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Physicochemical, Antioxidant and Sensory Properties of Peach Wine Made from Redhaven Cultivar

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ABSTRACT: Physicochemical, sensory, and health-related characteristics of peach wine produced from Redhaven variety and selected white wines produced from various grape varieties were determined and compared. The alcohol content, titratable acidity, and total extract of peach wine was significantly lower compared with that of white wines, while its pH value was higher. The content of total phenolics (TPC) and flavonoids (TFC) of peach wine (402.53 mg/L GAE and 332.67 mg CAE/L, respectively) have been found significantly higher in comparison with that of white wines (TPC range 243.67−319.00 mg/L GAE, TFC range 129.67−175.17 mg CAE/L). The main phenolic compounds found in peach wine were chlorogenic acid, caffeic acid, and catechin (3.59, 0.87, and 0.60 mg/L, respectively). Antioxidant capacities were strongly correlated with total phenolics with correlation coefficients over 0.99. The highest antioxidant capacity was ascribed to peach wine. The results of sensory analysis indicated that the peach wine was very well accepted by the regular consumers of wine and can be a very interesting product in the market.

KEYWORDS: *peach wine, physicochemical properties, antioxidants, phenolic compounds, sensory properties*

INTRODUCTION

Peach (*Prunus persica*) belongs to family *Rosaceae* and is a tasteful, sweet, and juicy drupe fruit. It originated in China where it has been cultivated from ancient times, which was recorded in numerous documents dating back to 1100 BC.[1] Commercial peach production in Serbia started in the early 1950s at the Fruit Research Institute in Čačak, and today is mainly located in the regions around the Danube and West Morava River.

Peach cultivars are commonly divided into freestone and clingstone in reference to the adherence of flesh (mesocarp) to the stone (endocarp or pit). Both free- and clingstone peaches can be either white- or yellow-fleshed depending on the color of the mesocarp.[2] White-fleshed peaches are mostly very sweet with low acid content and with distinct flavor because of which are predominantly used as fresh fruits. Additionally, most of them are very susceptible to skin bruising and enzymatic flesh browning and thus not suitable for industrial processing.[3] In contrast, yellow-fleshed cultivars have lower sugars, higher organic acids, and much higher carotenoid content. As a consequence, these peaches are more suitable for further industrial processing, because carotenoids can mask undesirable changes caused by oxidation.

From a nutritional point of view, peaches are a good source of carbohydrates, organic acids, dietary fiber, B vitamins, vitamin C, folic acid, minerals, and dietary antioxidants, particularly phenolic compounds and carotenoids.[4−7] However, the chemical composition of peaches and processed peach products as well as their nutritional and sensory quality are greatly influenced by genotype, geographical and climatic conditions, rootstock, seasonal and weather conditions, agronomic practices, maturity stage, storage conditions, and processing procedures.[3,8] The edible quality of peaches mainly depends on their sweetness and/or sourness, which are directly related to the sugar-to-organic acid ratio. Total sugars, organic acids, sucrose, sorbitol, malic-to-citric acid ratio, citric-to-shikimic acid ratio, and content of volatile aromatic compounds (particularly content of lactones, esters, and monoterpenes) have the greatest influences on the overall sensory perception of peach fruits.[9−11]

The quality of processed peach products such as juice, wine, jam, and jelly largely depends on the content of phenolic compounds and activity of polyphenol oxidase (PPO), because peaches are easily susceptible to undesirable enzymatic browning during processing. Besides the effects on product pigmentation and browning, phenolic compounds are the major source of dietary antioxidants with potential health-promoting properties.[12,13] For these reasons, new peach cultivars with high phenolic content and low PPO activity have been developed.[14]

Fruits and fruit products, such as juices and wines, are a very good source of some essential dietary micronutrients (minerals and vitamins) and phytochemicals (carotenoids and phenolic compounds). Fruit polyphenols exhibit considerable antioxidant activity in vitro and represent the most abundant antioxidants in human diets.[15]

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Wine is probably one of the oldest alcoholic beverages as confirmed by archeological records dating back more than 7500 years. It has most likely inspired more research and publications than any other beverage or food.[16] However, the word "wine" has a different meaning in different parts of the world. The most widely accepted definition of wine is "the fermented juice of freshly crushed and pressed grapes".[17] Nevertheless, in many countries the word "wine" is also used for fermented alcoholic beverages from fruits, cereals, honey, herbs, flowers, etc. These nongrape wines are generally known as country wines, and those made from fruits are simply called fruit wine.

