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CHARACTERIZATION THE INFLUENCE OF THE ROOTSTOCKS SO4, 44-53M, 110R AND FERCAL ON THE VOLATILE COMPOSITION OF RED WINES FROM THE HYBRID VARIETIES STORGOZIA (THREE HARVESTS) AND RUBIN (TWO HARVESTS) IN THE CONDITIONS OF CENTRAL NORTHERN BULGARIA

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ABSTRACT

A gas chromatographic (GC-FID) study to characterize the influence of SO4, 44-53M, 110R and Fercal rootstocks on the volatile composition of red wines from the hybrid varieties Storgozia (harvests: 2017, 2018 and 2019) and Rubin (harvests: 2017 and 2019) under the soil and climatic conditions of Central Northern Bulgaria was conducted. The 110R rootstock in Storgozia has been shown to generate the highest total volatile content (756.10 mg/dm^3) in 2017 harvest. 110R also affected the higher alcohols content of Storgozia. It generated the highest content of this indicator (713.00 mg/dm^3) again in wines from the 2017 harvest. Regarding the content of esters, aldehydes and terpenes no significant differences were observed between the experimental variants of wines from this grapevine variety. In the case of Rubin wines, a very high final total volatile content was proved at rootstock 44-53M (1717.24 mg/dm^3), harvest 2019. The highest concentration of higher alcohols in the 2017 harvest was identified for SO4, while in Rubin - the 2019 harvest, 110R generated the highest presence of higher alcohols. This fraction in both harvests was mainly represented by 2-methyl-1-butanol and 3-methyl-1-butanol. The esters were dominated by ethyl acetate and propyl acetate. In both harvests, the highest total terpene content was found in the wines from SO4 rootstock. The conducted research was evidence of the significant influence of different rootstocks on the volatile composition of wines from hybrid grapevine varieties in the conditions of Central Northern Bulgaria.

Keywords: rootstocks, volatile composition, wine, higher alcohols, esters, terpenes, aldehydes

INTRODUCTION

The use of rootstocks for grafting began to be actively used in viticulture in the mid-19th century, as a consequence of counteracting the rapid spread of phylloxera (*Philloxera vitifolii* Fitch. VITEUS VITIFOLIAE, HOMOPTERA: PHYLLOXERIDAE) in Europe, which destroys much of the vineyards grown on own root (**Cheng *et al.*, 2020**; **Abrasheva *et al.*, 2012**).
The rootstock used affects the grafted grapevine variety in many ways: improving protection against diseases and pests on the vine (**Vršič *et al.*, 2015**); increased and improved adaptation of the variety to environmental conditions (**Henderson *et al.*, 2018**); ripening rate and quality of grapes (**Corso and Bonghi, 2014**); influence on wine volatile composition and sensory parameters (**Olarte-Mantilla *et al.*, 2017**).
Although research has been found in the literature on grape yield and the quality of grape must and wine from varieties grafted on different rootstocks (**Wooldridge *et al.*, 2010**), their influence on the grapes physicochemical composition (**Ollat *et al.*, 2003**), effect on wine volatile and chemical composition (**Carrasco-Quroz *et al.*, 2020**), the main part of the research conclude that there is no universal rootstock. This is so, because globally, the soil and climatic conditions of each vine-growing region are a multi-component factor that affects differently the adaptation and expression of the potential of the vines grafted on different rootstocks. Thus, the choice of rootstock takes into account the characteristics of the variety, the characteristics of the region (soil, climate, terroir in general) and the characteristics of the environment (**Sampaio, 2007**).
All this provokes the aim of the current three-year study determining the impact on the volatile composition of wines obtained from two hybrid varieties (Storgozia and Rubin), grafted on four different rootstocks (SO4, 44-53M, 110R and Fercal) and grown in the soil-climatic conditions of the city of Pleven, Central Northern Bulgaria.

MATERIAL AND METHODS

Rootstocks

Berlandieri x Riparia SO4
This rootstock was imported to Bulgaria from France in 1966. It was created in 1896 from two scientists - Teleki and Fuhr. It is widely distributed in countries with developed viticulture (**Dimitrov *et al.*, 1973**).

