Vitis **54** (Special Issue), 151–154 (2015)

Evaluation of eno-carpological traits in Georgian grapevine varieties from Skra germplasm repository

E. Abashidze[1)], I. Mdinaradze[1)], R. Chipashvili[1)], L. Vashakidze[1)], D. Maghradze[1)], L. Rustioni[2)] and O. Failla[2)]

[1)]Institute of Horticulture, Viticulture and Oenology, Agricultural University of Georgia, Tbilisi, Georgia
[2)] Università degli studi di Milano, Dipartimento di Scienze Agrarie ed Ambientali, Milano, Italy

Summary

Eno-carpological traits were evaluated in twenty one colored and fifteen white Georgian autochthonous grapevine varieties grown in the Skra Germplasm Repository, during two years (2012 and 2013). Mostly of the studied accessions were minor varieties originated from various Georgian provinces. The spectrophotometric method proposed in the framework of the COST action FA1003 has been adopted for total anthocyanin and polyphenol analyses in skin and seed extracts. The obtained results showed that the content of phenolic compounds as well as other eno-carpological parameters varies greatly according to the variety. In general, the total phenol contents ranged from 546.7 to 2818.4 mg·kg^{-1} of grape, and anthocyanins varied from 49.5 to 2826.6 mg·kg^{-1} of grape. The highest content of total phenolics and total anthocyanins was found in the variety 'Saperavi Budeshuriseburi'.

K e y w o r d s : phenotyping; polyphenols; anthocyanins; spectrophotometer.

Introduction

Georgian grapevine germplasm accounts at least 525 autochthonous varieties (Ketskhoveli *et al.* 1960, Maghradze *et al.* 2012) with a great diversity of morphological and agronomical characteristics. The variability of their oenological quality and value is determined by the concentration of biochemical compounds, including phenolics, which play a major role in grape color and flavor properties. The evaluation of the phenolic potential of different grape varieties is essential to characterize cultivars, to optimize the winemaking techniques and to obtain high quality products (García-Beneyte*et al.* 2002, Maghradze *et al.*2009, Vacca *et al.* 2009, Teixeira *et al.* 2013). A large number of data on grape phenolic compounds is available in literature. However, the qualitative and quantitative characteristics of the phenolic compounds of the Georgian grapevine varieties are little studied, despite the publishing of a few works on this subject (Maghradze *et al.* 2009a, Rossoni *et al*. 2007).

Correspondance to: Dr. E. Abashidze; Institute of Horticulture, Viticulture and Oenology, Agricultural University of Georgia. David Aghmashenebeli Alley, 13th km, 0159 Tbilisi, Georgia. E-mail: e.abashidze@agruni.edu.ge

This study aims at the eno-carpological trait evaluation of rarely spread Georgian autochthonous grapevine varieties, in order to encourage their use in oenology or for future breeding programs.

Material and Methods

Samples of thirty six (white and colored) autochthonous grapevine varieties, originated from various provinces of Georgia (Tab. 1) were collected in the Skra Germplasm Repository (FAO code is GEO015) of the Institute of Horticulture, Viticulture and Oenology in 2012 and 2013. The collection was established in 2008, near the Skra village, in the Georgian viticulture and winemaking region of Shida Kartli (41°58' 6" Northand 44°0"14" West, 640 m above sea level). The distance between rows is 2.5 m and the distance between vines is 1.5 m. The scheme of pruning is double Guyot system with 12-16 winter buds/vine.

The standard phenotyping method proposed by the COST action FA1003 "East-West Collaboration for Grapevine Diversity Exploration and Mobilization of Adaptive Traits for Breeding" has been adopted for eno-carpological evaluation of varieties (Rustioni *et al.* 2014). According to the protocol 3 replications of representative 2 bunches for each variety were collected at full maturity stage and analyzed. Berry skin color variability was assessed visually by the OIV225 grape color descriptor (OIV 2007). For carpological assessment the following parameters were measured: bunch and berry weight, berry length and width, skin weight, seed number and weight. The total soluble solids (°Brix) was measured by a digital refractometer and titratable acidity - by titration of the juice with (0.1 N) NaOH with Bromothymol blue as the indicator.

The phenolic analysis were carried out with Unico S2100 Visible Spectrophotometer. The absorbance for skin total anthocyanins was measured at 540 nm using a cuvette with 1 cm optical path. Results were expressed as malvidin-3-*O*-glucoside equivalents in mg/kg of grape. Total polyphenols were quantified separately for skin and seed extracts, using the Folin–Ciocalteu reaction and the absorbance was measured at 700 nm (1 cm optical path). The concentration of total polyphenols was expressed as (+) catechin equivalents in mg/kg of grape.