A good quality fruit wine can be made from a number of different fruits, such as apple, pear, peach, blackberry, raspberry, strawberry, sour cherry, blueberry, plum, banana, acerola, mango, etc.[18,19] However, only a small number of fruit varieties give a high yield of must with a reasonable balance between acids and sugars. These fruits, such as apples, pears, peaches, and some berry fruits, are used for commercially production of fruit wines without any or with only little adjustment of the extract by addition of sugar (or some other sweetener) or acids.[17]

Peach wines are commercially produced in many countries, but the largest producer is probably the USA. These delicacy fruit wines are often characterized by intensively and immediately recognizable peachy aroma, with a pleasant mouth-feel and smooth finish. Numerous literature data refer to grape wines, but only a few studies have been conducted about physicochemical, antioxidant, and sensory properties of peach wine.[20,21]

Therefore, the aim of this work was to investigate the physicochemical properties, content of individual sugars, antioxidant activity, total phenolics and flavonoids content, content of individual phenolic compounds, and sensory acceptability of peach wine obtained from Redhaven cultivar (yellow-fleshed, freestone cultivar) and to compare results with those found in selected white grape wines.

MATERIALS AND METHODS

Chemicals. Folin−Ciocalteu's phenol reagent, hydrochloric acid, sodium acetate trihydrate, glacial acetic acid, and sodium carbonate (anhydrous) were purchased from Merck (Darmstadt, Germany). 2,4,6-Tripyridyl-s-triazine (TPTZ), ferric chloride hexahydrate, sodium nitrite, aluminum chloride, 2,2-diphenyl-1-picrylhydrazyl (DPPH), 6-hydroxy-2,5,7,8-tetramethylchroman-2-carboxylic acid (Trolox), and quercetin were purchased from Sigma-Aldrich (Steinheim, Germany). Sodium hydroxide was purchased from Fisher Scientific (Loughborough, UK). Ethanol (HPLC grade and reagent were obtained from Merck (Darmstadt, Germany). Standards of phenolic compounds (gallic acid, catechin, chlorogenic acid, caffeic acid, *p*-coumaric acid, ferulic acid, quercetin, naringenin, chrysin, pinocembrin, and galangin) and *cis*,*trans*-abscisic acid used for UHPLC-MS/MS quantification were purchased from Sigma-Aldrich (Steinheim, Germany). Ultrapure water (TKA Germany) was used to prepare standard solutions and dilutions. All other reagents were of analytical grade. Syringe filters (13 mm, PTFE membrane 0.45 μm, were purchased from Supelco (Bellefonte, PA).

Wine Samples. Peach fruit (Redhaven) and white grapes (Chardonnay, Riesling Rhine, and Riesling Italian) were obtained from experimental school estate "Radmilovac" of Faculty of Agriculture, Belgrade. The peaches were harvested at optimum maturity on the basis of skin color and concentration of soluble solids in the first week of August, 2011. The concentration of soluble solids in fruit samples was measured using an Abbe refractometer (Bellinghan & Stanley Ltd., UK). The fruits were sorted manually and washed in cold water, and the clean peaches were halved and pitted with a sharp stainless steel knife. For wine production, we chose smaller fruits to increase the content of aromatic compounds, which are mainly localized in the internal cell layers of the skin. The peach halves (95 kg) were crushed in a laboratory fruit crusher (Pigo PR 114M), and the obtained mash was sulfurized with sulfur dioxide by the addition of potassium metabisulfite to a total SO_2 level of 30 mg/kg (to prevent enzymatic browning and microbial growth). After sulfurization, pectolytic enzyme ZYM AROM MP (Enartis, San Martino-Trecate, Italy) was added and the peach mash was macerated for 24 h at room temperature (20 ± 1 °C). Thereafter, the mash was pressed using a hydraulic press and the obtained must (34 L) was transferred into 50 L double-jacketed stainless steel fermenters. Before fermentation, the must was sulfurized once again (50 mg/L SO_2) to inhibit the growth of indigenous microflora. The peach must was inoculated with approximately 10^8 cells/mL of selected yeast strain *S. cerevisae* Aroma White (Enartis, San Martino-Trecate, Italy) at 17 °C. This temperature was maintained during the fermentation, and the process was monitored by the daily measurement of the soluble solids and alcohol content. After two weeks, the fermentation was finished and the wine was transferred into a maturation vessel (stainless steel tanks). At this stage, wine was sulfurized once again (100 mg/L potassium metabisulfite) to prevent microbial spoilage. The white grape wines were produced in the same manner.