Berlandieri x Rupestris 110 Richter
The rootstock was imported to Bulgaria in the distant 1927, but despite this nowadays it is not widely distributed in the country. On the Balkan Peninsula it is distributed in Greece and Turkey. It is used in countries with developed viticulture and winemaking, such as Portugal, Spain and Italy, it is also widespread in Algeria. It was created in France in 1889 by Richter.

44-53 Malègue [Riparia grand glabre x 144 M (Cordifolia x Rupestris)]
It is a complex hybrid. It was created in 1890 by Malègue. Due to its resistance to the short-knot virus and drought, it was widely distributed in France in the period from 1945 to 1960. The rootstock is not widely distributed in Bulgaria, although it was imported in 1966.

Fercal [BC1 (Berlandieri x Colombard №1) x Z33 EM (Berlandieri x Cabernet Sauvignon)]
It was obtained by Peugeot in 1959 in France. It is used in soils with a high chlorinating power.

Grapevine varieties, climate, soils, vinification

The study was conducted at the Institute of Viticulture and Enology (IVE) - Pleven, in the period 2017 - 2019. The object of this study were red wines of the interspecific hybrid variety Storgozia (*parental forms*: Bouquet x Save vilar 12755) (**Ivanov *et al.*, 1984; Katerov *et al.*, 1990**), obtained from three harvests (2017, 2018 and 2019) and the intraspecific hybrid Rubin (*parental forms*: Nebbiolo x Shiraz) (**Petkov, 1977**), obtained from two harvests (2017 and 2019). Both varieties were grown in the region of Central Northern Bulgaria in the experimental vineyards at the Experimental Base of IVE, Pleven. The experimental plantation was planted in the spring of 2009 on leached chernozem and includes 75 pcs. vines of each variant. The vines were formed in the middle stem, type double improved Guyot. The planting distance was 2.00/1.30 m. The pruning and loading of the vines was the same in all variants - 28 winter eyes, realized with 2 arrows on the vine (one on the cordon) with 8 winter eyes and 6 pegs (3 on the cordon) with 2 winter eyes. During the phase of "grape ripening" the dynamics of sugar accumulation with a refractometer was monitored to determined the moment of grapes technological maturity.

Pleven is situated in the northern wine region of Bulgaria. The town is located in the Danube plain. The climate is continental. Spring comes early. Summers are relatively dry and hot. The autumn period is long and cold. Winter is frosty and cold. The soils are chernozems. The characteristic sum of the temperature during the vegetation period of the vine plant ranges from 3130 °C to 4003 °C. The vegetation period usually lasts within 190 to 210 days. The frosts are not observed for a period of 178 to 223 days. Usually, the vine vegetation period in the region starts within the month of April - from its beginning until around April 14th. The region is characterized by up to 20% spring frosts. Average temperatures from 20.03 °C to 24.02 °C are characteristic for the warmest months. The precipitation (as an annual total) ranges from 532 mm·dm^{-3} to 753 mm·dm^{-3} (**Katerov *et al*., 1990; Pandeliev *et al*., 2005**).

30 kg of grapes were used for each variety. The grapes were vinified in the Experimental Wine Cellar of IVE according to a classic technological scheme for obtaining of dry red wines (Yankov, 1992).

Determination of the wines volatile content by GC-FID

The volatile composition was determined by GC-FID. The content of the volatile fraction in the wines was identified and defined by the preparation and initial injection of a standard solution of pure compounds (with a purity higher than 99%, ordered from Merck, Darmstadt, Germany) in accordance with method IS 3752:2005. This solution consisted of 32 compounds that were injected into the chromatograph (in an amount of 2 μL) and their retention times (RT) were defined. Table 1 presents the data for each compound in the standard solution with its corresponding RT. For the quantitative determination of the volatile fraction in the analyzed wines, 1-octanol was used as an internal standard, with a retention time of 16.345 min.