Descriptive statistical analysis was conducted with the program SPSS software (SPSS, Chicago, Illinois, USA) version 22.0. Analysis was carried out in triplicate during two (2012 and 2013) years. Measurements are given as the mean of replicates with the standard deviations (s.d.).

Table 1

Carpological parameters of Georgian grapevine varieties. Skra Germplasm Repository (average data of 2012 and 2013)

Accession name	Berry color (OIV descriptor)	Berry weight (g)	Skin weight (g)	Number of seeds/ berry	Seed weight (mg)	Berry length (mm)	Berry width (mm)	Bunch weight (g)
Argvetuli Sapere	blue-black	2.1±0.1	0.8±0.08	2.9±0.4	30.4±0.5	14.5±0.7	18.0±6.3	254.2±21.5
Aspindzura	blue-black	2.0±0.2	0.8±0.3	2.2±0.3	35.1±1.6	14.5±0.8	13.2±0.4	188.0±37.3
Buza	blue-black	1.7±0.2	0.7±0.2	1.6±0.1	49.2±1.3	12.2±0.3	12.3±0.3	89.3±3.0
ChitistvalaBodburi	green-yellow	1.5±0.2	0.5±0.2	2.2±0.4	38.5±2.6	12.2±0.3	11.7±0.5	161.0±55.1
Chvartala	green-yellow	2.7±0.7	0.6±0.2	2.0±0.4	51.1±3.8	16.7±0.8	15.0±1.3	200.6±54.4
Danakharuli	blue-black	2.7±0.4	0.9±0.4	1.8±0.3	51.3±3.5	15.9±1.3	14.8±0.9	206.8 ±24.8
Didmtevana	blue-black	2.8±0.5	0.7±0.2	2.3±0.3	41.4±3.6	15.8±2.1	14.7±0.9	138.0±31.4
Dziragoulis Shavi	blue-black	3.4±0.4	0.9±0.3	2.5±0.5	34.5±3.7	17.6±0.9	15.7±0.6	177.3±27.8
Ghrubela Kakhuri	grey	2.7±0.3	0.7±0.3	2.2±0.3	46.4±3.8	15.7±0.7	14.7±0.7	184.0±20.3
GvinisTsiteli	blue-black	1.9±0.5	0.5±0.1	2.4±0.7	40.2±15.6	13.4±1.6	14.6±3.4	88.5±55.1
IkaltosTsiteli	blue-black	1.7±0.2	0.6±0.1	1.9±0.3	44.6±4.9	13.5±0.5	12.5±0.6	292.5±69.7
Jvari	green-yellow	2.8±0.2	0.9±0.05	1.3±0.4	67.1±17.9	16.2±0.3	15.4±0.2	207.0±27.8
Kharistvala Shavi	blue-black	2.3±0.2	0.5±0.1	2.0±0.3	38.2±7.7	14.4±0.9	13.7±0.4	167.6±18.7
Khikhvi	green-yellow	2.2±0.3	0.7±0.1	1.6±0.3	53.2±5.9	14.6±0.9	13.8±1.1	106.2±23.2
Khikhvi, clone 430	green-yellow	2.1±0.3	0.5±0.09	1.5±0.1	50.5 ±4.8	14.3±0.8	12.6±0.8	133.5±18.4
Kishuri	green-yellow	1.9±0.2	0.7±0.1	1.9±0.2	37.1±2.4	15.1±0.7	12.6±0.5	121.8±14.9
Kisi	green-yellow	1.5±0.1	0.6±0.07	1.1±0.1	66.4±5.4	13.0±0.4	12.5±0.3	79.0±3.6
Ktsia	blue-black	3.0±0.5	0.7±0.2	2.2±0.3	33.8±4.9	17.6±4.4	15.7±0.9	401.5±192.6
Kurkena	green-yellow	2.5±0.5	0.8±0.1	1.9±0.3	52.5±2.7	15.1±1.6	14.0±1.3	107.3±11.1
Mujuretuli	blue-black	1.4±0.2	0.5±0.06	1.6±0.4	40.1±7.7	14.1±0.9	10.5±0.3	114.0±10.5
Muradouli	green-yellow	2.5±0.7	0.6±0.06	2.4±0.3	44.8±9.4	15.3±0.3	14.7±0.3	192.3±39.0
Partala Shavi	blue-black	2.1±0.9	0.6±0.08	1.4±0.2	49.4±4.1	13.9±0.5	13.7±0.4	122.5±29.5
Rkatsiteli	green-yellow	2.4±0.2	0.8±0.2	2.0±0.3	48.1±1.9	16.4±0.6	13.1±2.8	237.5±22.1
Rkatsiteli Vardisperi	rose	2.5±0.2	0.8±0.1	2.2±0.3	47.3±1.6	15.8±0.7	14.2±0.9	299.3±23.2
Sapena	green-yellow	2.1±0.5	0.6±0.05	1.7±0.5	53.3±4.6	13.6±0.8	14.0±1.0	208.3±15.1
Saperavi Atenis	blue-black	2.2±0.6	0.7±0.2	1.8±0.4	41.8±4.4	15.6±1.4	13.4±1.6	171.1±57.8
Saperavi Budeshuriseburi	blue-black	1.4±0.2	0.5±0.1	1.3±0.2	40.2±3.5	14.3±0.8	11.5±0.9	126.6±32
Shavtsitska	blue-black	2.0±0.2	0.5±0. 2	2.3±0.2	33.0±4.0	13.6±0.5	15.6±4.9	130.6±45.9
Tavkveri Saperaviseburi	blue-black	3.0±0.6	1.2±0.03	2.1±0.2	53.1±3.1	17.4±0.2	15.1±0.2	150.8±58.1
Tavtsitela	blue-black	2.0±0.2	0.7±0.1	1.9±0.2	48.4±11.8	14.2±0.6	13.2±0.4	151.3±56.9
TsirkvalisTetri	green-yellow	2.3±0.1	0.7±0.06	2.0±0.3	51.1±2.7	14.8±0.3	14.2±0.5	90.6±7.3
Tsitska	green-yellow	1.5±0.1	0.4±0.08	1.8±0.2	41.1±4.8	12.5±0.3	11.8±0.5	168.0±67.5
TsnorisTetri	green-yellow	1.7±0.4	0.4±0.04	1.3±0.2	45.1±4.9	13.1±0.2	11.3±0.5	98.6±28.5
VazisubnisTsiteli	blue-black	1.9±0.2	0.5±0. 2	2.3±0.4	49.0±3.2	13.8±0.3	13.2±0.7	127.0±51.1
Zerdagi	green-yellow	2.9±0.4	0.9±0.09	2.2±0.4	51.2±4.3	17.5±0.5	16.1±0.5	104.6±8.3
ZhgiaSagviano	blue-black	2.4±0.3	0.5±0.07	2.0±0.2	46.9±4.3	17.0±0.2	15.5±0.5	377.3± 76.3