Physicochemical Measurements. The total soluble solids of peach and grape musts were measured using an Abbe refractometer (Bellinghan & Stanley Ltd.). Alcohol contents, total extracts, degrees of fermentation, and calories were determined using Alcolyzer Wine M/ME - Wine analysis system (Anton Paar GmbH, Graz, Austria). The titratable acidity was estimated by titration with 0.1 M NaOH solution to pH 8.2, and results were expressed as grams of tartaric acid per liter of wine.[22] Volatile acidity was determined by steam-distillation using a Buchi distillation unit K-355 and expressed as grams of acetic acid per liter of wine.[22] The color of wines was measured using a portable chromameter CR-410 (Minolta, Ramsey, NJ). The results are expressed in Commission Internationale d Eclairage (CIElab) L^*, a^*, and b^* color−space coordinates. These parameters are defined as follows: L^* (lightness: 0 = black, 100 = white), a^* (from green to red), b^* (from blue to yellow), C^* (chroma or saturation), and h (hue angle). CIElab parameters were calculated for the CIE illuminant D_{65}. All physicochemical measurements were performed in triplicate.

Determination of Individual Sugars. The method described by Kumbola et al.[23] was adopted with minor modification for determination of sugars (trehalose, glucose, fructose, sucrose, and maltose). Separation and quantification of sugars in the samples were performed using a Dionex ICS 3000 equipment containing a DP gradient pump. Separation of carbohydrates was carried out on a CarboPac PA-100 guard column (4 × 50 mm) and a CarboPac PA-100 anion-exchange column (4 × 250 mm). The flow rate was 0.7 mL/min, and carbohydrates were detected by electrochemical detector with a gold working electrode and Ag/AgCl reference electrode. Running time (t_R) was 30 min. Carbohydrates were eluted by a gradient prepared from 600 mM sodium hydroxide (eluent A), 500 mM sodium acetate (eluent B), and deionized water (eluent C). Eluent A was constant (15%) during 20 min and increased to 20% at 20 min, eluent B changed from 0% to 20%, and eluent C changed from 85% to 60%. During chromatography, the eluents were kept under a blanket of He, and the mobile phase was purged with He to minimize carbonate contamination, which can affect the retention times of the sugars.

Determination of Total Phenolics. The amounts of total phenolics (TPC) in wine samples were determined according to the Folin−Ciocalteu method described by Singleton and Rossi.[24] Briefly, 0.5 mL of diluted wines was mixed with 2.5 mL of 10-fold diluted Folin−Ciocalteu's phenol reagent and allowed to react for 5 min. Two milliliters of sodium carbonate solution (75 g/L) was added to the mixture and then shaken. After 2 h of reaction at room temperature, the absorbance at 760 nm was measured. The calibration curve was prepared with gallic acid solution, and the results are expressed as milligrams of gallic acid equivalents per liter of sample (mg GAE/L). Triplicate measurements were performed.