Table 1 Standard solution compounds with their retention times (RT)

№	COMPOUNDS IN THE STANDARD SOLUTION	RT, MIN
1	Acetaldehyde	3.141
2	Ethyl acetate	3.758
3	Methanol	3.871
4	2-propanol	5.170
5	Isopropyl acetate	5.975
6	1-propanol	6.568
7	2-butanol	7.731
8	Propyl acetate	9.403
9	2-methyl-propanol	10.970
10	1-butanol	11.509
11	Isobutyl acetate	11.662
12	Ethyl butyrate	12.710
13	Butyl acetate	12.752
14	2-methyl-1-butanol	13.054
15	4-methyl-2-pentanol	13.629
16	3-methyl-1-butanol	13.840
17	1-pentanol	15.180
18	Isopentyl acetate	15.965
19	Pentyl acetate	16.033
20	1-hexanol	16.276
21	Ethyl hexanoate	16.376
22	Hexyl acetate	16.510
23	1-heptanol	16.596
24	Linalool oxide	16.684
25	Phenyl acetate	18.055
26	Ethyl caprylate	18.625
27	α-terpineol	19.066
28	2-phenyl ethanol	19.369
29	Nerol	19.694
30	β-citronellol	19.743
31	Geraniol	19.831
32	Ethyl decanoate	19.904

The used chromatograph was Varian 3900 (Varian Analytical Instruments, Walnut Creek, California, USA). The column used was VF max MS (30 m, 0.25 mm ID, DF = 0.25 μm), the dector was FID. The gases used were: He (carrier gas) amd H (combustion gas). GC analysis parameters were: 220 °C (temperature of the injector); 250 °C (temperature of the detector), 35 °C (initial temperature of the oven)/retention 1 min, rise to 55 °C with step of 2 °C·min^{-1} for 11 min, rise to 230 °C with step of 15 °C·min^{-1} for 3 min. Analysis time – 25.67 min. Wine samples were previously distilled. The distillates were injected into the chromatograph and the volatile wine fractions were identified and quantified.

RESULTS AND DISCUSSION

The results for the volatile composition and aromatic profile (GC-FID) of red wines from Storgozia variety (three harvests - 2017, 2018 and 2019) for the four different rootstocks studied are presented in Tables 2, 3 and 4.

Regarding the total volatile composition in the 2017 harvest, the variant 110R (756.10 mg/dm^3) was observed with the highest concentration. It had a significantly higher content of volatile compounds compared to the other variants of the same harvest. The other three variants showed relatively close concentrations of total volatile compounds, ranging from 178.27 mg/dm^3 (Fercal) - 191.58 mg/dm^3 (44-53M). The data related with the established high total volatile composition of Storgozia wines at 110R rootstock correlated with the results in the studies of **Olarte-Mantilla *et al*. (2017)** who proved that the use of this rootstock has a significant positive effect on the chemical composition, organoleptic profile and quality of Syrah wine. **Vilanova *et al*. (2021)** reached the same conclusion. The team proved that 110R positively affected the volatile composition of Albariño wines under the climatic conditions of the Salinas Valley (Galicia, Spain).

The wines from the 2018 harvest showed higher values by variants compared to those of the previous harvest. The only exception was the wine from 110R. The highest total volatile content in this harvest was found in Storgozia wine with SO4 rootstock (640.39 mg/dm^3), which had a control role in the research. All other experimental variants showed a lower quantitative presence of total volatile compounds. In the 2019 harvest, the total volatile content found in the studied variants varied from 180.54 mg/dm^3 (44-53M) - 310.44 mg/dm^3 (Fercal). The wine obtained from Storgozia on Fercal showed quantitatively the highest volatile content in this particular harvest.

Table 2 Volatile composition of red wines from Storgozia variety (harvest 2017) on different rootstocks

IDENTIFIED COMPOUNDS mg/dm^3	WINES (HARVEST 2017)			
	STORGOZIA			
	SO4	*4453-M*	*110 R*	*FERCAL*
Ethyl alcohol, vol.%	14.79	14.79	14.98	14.84
Acetaldehyde	0.05	0.05	0.05	0.05
Methanol	19.40	16.78	17.08	17.76
2-methyl-1-propanol	ND	ND	ND	ND
2-methyl-1-butanol	ND	ND	582.77	ND
3-methyl-1-butanol	114.00	124.56	87.56	113.60
4-methyl-2-pentanol	ND	ND	19.75	ND
1-butanol	27.65	26.90	22.87	26.80
1-hexanol	0.05	0.05	0.05	0.05
Total higher alcohols	***141.70***	***151.51***	***713.00***	***140.45***
Ethyl acetate	21.93	23.14	25.87	19.42
Propyl acetate	0.05	0.05	0.05	0.05
Total esters	***21.98***	***23.19***	***25.92***	***19.47***
Geraniol	ND	0.05	0.05	0.54
Total terpenes	***ND***	***0.05***	***0.05***	***0.54***
TOTAL CONTENT	***183.13***	***191.58***	***756.10***	***178.27***