Results and Discussion

The average carpological parameters for 36 Georgian grapevine varieties are shown in Tab. 1. It represents varieties with a wide range of grape colors (blue-black, green-yellow, gray, rose) and a significant variability for measured features. With regard to berry weight, which varies from 1.4 g to 3.4 g, the smallest sized berries were recorded in 'Saperavi Budeshuriseburi' and 'Mujuretuli'. The largest berries belonged to 'Dziragoulis Shavi'. There was a significant variability between bunch average weights – 'Ktsia' had the highest average bunch weight (401 g), while 'Kisi' had the lowest one (79 g). The results of the basic chemical composition of grapes (total soluble solids, total acidity, total anthocyanins and total polyphenols) are presented in Tab. 2. The highest concentration of total soluble solids (27.4 °Brix) was found in the berries of 'Mujuretuli', while 'Ghrubela Kakhuri' showed a significantly lower value (17.5 °Brix). In most of the varieties, total soluble solids varied from 18.0 to 24.6 °Brix. The total acidity in 'Ktsia' and 'Jvari' was higher than in all the other varieties (11.2 and 11.8 $g \cdot L^{-1}$ of tartaric acid, respectively). 'Saperavi Atenis' reported the lowest total acidity value (4.7 $g \cdot L^{-1}$ of tartaric acid).