Table 1. Physicochemical Properties[a] of Wine Samples

parameters	peach wine	Riesling Italian	Riesling Rhine	Chardonnay
TSS in must (°Brix)	14.50 ± 0.10[a]	21.43 ± 0.08[b]	24.00 ± 0.09[c]	24 0.82 ± 0.15[c]
total extract (% w/w)	2.87 ± 0.03[a]	3.97 ± 0.01[b]	1.98 ± 0.06[c]	2.09 ± 0.03[d]
alcohol (% v/v)	8.12 ± 0.03[a]	12.01 ± 0.01[b]	13.45 ± 0.07[c]	13.9 ± 0.04[d]
degree of fermentation (%)	82.22 ± 0.06[a]	83.19 ± 0.08[b]	91.82 ± 0.04[c]	91.67 ± 0.07[c]
calories (kJ/100 mL)	228.94 ± 0.04[a]	334.28 ± 0.06[b]	337.11 ± 0.07[c]	349.18 ± 0.03[d]
pH	3.90 ± 0.01[a]	3.03 ± 0.01[b]	3.17 ± 0.02[c]	3.34 ± 0.01[d]
titratable acidity (g/L)	4.47 ± 0.09[a]	6.75 ± 0.08[b]	7.44 ± 0.10[c]	6.41 ± 0.08[d]
volatile acidity (g/L)	0.78 ± 0.02[a]	0.84 ± 0.03[a]	0.78 ± 0.03[a]	0.60 ± 0.05[b]

[a]Values represent means of triplicate determinations ± standard deviation. Different letters in same row denote a significant difference according to Tukey's test, $p < 0.05$.

Determination of Flavonoids. The total flavonoid concentration (TFC) was determined using a method developed by Zhishen et al.,[25] with some modification. Briefly, 0.5 mL of appropriately diluted sample was added to 2 mL of distilled water. At time zero, 0.15 mL of 5% $NaNO_2$ was added; at 5 min, 0.15 mL of 10% $AlCl_3$ was added; at 6 min, 1 mL of 1 M NaOH was added. Afterward, the total volume of solution was immediately made up to 5 mL with distilled water and mixed well. The absorbance was measured at 510 nm against an appropriate blank. The calibration curve was prepared with catechin standard solutions in ethanol, and results are expressed in milligrams of catechin equivalents per liter of sample. Measurements were performed in triplicate.

DPPH Radical-Scavenging Activity. DPPH radical-scavenging activity of wines was estimated following the slightly modified procedure described by Kaneda et al.[26] Every diluted wine sample (0.2 mL) was added to the DPPH working solution (2.8 mL) (mixture of 1.86×10^{-4} mol/L DPPH in ethanol and 0.1 M acetate buffer (pH 4.3) in ratio 2:1 (v/v)). The absorbance at 525 nm was measured after the solution had been allowed to stand in the dark for 60 min. The Trolox calibration curve was plotted as a function of the percentage of inhibition of DPPH radical. The results are expressed as millimoles of Trolox equvivalents per liter of sample (mM TE/L). Triplicate measurements were performed.

FRAP Assay. The FRAP assay was performed according to the procedure previously described by Benzie and Strain,[27] with some modification. The FRAP reagent solution was made by mixing acetate buffering agent (pH = 3.6), TPTZ (10 mM TPTZ solution in 40 mM HCl) and $FeCl_3 \cdot 6H_2O$ in volume ratio 10:1:1, respectively). All samples, standards, and reagents were preincubated at 37 °C. An aliquot of each diluted wine sample (0.1 mL) was mixed with distilled water (0.3 mL) and FRAP reagent (3 mL). After the reaction at 37 °C for 40 min, the absorbance at 593 nm was measured. The calibration curve was prepared with Trolox solution, and the results are expressed as millimoles of Trolox equvivalents per liter of sample (mM TE/L). Measurements were done in triplicate.

UHPLC-MS/MS Orbitrap Analysis. Wine samples were filtered and analyzed without dilution. All experiments were performed using a Thermo Scientific liquid chromatography system composed of a quaternary Accela 600 pump and Accela Autosampler, connected to a linear ion trap−orbitrap hybrid mass spectrometer (LTQ-Orbitrap XL, Thermo Fisher Scientific, Bremen, Germany), with electron spray ionization (ESI).

Separations were performed on a Hypersil gold C18 (100 × 2.1 mm, 1.9 μm) from Thermo Fisher Scientific. The mobile phase consisted of (A) water + 0.1% formic acid and (B) acetonitrile + 0.1% formic acid. A linear gradient program at a flow rate of 0.400 mL/min was used: 0−7 min from 5% to 95% B, 7−9 min 95% B, then 4 min 5% B.