* ND - Not Detected

Table 3 Volatile composition of red wines from Storgozia variety (harvest 2018) on different rootstocks

IDENTIFIED COMPOUNDS mg/dm^3	WINES (HARVEST 2018)			
	STORGOZIA			
	SO4	*4453-M*	*110 R*	*FERCAL*
Ethyl alcohol, vol.%	14.53	15.50	14.01	14.53
Acetaldehyde	80.29	30.00	0.05	0.05
Methanol	72.70	37.54	120.00	66.76
2-methyl-1-butanol	26.96	26.29	48.10	28.04
3-methyl-1-butanol	89.06	91.56	182.98	103.37
4-methyl-2-pentanol	ND	ND	0.05	0.05
2-phenylethanol	ND	ND	0.05	ND
1-propanol	ND	0.05	0.05	0.05
2-butanol	25.63	0.05	57.38	41.83
1-pentanol	ND	12.45	0.05	0.05
Total higher alcohols	***141.65***	***130.40***	***288.66***	***173.39***
Ethyl acetate	30.95	23.44	43.26	25.02
Propyl acetate	65.69	ND	ND	ND
Ethyl decanoate	74.50	55.14	0.05	0.05
Ethyl caprylate	174.61	ND	ND	ND
Total esters	***345.75***	***78.58***	***43.31***	***25.07***
α – terpineol	ND	ND	0.05	ND
Linalool oxide	ND	ND	ND	0.05
β – citronellol	ND	ND	0.05	ND
Total terpenes	-	-	***0.10***	***0.05***
TOTAL CONTENT	***640.39***	***276.52***	***452.12***	***265.32***

* ND - Not Detected

No significant difference in the amount of total volatile compounds was observed between the three harvests. The only difference was observed in the variant 110R of the 2017 harvest in which was identified the highest amount of volatile compounds among all studied wines from the three harvests.
The total content of higher alcohols in the studied wines showed a similar trend. In the 2017 harvest, a significantly higher amount of higher alcohols was identified in variant 110R (713.00 mg/dm^3). The other variants showed very close concentrations when they were compared to each other.
In the 2018 harvest, the established quantitative variations of higher alcohols ranged from 130.40 mg/dm^3 (44-53M) to 288.66 mg/dm^3 (110R). Here again, the 110R rootstock variant showed the highest quantitative presence of higher alcohols.
In the 2019 harvest, the lowest established concentrations of higher alcohols were found, compared to the other two harvests. They ranged from 48.86 mg/dm^3 (SO4) to 206.79 mg/dm^3 (Fercal). The highest presence of higher alcohols in the wines of this harvest was found in Fercal.
The most significant species diversity of higher alcohols was found in the wines from the 2019 harvest (8 identified representatives). In the wines of Storgozia, harvest 2017, the main representatives of higher alcohols were 3-methyl-1-butanol (quantitatively dominant), 1-butanol and 1-hexanol. The wines of the 2018 harvest were represented mainly by 2-methyl-1-butanol, 3-methyl-1-butanol, 1-propanol, 2-butanol and 1-pentanol. Those from the 2019 harvest were dominated by 2-methyl-1-butanol, 3-methyl-1-butanol and 1-propanol. The data correlated with the studies of **Vilanova *et al*. (2021)**, which investigated the influence of 9 rootstocks on the volatile composition of Albariño wines (Spain). In all tested variants, they found the main presence of 3 higher alcohols - 2-methyl-1-butanol, 3-methyl-1-butanol and 2-phenylethanol. The total ester content in the wines of the 2017 harvest was low. It ranged from 19.47 mg/dm^3 (Fercal) to 25.92 mg/dm^3 (110R). There was no noticeable difference in the content of esters in the wines from this harvest. The wines of the 2018 harvest showed a significantly higher concentration of esters than the previous harvest. The ester content in the control variant SO4 (345.75 mg/dm^3) significantly exceeding the established concentrations in the experimental variants.

