179. http://dx.doi.org/10.1016/j.neulet.2008.10.046

Chircu Brad, C., Muste, S., Mudura, E., Bobis, O. 2012. The content of polyphenolic compounds and antioxidant activity of three monovarietal wines and their blending, used for sparkling wine production. Bulletin UASVM serie Agriculture, vol. 69, no. 2, p. 222-227.

Droboń-Słowik, M., Karczewicz, D. K., 2007. The potential role of oxidative stress in the pathogenesis of the age-related macular degeneration (AMD). Postepy Higieny i Medycyny Doswiadczalnej, vol. 61, p. 28-37. PMID:17245315

Frankel, E. N., Waterhouse, A. L., Teissére, P. L. 1995. Principal phenolic phytochemicals in selected California wines and their antioxidant activity in inhibiting oxidation of human low-density lipoproteins. Journal of Agricultural and Food Chemistry, vol. 43, no. 4, p. 890-894. http://dx.doi.org/10.1021/jf00052a008

Gresele, P., Cerletti, C., Guglielmelli, G., Pignatelli, P., de Gaetano, G., Voli, F. 2011. Effects of resveratrol and other wine polyphenols on vascular function: an update. The Journal of Nutritional biochemistry, vol. 22, no. 3, p. 201-211. http://dx.doi.org/10.1016/j.jnutbio.2010.07.004

Guerci, B., Bohme, P., Kearney-Schwartz, A., Zannad, F., Drouin, P. 2001. Endothelial dysfunction and type 2 diabetes. Part 2: Altered endothelial function and the effects of treatments in type 2 diabetes mellitus. Diabetes & Metabolism, vol. 27, no. 4, p. 436-447. PMId:11547217

Huang, D. J., Lin, C. D., Chen, H. J., Lin, Y. H. 2004. Antioxidant and anti proliferative activities of sweet potato (Ipomoea batatas [L.] Lam ‘Tainong 57’) constituents. Botanical Bulletin of Academia Sinica, vol. 45, p. 179-186.

Ivanova, V., Stefova, M., Chinnici, F. 2010. Determination of the polyphenol contents in Macedonian grapes and wines by standardized spectrophotometric methods. Journal of the Serbian Chemical Society, vol. 75, no. 1, p. 45-59. https://doi.org/10.2298/JSC1001045I

King, R. E., Bomser, J. A., Min, D. B. 2006. Bioactivity of resveratrol. Comprehensive Reviews in Food Science and Food Safety, vol. 5, no. 3, p. 65-70. http://dx.doi.org/10.1111/j.1541-4337.2006.00001.x

Lee, J., Rennaker, C. 2007. Antioxidant capacity and stilbene contents of wines produced in the Snake River Valley of Idaho. Food Chemistry, vol. 105, no. 1, p. 195-203. http://dx.doi.org/10.1016/j.foodchem.2007.03.069

Li, H., Wang, X., Li, Y., Li, P., Wang, H. 2009. Polyphenolic compounds and antioxidant properties of selected China wines. Food Chemistry, vol. 112, no. 2, p. 454-460. http://dx.doi.org/10.1016/j.foodchem.2008.05.111

Lužar, J., Jug, T., Jamnik, P., Košmerl, T. 2016. Comparison of total polyphenols content and antioxidant potential of wines from ‘Welschriesling’ and ‘Sauvignon Blanc’ varieties during ageing on fine lees. Acta Agriculturae Slovenica, vol. 107, no. 2, p. 473-482. http://dx.doi.org/10.14720/aas.2016.107.2.18

Ma, T. T., Sun, X. Y., Gao, G. T., Wang, X. Y., Liu, X. Y., Du, G. R., Zhan, J. C. 2014. Phenolic Characterisation and Antioxidant Capacity of Young Wines Made From Different Grape Varieties Grown in Helanshan Donglu Wine Zone (China). South African Journal of Enology and Viticulture, vol. 35, no. 2, p. 321-331. http://dx.doi.org/10.21548/35-2-1020

Marfak, A. 2003. Radiolyse gamma des flavonoïdes: Étude de leur réactivité avec les radicaux issus des alcools: formation des dépsides : dissertation theses. France : University of Limoges. 220 p.

Minussi, R. C., Rossi, M., Bologna, L., Cordi, L., Rotilio, D., Pastore, G. M., Duran, N. 2003. Phenolic compounds and total antioxidant potential of commercial wines. Food Chemistry, vol. 82, no. 3, p. 409-416. http://dx.doi.org/10.1016/j.ijfoodmicro.2013.11.008
Polyphenolic content and total antioxidant activity in wines as determined by spectrophotometric methods. *Czech Journal of Food Sciences*, vol. 26, no. 4, p. 242-253.

Špakovská, E., Marcinčák, S., Bača, M., Turek, P. 2012. Polyphenolic content and antioxidative activity of wines from Sobrance region. *Potravinarstvo*, vol. 6, no. 3, p. 32-35. http://dx.doi.org/10.5219/204

Vitaglione, P., Sforza, S., Galaverna, G., Ghidini, C., Caporaso, N., Vescovi, P. P., Fogliano, V., Marchelli, R. 2005. Bioavailability of trans-resveratrol from red wine in humans. *Molecular Nutrition & Food Research*, vol. 49, no. 5, p. 495-504. http://dx.doi.org/10.1002/mnfr.200500002

Vitor, R. F., Mota-Filipe, H., Teixeira, G., Borges, C., Rodrigues, A. I., Teixeira, A., Paulo, A. 2004. Flavonoids of an extract of *Pterospermum tridentatum* showing endothelial protection against oxidative injury. *Journal of Ethnopharmacology*, vol. 93, no. 2-3, p. 363-370. http://dx.doi.org/10.1016/j.jep.2004.04.003

Zafra-Stone, S., Yassin, T., Bagchi, M., Chattejee, A., Vinson, J. A., Bagchi, D., 2007. Berry anthocyanins as novel antioxidants in human health and disease prevention. *Molecular Nutrition & Food Research*, vol. 51, no. 6, p. 675-683. http://dx.doi.org/10.1002/mnfr.200700002

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