The mass spectrometer was operated in negative selected ion monitoring (SIM) mode. ESI-source parameters were as follows: source voltage 4 kV, capillary voltage −47 V, tube lens voltage −159.11 V, capillary temperature 275 °C, sheath and auxiliary gas flow (N_2) 25 and 8 (arbitrary units). MS spectra were acquired by full range acquisition covering m/z 100−900. For fragmentation study, a data-dependent scan was performed by deploying collision-induced dissociation (CID). The normalized collision energy of the collision-induced dissociation (CID) cell was set at 35 eV.

Phenolics were identified and quantified in wines according to the corresponding spectral characteristics: mass spectra, exact mass, characteristic fragmentation, and characteristic retention time. Xcalibur software (version 2.1) was used for instrument control, data acquisition, and data analysis.

Sensory Evaluation. The sensory acceptability (degree of liking) of the wine samples was assessed using the nine-point hedonic scale (1 = dislike extremely, 9 = like extremely).[28] The samples were evaluated by 80 panelists (consumers), males and females, 22−50 years of age, who were regular users of such products. Each assessor received four randomized, refrigerated (10 °C) samples of wine (25−30 mL of Peach wine, Riesling Italian, Riesling Rhine, and Chardonnay) in clear, tulip-shaped glasses with a volume of 100 mL. The samples were coded with three-digit random numbers and covered with watch glasses to prevent the loss of volatiles. A card containing scales of nine categories was provided, and assessors were asked to indicate their hedonic response to the samples on the appropriate scale. All the assessments were carried out at room temperature under white light.

Statistical Analysis. Data of all measurements performed in triplicate are expressed as mean ± standard deviation (SD). The experimental data were subjected to a one-way analysis of variance (ANOVA), and Tuckey's test was used to detect the difference ($p \leq 0.05$) between the mean values. Statistical analyses were performed with the statistical program MS Excel (Microsoft Office 2007 Professional). The coefficient of correlation between total phenolic content, flavonoids content, and antioxidant activity was determined by using MS Excel (Microsoft Office 2007 Professional).

RESULTS AND DISCUSSION

ANOVA showed a statistically significant difference between experimental data ($p = 0.000$), and therefore Tuckey's test was used to detect the difference ($p \leq 0.05$) between individual samples. Some physicochemical characteristics of peach wine and white grape wines are compared in Table 1. These parameters have a great influence on sensory quality and microbiological stability of wines: higher content of alcohol and lower pH value increase microbial stability, while a good acid−sugar balance is very important for wine taste. The total soluble solids content of peach must was significantly lower compared with that of white grape musts, and therefore the concentration of alcohol in peach wine was also lower. Besides low alcohol content, peach wine had the relatively high pH value and because of that its microbial stability has to be maintained with a higher concentration of sulfur dioxide or with some other type of preservation (e.g., pasteurization). Volatile acidity is used as an indicator of wine spoilage, and if its value exceeds the limit of 1 g/L, the wine is unmarketable. All analyzed wine samples had an acceptable amount of volatile acids, with no

Table 2. CIELab Chromatic Parameters[a] of Wine Samples

samples	L^* (D65)	a^* (D65)	b^* (D65)	C^* (D65)	h (D65)
peach wine	59.49 ± 0.00[a]	−1.03 ± 0.01[a]	16.49 ± 0.00[a]	16.52 ± 0.00[a]	93.56 ± 0.04[a]
Riesling Italian	59.75 ± 0.01[b]	−0.62 ± 0.01[b]	8.09 ± 0.01[b]	8.12 ± 0.01[b]	94.35 ± 0.07[b]
Riesling Rhine	62.76 ± 0.01[c]	−1.21 ± 0.00[c]	7.37 ± 0.01[c]	7.47 ± 0.01[c]	99.34 ± 0.01[c]
Chardonnay	62.06 ± 0.00[d]	−0.81 ± 0.01[d]	8.10 ± 0.01[b]	8.14 ± 0.01[d]	95.72 ± 0.05[d]

[a]Values represent means of triplicate determinations ± standard deviation. Different letters in the same column denote a significant difference according to Tukey's test, $p < 0.05$.

significance differences between peach wine and Riesling wines, while the lowest value was found in Chardonnay wine.