Table 4 Volatile composition of red wines from Storgozia variety (harvest 2019) on different rootstocks

IDENTIFIED COMPOUNDS mg/dm^3	**WINES (HARVEST 2019)**			
	STORGOZIA			
	SO4	***4453-M***	***110 R***	***FERCAL***
Ethyl alcohol, vol.%	12.98	14.91	14.97	14.57
Acetaldehyde	47.89	21.81	54.34	13.03
Methanol	21.53	12.06	9.34	20.57
2-methyl-1-butanol	9.88	9.82	7.23	12.57
3-methyl-1-butanol	32.93	21.21	15.41	31.10
2-phenylethanol	ND	ND	ND	135.92
1-propanol	6.05	7.89	27.52	ND
2-propanol	ND	ND	ND	8.10
1-butanol	ND	ND	11.13	ND
2-butanol	ND	ND	ND	17.97
1-pentanol	ND	ND	ND	1.13
Total higher alcohols	***48.86***	***38.92***	***61.29***	***206.79***
Ethyl acetate	65.67	25.83	36.76	11.32
Propyl acetate	12.15	6.62	7.91	16.26
Isopropyl acetate	ND	ND	ND	14.90
Isopentyl acetate	23.50	64.51	28.51	ND
Pentyl acetate	ND	10.51	ND	ND
Phenyl acetate	ND	ND	ND	27.29
Ethyl caprylate	24.74	ND	ND	ND
Total esters	***126.06***	***107.47***	***73.18***	***69.77***
α – terpineol	0.69	ND	ND	ND
Nerol	0.30	0.28	0.57	0.28
β – citronellol	0.28	ND	ND	ND
Total terpenes	***1.27***	***0.28***	***0.57***	***0.28***
TOTAL CONTENT	***245.61***	***180.54***	***198.72***	***310.44***

* ND - Not Detected

In the 2019 harvest, significantly higher concentrations of esters were also observed, compared to the 2017 harvest. Again, their presence in the control variant SO4 (126.06 mg/dm^3) was significant. The 44-53M variant (107.47 mg/dm^3) also showed a good result on this indicator.
The 2017 harvest was represented by 2 identified esters - ethyl acetate and propyl acetate. In the wine of the 2018 harvest, 4 esters were identified, with a predominant presence of ethyl acetate and ethyl decanoate. The 2019 harvest showed 7 identified esters, mainly ethyl acetate, propyl acetate and isopentyl acetate.
The aldehyde fraction in all three harvests was represented by acetaldehyde. This compound was identified in low concentrations in the wines of the 2017 harvest. In those of the 2018 harvest, its content varied from 0.05 mg/dm^3 - 80.29 mg/dm^3. Its concentration was highest in the control variant SO4. In the wines of Storgozia, harvest 2019, its variation was 13.03 mg/dm^3 (Fercal) - 54.34 mg/dm^3 (110R).
In all studied wines the concentration of acetaldehyde was below the threshold (110.00 mg/dm^3), above which it begins to have a negative impact on the aromatic quality. The wines of the 2017 harvest had low terpenes concentration. The highest total content of terpene alcohols was identified in Storgozia on Fercal (0.54 mg/dm^3). In the control SO4 terpenes were not identified, and the experimental variants were represented only by geraniol. The results for the next harvest (2018) were identical. Terpenes were identified only in variants 110R (0.10 mg/dm^3) and Fercal (0.05 mg/dm^3) with a very low quantitative presence.
The wines of the 2019 harvest showed the highest terpene profile of the three harvests studied. The highest total amount was found in the control SO4 (1.27 mg/dm^3). In the other variants it was lower, but higher than that established in the previous two harvests. Three terpenes were identified - α-terpineol, nerol and β-citronellol, the main one being nerol.
The methanol content in red wines is allowed up to 350.00 mg/dm^3. In the wines of the 2017 harvest, it varied from 16.78 mg/dm^3 (44-53M) to 19.40 mg/dm^3 (SO4). In the next harvest (2018) a variation from 37.54 mg/dm^3 (44-53M) to 120.00 mg/dm^3 (110R) was found. The wines of the 2019 harvest showed the presence of this component, ranging from 9.34 mg/dm^3 (110R) to 21.53 mg/dm^3 (SO4).
All established concentrations of methyl alcohol in the studied wines were normal, with a content that was typical for red wines.
The data on the established volatile composition (GC-FID) of red wines of the Rubin variety (two harvests - 2017 and 2019) on the rootstocks SO4, 44-53M, 110R and Fercal are presented in Tables 5 and 6.