Tab. 2 shows the differences in the total skin anthocyanin contents for the 21 colored grapevine varieties. As it was expected, two varieties, 'Rkatsiteli Vardisperi' with pink color berries and 'Ghrubela Kakhuri' with gray color berries, had a very low anthocyanin content (49.5 and 59.0 $mg \cdot kg^{-1}$). Among other intensely colored varieties 'Saperavi Budeshuriseburi' had the highest anthocyanin content (2826.6 $mg \cdot kg^{-1}$). 'Saperavi Budeshuriseburi' - rarely distributed variety in Kakheti region of East Georgia is considered to be a clone of 'Saperavi', with much

Table 2

The basic chemical composition (total soluble solids (TSS), titratable acidity (TA), total anthocyanins (TAnt) and total phenolics (TP) of Georgian grape varieties. Skra Germplasm Repository (average data of 2012 and 2013)

Accession name	TSS (°Brix)	TA ($g \cdot L^{-1}$ of tartaric acid)	TAnt ($mg \cdot kg^{-1}$)	Skin TP ($mg \cdot kg^{-1}$)	Seed TP ($mg \cdot kg^{-1}$)	TP content ($mg \cdot kg^{-1}$)
Argvetuli Sapere (C)	22.0±1.9	8.9±0.4	560.6±397.8	1107.9±423.7	86.1±22.3	1194.1±442.7
Aspindzura (C)	20.8±2.0	6.0±0.4	714.2±210.3	1996.8±552.1	133.8±32.2	2130.6±574.6
Buza (C)	24.6±07	5.8±0.5	787.2±112.3	2032.8±248.6	92.2±23.2	2125.1±268.5
ChitistvalaBodburi (W)	24.3±1.0	5.8±0.7	-	1477.8±475.9	381.2±122.9	1858.9±571.3
Chvartala (W)	17.6±2.3	6.3±1.6	-	827.5±95.9	93.9±44.5	921.5±138.4
Danakharuli (C)	21.0±1.4	7.1±0.7	809.9±344.6	1412.0±512.9	54.8±23.4	1466.9±521.5
Didmtevana (C)	20.5±5.1	8.0±1.5	812,0±156,0	850.4±341.9	52.1±46.2	902.5±385.4
Dziragoulis Shavi (C)	18.5±0.6	7.3±0.5	446.9±225.8	883.6±355.3	46.0±12.4	929.6±363.2
Ghrubela Kakhuri (C)	17.5±0.6	6.2±1.3	59.0±13.9	694.0±258	70.1±20.9	764.0±253.7
GvinisTsiteli (C)	22.2±3.4	7.2±0.3	558.1±120.8	1258.4±269.7	191.6±45.2	1531.3±77.2
IkaltosTsiteli (C)	21.1±0.7	7.3±1.0	610.6±169.4	2094.8±417.9	187±39.5	2282.1±425.7
Jvari (W)	19.8±1.3	11.8±0.9	-	520.1±49.2	26.5±11.3	546.7±59.9
Kharistvala Shavi (C)	21.9±2.2	6.8±1.5	400.1±119.0	1159.7±267.4	64.6±36.9	1224.4±252.9
Khikhvi (W)	24.0±1.4	6.7±0.6	-	800.5±281.9	274.7±107.0	1075.2±485.5
Khikhvi, clone 430 (W)	22.8±0.5	6.3±0.3	-	938.6±400.2	97.2±26.6	1035.8±426.8
Kishuri (W)	21.9±1.9	5.2±0.2	-	847.5±150.8	103.8±22.3	951.3±164.5
Kisi (W)	22.8±1.2	8.6±1.0	-	884.8±80.3	335.9±195.3	1120.7±193.3
Ktsia (C)	17.9±1.0	11.2±0.7	706.8±229.8	1333.9±554.5	44.2±7.9	1378.1±553.3
Kurkena (W)	21.9±1.6	6.9±1.4	-	924.0±161.1	58.9±29.8	982.9±177.9
Mujuretuli (C)	27.4±0.3	8.0±0.8	842.0±342.8	1591.2±590.9	194.1±97.9	1785.4±607.4
Muradouli (W)	18.8±2.4	8.0±0.2	-	1343.6±245.9	194.0±19.4	1537.7±260.7
Partala Shavi (C)	22.3±2.9	5.9±0.6	785.5±183.4	1781.3±71.7	142.5±126.0	1923.8±152.7
Rkatsiteli (W)	20.3±0.8	6.3±0.7	-	404.7±58.3	378.7±189.0	779±237.3
Rkatsiteli Vardisperi (C)	18.2±0.9	9.1±0.9	49.5±12.2	510.4±96.5	65.2±35.2	576.2±113.8
Sapena (W)	23.4±0.3	5.1±0.5	-	1129.9±236.9	94.9±39.8	1224.8±275.8
Saperavi Atenis (C)	19.2±0.9	4.7±0.6	758.2±125.3	1588.4±103.2	52.2±29.3	1630.8±138.4
Saperavi Budeshuriseburi (C)	25.8±0.7	7.5±0.8	2826.6±263.2	2669.3±63.2	149.1±65.2	2818.4±128.5
Shavtsitska (C)	21.0±0.9	5.5±0.5	493.3±142.3	1007.5±327.2	84.4±34.3	1091.9±328.3
Tavkveri Saperaviseburi (C)	19.6±0.4	7.1±0.5	390.6±66.8	878.9±99.9	233.5±155.0	1112.4±185.3
Tavtsitela (C)	19.5±0.9	6.7±0.3	358.2±103.6	1044.7±405.4	68.0±23.2	1112.7±388.7
TsirkvalisTetri (W)	19.3±0.5	9.1±0.5	-	1325±178.9	200.1±45.9	1525.4±224.3
Tsitska (W)	22.7±1.5	9.9±0.7	-	1716.4±54.1	129.9±32.6	1846.4±37.6
Tsnoris Tetri (W)	21.2±2.2	8.5±1.1	-	662.9±265.3	129.2±59.0	792.1±305.4
VazisubnisTsiteli (C)	23.5±0.6	7.2±0.4	912.3±185.8	1311.6±330.8	61.0±20.2	1372.7±336.1
Zerdagi (W)	18.3±3.8	7.0±1.0	-	809.1±121.8	33.0±13.5	842.1±132.9
ZhgiaSagviano (C)	18.0±1.6	6.3±0.3	619.1±110.6	1037.5±84.9	88.9±7.2	1126.5±90.74