Wine color is one of the most easily recognizable characteristics of wines and has the most important impact on wine appearance. The visual characteristics of a wine can provide useful indicators of quality, style, and varietal origin.[29] CIELab chromatic parameters of wine samples are presented in Table 2. On the basis of the parameters a^*, b^*, and hue angle, it can be concluded that color of all samples was yellow with a certain proportion of greenness. The peach wine had the lowest value for lightness (L^*) and the highest values for b^* and C^*, which indicates that this sample was the darkest with the highest proportion of yellow color. The value of parameter a^* was in range from −1.21 to −0.62, indicating that all the samples had a very low proportion of greenness.

The content of individual and total sugars is shown in Table 3. According to the content of total sugars, all analyzed wines

Table 3. Content of Individual and Total Sugars (g/L) in Wines

samples	trehalose	glucose	fructose	sucrose	maltose	total sugars
peach wine	0.20	0.14	0.04	–	–	0.38
Riesling Italian	0.31	0.21	0.55	0.06	0.04	1.17
Riesling Rhine	0.25	0.13	0.17	0.06	0.03	0.64
Chardonnay	0.26	0.16	0.09	0.06	0.05	0.63

can be classified into dry wines (wines in which the residual sugar content is less than 1.5 g/L). Glucose and fructose are the predominant sugars in grapes, and they are the most important source of metabolic energy for wine yeasts. For this reason, only a small amount of these sugars are presented in wines. Trehalose is a common fungal sugar and can be used as an indicator of fungal infection on grape.[16] The peach wine had significantly lower content of total sugars, trehalose, and fructose compared with white wines. In addition, sucrose and maltose were not detected in peach wine, while their concentration was very low in other analyzed white wine samples.

The total phenolic and flavonoids content and antioxidant activity of wine samples are presented in Table 4. It is well-known that moderate wine consumption reduces the risk of coronary heart disease. Such a wine effect can be explained by a high content of natural antioxidants, particularly phenolic compounds. The amounts of phenolic compounds vary markedly in different types of wines, depending on the grape/fruit cultivar, environmental conditions, and winemaking procedure. The peach wine had a significantly higher content of total phenolic compounds as well as flavonoids compared with selected white wines. These results are in agreement with those available in the literature.[30,31] The correlation between TPC and content of flavonoids (TFC) was very high but was not statistically significant (Table 5).

Table 5. Correlation[a] between TPC, TFC, and Antioxidant Characteristics

	TPC		TFC		DPPH	
method	r[a]	p[b]	r	p	r	p
TFC	0.941	0.059				
DPPH	**0.994**[c]	**0.006**	**0.955**	**0.045**		
FRAP	**0.981**	**0.010**	**0.973**	**0.027**	**0.998**	**0.002**

[a]Correlation coefficient. [b]Level of significance. [c]Bolded numbers indicate statistically significant correlation ($p < 0.05$).

A number of different assays are developed for the measurement of antioxidant capacity, so there is no standardized method. Because of that, two more frequently used methods (DPPH and FRAP) were selected to analyze antioxidant capacity of wine samples. Antioxidant capacity of samples was strongly and statistically significantly correlated with TPC and TFC (Table 5), so the antioxidant capacity of peach wine was remarkably higher compared with that of white wines. Consequently, it can be concluded that the peach wine is a better source of natural antioxidants than white wines.

Total of eleven phenolics together with *cis*,*trans*-abscisic acid were quantified in wine samples. The UHPLC-MS total ion chromatogram (TIC) for the polyphenolic fraction of the peach wine together with structures of the quantified compounds is presented in Figure 1. Results of the UHPLC-MS/MS analysis showed significant differences in the content of individual

Table 4. Total Phenolic and Total Flavonoid Contents and Antioxidant Activity of Wine Samples[a]

samples	TPC (mg GAE/L)	TFC (mg CAE/L)	DPPH (mM TE)	FRAP (mM TE)
peach wine	402.53 ± 3.06a	332.67 ± 9.75a	1.55 ± 0.09a	3.01 ± 0.12a
Riesling Italian	243.67 ± 1.53b	134.17 ± 1.44b	1.20 ± 0.00b	1.72 ± 0.01b
Riesling Rhine	319.00 ± 14.73c	175.17 ± 3.06c	1.33 ± 0.01b	2.17 ± 0.01c
Chardonnay	288.00 ± 8.66c	129.67 ± 0.76b	1.30 ± 0.05b	2.00 ± 0.02d

[a]Values represent means of triplicate determinations ± standard deviation. Different letters in same column denote a significant difference according to Tukey's test, $p < 0.05$.