Table 5 Volatile composition of red wines from Rubin variety (harvest 2017) on different rootstocks

IDENTIFIED COMPOUNDS mg/dm^3	**WINES (HARVEST 2017)**			
	RUBIN			
	SO4	***4453-M***	***110 R***	***FERCAL***
Ethyl alcohol, vol.%	14.82	15.64	14.73	14.43
Acetaldehyde	67.43	0.05	0.05	0.05
Methanol	0.05	11.89	7.36	11.57
2-methyl-1-propanol	121.07	ND	ND	ND
2-methyl-1-butanol	25.64	ND	ND	ND
3-methyl-1-butanol	121.48	25.28	140.63	158.30
2-phenylethanol	12.26	0.05	ND	ND
1-propanol	ND	15.18	ND	ND
1-butanol	ND	29.68	31.50	33.00
1-pentanol	ND	116.54	ND	ND
1-hexanol	0.05	0.05	0.05	0.05
1-heptanol	ND	ND	0.05	0.05
Total higher alcohols	***280.50***	***186.78***	***172.23***	***191.40***
Ethyl acetate	32.45	10.36	11.62	12.84
Propyl acetate	ND	0.05	0.05	0.05
Pentyl acetate	ND	0.05	ND	ND
Ethyl decanoate	ND	0.05	ND	ND
Total esters	***32.45***	***10.51***	***11.67***	***12.89***
α – terpineol	ND	0.05	ND	ND
Linalool oxide	ND	0.12	ND	ND
Nerol	ND	0.05	0.05	ND
β – citronellol	ND	ND	ND	0.05
Geraniol	0.84	0.05	0.70	0.25
Total terpenes	***0.84***	***0.27***	***0.75***	***0.30***
TOTAL CONTENT	***381.27***	***209.50***	***192.06***	***216.21***

* ND - Not Detected

Table 6 Volatile composition of red wines from Rubin variety (harvest 2019) on different rootstocks

IDENTIFIED COMPOUNDS mg/dm^3	**WINES (HARVEST 2019)**			
	RUBIN			
	SO4	***4453-M***	***110 R***	***FERCAL***
Ethyl alcohol, vol.%	14.82	15.26	15.14	14.78
Acetaldehyde	10.98	7.10	16.12	16.51
Methanol	12.12	112.56	10.55	9.45
2-methyl-1-butanol	17.30	106.84	6.05	50.86
3-methyl-1-butanol	40.39	525.49	29.36	45.11
2-phenylethanol	ND	ND	107.47	129.18
1-propanol	ND	29.48	11.65	7.96
2-butanol	46.35	ND	ND	ND
1-pentanol	ND	ND	ND	16.83
Total higher alcohols	***104.04***	***661.81***	***154.53***	***249.94***
Ethyl acetate	12.98	153.15	25.40	14.89
Propyl acetate	35.95	487.71	22.16	40.05
Isopropyl acetate	21.53	122.89	ND	25.36
Phenyl acetate	ND	171.46	ND	25.49
Ethyl caprylate	14.01	ND	ND	ND
Total esters	***84.47***	***935.21***	***47.56***	***105.79***
α – terpineol	ND	0.45	ND	0.60
Nerol	0.79	0.11	0.30	ND
β – citronellol	0.36	ND	ND	ND
Total terpenes	***1.15***	***0.56***	***0.30***	***0.60***
TOTAL CONTENT	***212.76***	***1717.24***	***229.06***	***382.29***

* ND - Not Detected

Comparing the total content of volatile compounds in the wines of the two harvests, it could be seen that the 2019 harvest showed an increased content of volatile compounds, compared to the 2017 harvest. It is noteworthy that the Rubin wine (harvest 2019), at rootstock 44-53M, had a very high final level of volatile compounds (1717.24 mg/dm^3). In the 2019 harvest, it was visible also that in the wine of the used control rootstock SO4 the lowest total amount of volatile compounds (212.76 mg/dm^3) was found compared to the experimental variants, where it ranged from 229.06 mg/ dm^3 (110R) - 1717.24 mg/dm^3 (44-53M).

Wines from the 2017 harvest showed a significantly different picture. In them, the control variant SO4 showed the highest concentration of volatile compounds (381.27 mg/dm^3) compared to the experimental variants, in which the final total volatile content varied from 192.06 mg/dm^3 (110R) - 216.21 mg/dm^3 (Fercal).