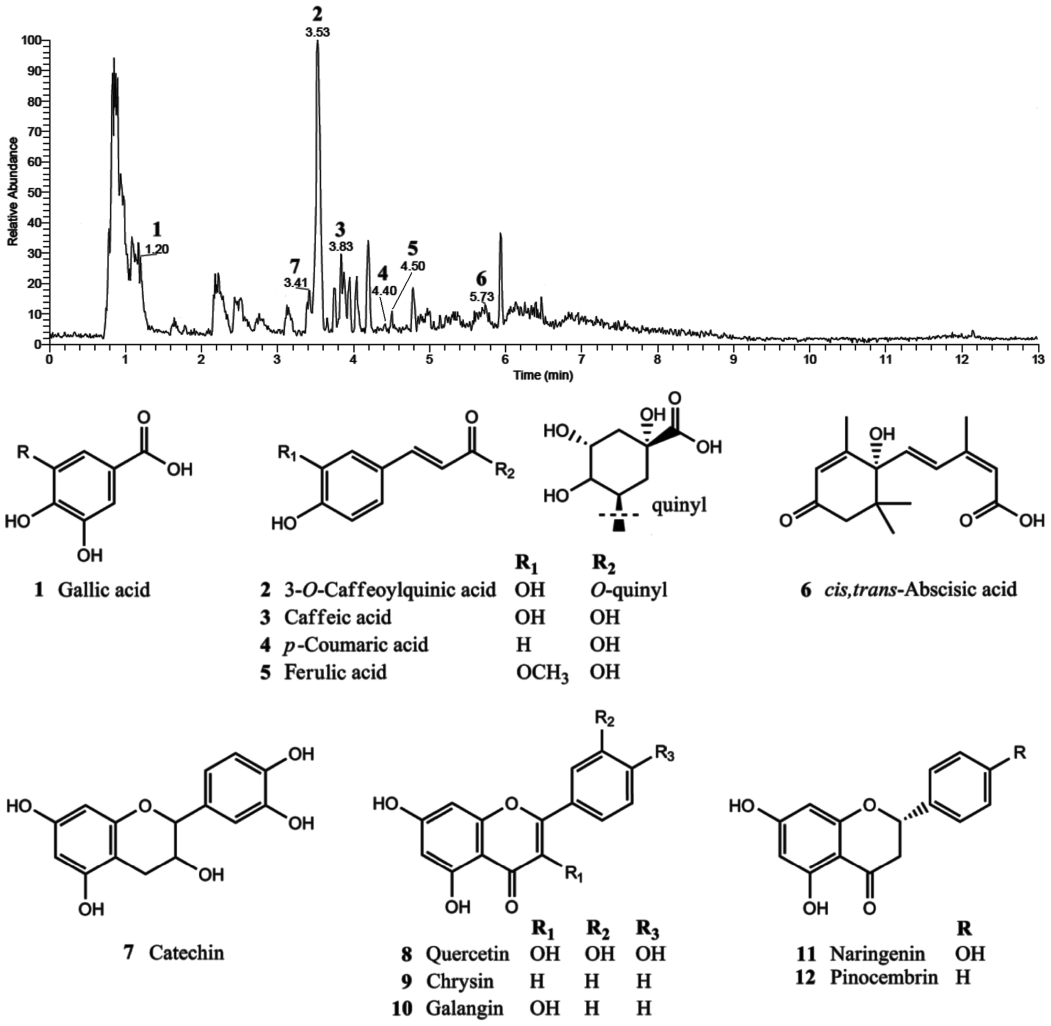

Figure 1. UHPLC-MS total ion chromatogram (TIC) for the polyphenolic fraction of the peach wine together with structures of the quantified compounds.