The higher total amounts of volatile compounds in the wines of the 2019 harvest were probably due to the climatic conditions of the year - higher temperatures and less rainfall, which was reflected in high sugar accumulation in grapes, where yeasts in the vinification process carried out stronger, more active biotransformation of sugars with the production of higher amounts of volatile compounds.

According to the indicator "total volatile composition" in both harvests good results showed Rubin's wine at the Fercal rootstock. In the 2017 harvest, the highest total amounts of volatile compounds were found in it, and in the 2019 harvest it was ranked second, after the variant at 44-53M. Rubin's wine at 44-53M, harvest 2019, showed very high total levels of volatile compounds.

With regard to the total content of the identified higher alcohols in the wines of the two harvests, the same trend was found as for the total volatile composition. In wines from the 2017 harvest, the highest level of higher alcohol content was registered in the control SO4 (280.50 mg/dm^3). In the experimental variants it was lower, varied from 172.23 mg/dm^3 (110R) - 191.40 mg/dm^3 (Fercal).

For the wines from the 2019 harvest, SO4 control showed the lowest concentration presence of higher alcohols (104.04 mg/dm^3), compared to the experimental variants, where it varied from 154.53 mg/dm^3 (110R) to 661.81 mg/dm^3 (44-53M). Again, Rubin wine at 44-53M had a significantly dominant presence of higher alcohols in this harvest, followed by Fercal (249.94 mg/dm^3).

Nine higher alcohols were identified in the wines of the 2017 harvest, and six in the wines of the 2019 harvest, respectively. The main representatives of this fraction in the 2017 harvest were 3-methyl-1-butanol, 1-butanol and 1-hexanol. The 2019 harvest was represented mainly by 2-methyl-1-butanol, 3-methyl-1-butanol and 1-propanol.

The wines from the 2019 harvest showed higher total ester composition than those from the 2017 harvest. The highest final ester content in Rubin wines, harvest 2017, was identified in the SO4 control (32.45 mg/dm^3). The experimental variants of this harvest were not differed significantly by this indicator. The variation of total esters between them was in the range of 10.51 mg/dm^3 (44-53M) - 12.89 mg/dm^3 (Fercal). In general, the levels of esters in the wines of the 2017 harvest were low.

The 2019 harvest showed significantly higher concentration of esters. Very high ester levels were found in Rubin wine at 44-53M (935.21 mg/dm^3). In the other variants it varied from 47.56 mg/dm^3 (110R) - 105.79 mg/dm^3 (Fercal). The wines of this harvest showed significant accumulation of esters, which was probably due to the climatic features of the year - dry summer, high temperatures and low rainfall, generating high sugar accumulation in the grapes.

The ester fraction in the variants of the 2017 harvest was represented by four identified esters, while the 2019 harvest showed more diverse species ester presence - five representatives. The wines from both harvests were dominated by ethyl acetate and propyl acetate. In the 2019 harvest, their quantity were higher than in the 2017 harvest.

The aldehyde fraction was represented by acetaldehyde. For the wines from the 2017 harvest, it varied from 0.05 mg/dm^3 - 67.43 mg/dm^3. In the highest concentration it was found in the control variant, with SO4 rootstock. In the experimental variants, its amounts were low.

In 2019 harvest, the aldehyde varied from 7.10 mg/dm^3 (44-53M) - 16.51 mg/dm^3 (Fercal). The threshold concentration for the positive effect of acetaldehyde is 110.00 mg/dm^3. In all tested wine variants (for both harvests) acetaldehyde was identified below this concentration, which was direct evidence of its positive effect on wine aromatic quality.

Regarding the total content of terpenes in the analyzed wines, it was found that 2019 harvest showed significantly higher presence of terpenes, ranging from 0.30 mg/dm^3 (110R) - 1.15 mg/dm^3 (SO4), compared to the 2017 harvest - 0.27 mg/dm^3 (44-53M) - 0.84 mg/dm^3 (SO4). It was noteworthy that the highest total concentration of terpenes in the studied wines was found in the control variant - SO4 rootstock. The wines from the 2017 harvest showed greater species diversity of terpenes (5 terpenes identified) than those of the 2017 harvest (3 terpenes identified). In the 2019 harvest, nerol dominated, and in 2017 - geraniol.