phenolic compounds found in wine samples (Table 6). Large amounts of caffeic acid and its derivate, chlorogenic acid (3-*O*-caffeoylquinic acid), were found in peach wine. Moreover, chlorogenic acid was not detected only in white wine samples. High content of chlorogenic acid in peach wine (3.59 mg/L) is expected, as it is already reported as one of the major phenolic compounds found in peach fruit.[32,33] Similarly, catechin is known as a compound which is present in significant content in peach fruit,[32] and our results showed significant content (0.60 mg/L) in peach wine. Concentrations of other identified phenolic compounds in peach wine are several times lower in comparison to mentioned phenolic acids.

Table 6. Content of Some Polyphenols in Different Wine Samples (mg/L wine)

compound	peach	Riesling Italian	Riesling Rhine	Chardonnay
gallic acid	0.04	0.01	0.00	0.08
catechin	0.60	0.03	0.02	0.08
chlorogenic acid	3.59	0.00	0.00	0.00
caffeic acid	0.87	0.20	0.25	0.16
p-coumaric acid	0.04	0.05	0.01	0.11
ferulic acid	0.06	0.16	0.15	0.25
quercetin	0.00	0.01	0.00	0.02
cis,trans-abscisic acid	0.09	0.01	0.01	0.01
naringenin	0.03	0.00	0.00	0.00
chrysin	0.02	0.01	0.00	0.02
pinocembrin	0.01	0.00	0.00	0.00
galangin	0.00	0.02	0.00	0.02

The results of the consumers' acceptance test of given wine samples are shown in Table 7. This longer nine-point scale was chosen because it tends to be more discriminatory than shorter scales (up to five intervals). Although this scale has no true interval level of measurement, the parametric approach was achieved with the larger sample size (80 consumers). It is obvious that the peach wine was very well accepted by the regular consumers of wine. According to the results of sensory analysis, the peach wine was statistically very significantly better than white grape wine. Riesling Italian and Riesling Rhine were not statistically different, while the Chardonnay had the lowest marks. These results indicate that peach wine can be a very interesting product in the Serbian market, where it is currently very poorly represented.

According to the results obtained in the present work, physicochemical characteristics of wines, such as alcohol content, pH value, titratable and volatile acidity, color, and total extract, have a great influence on their overall quality. The

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Table 7. Basic Statistical Parameters[a] of the Results Obtained Using the Nine-Point Hedonic Scale

samples	mean	median	min	max.	std dev	coef var	std error
peach wine	8.22a	8.00	7.00	9.00	0.79	9.62	0.09
Riesling Italian	7.11b	7.00	5.00	9.00	1.21	16.95	0.14
Riesling Rhine	7.22b	8.00	5.00	9.00	1.48	20.55	0.17
Chardonnay	6.22c	7.00	4.00	7.00	1.24	19.86	0.15

[a]Different letters in same column denote a significant difference according to Tukey's test, $p < 0.05$.

alcohol content of peach wine was significantly lower compared with white grape wines, while its pH value was relatively high. For these reasons, the peach wine had a lower microbiological stability and required a higher concentration of sulfur dioxide for preservation. The content of volatile acids was similar in all analyzed wine samples and was below the upper acceptability limit. According to the CIELab chromatic parameters, the color of all samples was yellow with a certain proportion of greenness, while the peach wine was the darkest with the highest proportion of yellow color. The content of total sugars was less than 1.5 g/L in all samples, which is why these wines can be classified into dry wines. The peach wine had the lowest content of total sugars, trehalose and fructose, while sucrose and maltose were not detected. The total phenolics and flavonoids content were significantly higher in peach wine compared with that in selected white wines. Because the TPC and TFC were strongly correlated with antioxidant capacity, the peach wine had remarkably higher antioxidant capacity compared with that of white wines. Therefore, the peach wine is a better source of natural antioxidants than white wines. Chlorogenic acid, caffeic acid, and catechin were the main phenolic compounds found in peach wine. The results of sensory analysis indicate that the peach wine was very well accepted by the regular consumers of wine and can be a very interesting product in the Serbian market.

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Notes

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