The methyl alcohol was found in practically all studied wines from both harvests. In the 2017 harvest, it ranged from 0.05 mg/dm^3 (SO4) to 11.89 mg/dm^3 (44-53M). The wines of the 2019 harvest showed slightly higher values for the presence of methanol, respectively from 7.10 mg/dm^3 (44-53M) to 16.51 mg/dm^3 (Fercal).

The methyl alcohol is a normally present component of the volatile wine composition. It is obtained on the basis of degradation of fruit pectin under the action of the pectolytic enzyme complex of the fruit. In red wines its presence is allowed up to 350.00 mg/dm^3.

All detected amounts of methanol in the studied wines were normal, which proved their safety from a toxicological point of view.

CONCLUSION

The following conclusions could be made from the results on the volatile composition of Storgozia wines:

• No significant difference was found in the indicator "total volatile content" in the wines of Storgozia in the three studied harvests. The only difference was the 110R variant, harvest 2017, in which the highest amount of volatile compounds (756.10 mg/dm^3) of all tested harvests was found.

• The wines of the 2019 harvest showed the lowest total amount of higher alcohols compared to the other two harvests. Significantly higher amount of higher alcohols was identified in variant 110R of the 2017 harvest (713.00 mg/dm^3).

• The greatest species diversity of higher alcohols was found in the wines of the 2019 harvest - 8 identified representatives.

• The lowest ester content was found in the wines of the 2017 harvest. The other two harvests showed higher levels on this indicator. The main esters were ethyl acetate and propyl acetate.

• The aldehyde fraction was represented by acetaldehyde, and its concentrations were normal to showed its positive effect on the aromatic wine quality.

• The wines from the 2017 and 2018 harvests had low total terpenes concentration, while those from the 2019 harvest showed a higher quantitative and species presence of these compounds.

• The established content of methyl alcohol was typical for red wines and in the norm, determining their toxicological safety.

The results for the characterization of the volatile composition of Rubin wines showed the following conclusions:

• According to the indicator "total content of volatile compounds" it was proved that given the climatic features of the year, wines of the 2019 harvest accumulated more volatile compounds than those of the 2017 harvest. 44-53M, harvest 2019, showed a very high final amount of volatile compounds (1717.24 mg/dm^3). The variant on Fercal rootstock also demonstrated good wine aromatic quality in both harvests.

• The experimental variants of wines from the 2017 harvest showed lower content of higher alcohols (from 172.23 mg/dm^3 - 110R to 191.40 mg/dm^3 - Fercal), compared to the control SO4 (280.50 mg/dm^3). The opposite trend for the 2019 harvest was proved - the lowest amount of higher alcohols (104.04 mg/dm^3) was registered in the control, compared to the experimental variants (from 154.53 mg/dm^3 - 110R to 661.81 mg/dm^3 - 44-53M).

• The wines of the 2017 harvest were more diverse in terms of higher alcohols (9 identified representatives) than those of 2019 (6 identified representatives). The main representatives of this fraction for the 2017 harvest were 3-methyl-1-butanol, 1-butanol and 1-hexanol. The 2019 harvest was represented mainly by 2-methyl-1-butanol, 3-methyl-1-butanol and 1-propanol.

• The wines of the 2019 harvest showed higher total ester content than those of 2017 harvest. The significantly higher accumulation of esters in the 2019 harvest wines was probably due to the specific climatic features of the year. The main representatives of this fraction in the wines of both harvests were ethyl acetate and propyl acetate.

• The aldehyde fraction was represented by acetaldehyde. In all tested wine variants (for both harvests) acetaldehyde was identified in concentrations that directly indicated its positive effect on wine aromatic quality.

• The 2019 harvest showed significantly higher presence of terpenes, ranging from 0.30 mg/dm^3 (110R) - 1.15 mg/dm^3 (SO4), compared to 2017 harvest - 0.27 mg/dm^3 (44-53M) - 0.84 mg/dm^3 (SO4).

• Methyl alcohol was found in practically all tested wines from both harvests. All detected amounts of methanol in the studied wines were normal, which proved their safety from a toxicological point of view.

The conducted research was evidence for the significant influence of different rootstocks on the volatile composition of wines from hybrid grapevine varieties in the conditions of Central Northern Bulgaria.

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