(C: for colored, W: for white).

more oblong berry and earlier maturity (Maghradze *et al.* 2012). In the other colored varieties the total extractable anthocyanin content ranged from 358.2 to 912.3 $mg \cdot kg^{-1}$ of grapes.

Taking into account the Georgian winemaking traditional technique (white grapes undergo a skin, stem and seed maceration as well as red ones) (Glonti, 2010) total polyphenols have been evaluated for both colored and white grape varieties. Results summarized in Tab. 2 represent among all analyzed grape varieties, the highest total polyphenol contents in the skin was found in four colored varieties: 'Saperavi Budeshuriseburi' (2669.3 $mg \cdot kg^{-1}$); 'IkaltosTsiteli' (2094.8 $mg \cdot kg^{-1}$); 'Buza' (2032.8 $mg \cdot kg^{-1}$); 'Aspindzura' (1996.8 $mg \cdot kg^{-1}$) (Tab. 2). The skin total polyphenol contents in colored grapes varied from 850.4 to 2669.3 $mg \cdot kg^{-1}$ and in white grapes – from 404.7 to 1716.4 $mg \cdot kg^{-1}$. The lowest content of skin polyphenols among the white varieties was recorded in 'Rkatsiteli' (404.7 $mg \cdot kg^{-1}$) and the highest content was found in 'Tsitska' (1716.4 $mg \cdot kg^{-1}$).

In general, in all analyzed grape varieties, the total polyphenolic contents recoded in seeds were significantly lower than the ones found in skins (Tab. 2). The seeds of white varieties showed to have a higher polyphenolic content in particular varieties – 'Chitistvala Bodburi' (381.2 $mg \cdot kg^{-1}$), 'Rkatsiteli' (378.7 $mg \cdot kg^{-1}$) and 'Kisi' (335.9 $mg \cdot kg^{-1}$). In the colored varieties seed polyphenolics ranged between 44.2 – 194.1 $mg \cdot kg^{-1}$, only 'Tavkveri Saperaviseburi' (233.5 $mg \cdot kg^{-1}$) showed relatively higher value of extractable polyphenols. In Tab. 2 the total polyphenolic

Table 3

Total phenolic range of colored and white Georgian grape varieties (expressed as catechin, mg per kg of grape). Skra Germplasm Repository (average data of 2012 and 2013)

Range	Berry color	Variety
500 - 1000	Colored	Rkatsiteli Vardisperi, Ghrubela Kakhuri, Didmtevana, Dziragoulis Shavi
	White	Jvari, Rkatsiteli,TsnorisTetri, Zerdagi, Chvartala, Kishuri, Kurkena
1000 - 1500	Colored	Shavtsitska, Tavkveri Saperaviseburi, Tavtsitela, Zhgia Sagviano, Argvetuli Sapere, Kharistvala Shavi, Vazisubnis Tsiteli, Ktsia, Danakharuli
	White	Khikhvi, clone 430, Khikhvi, Kisi, Sapena
≥ 1500	Colored	Gvinis Tsiteli, Saperavi Atenis, Mujuretuli, Partala Shavi, Buza, Aspindzura, Ikaltos Tsiteli, Saperavi Budeshuriseburi
	White	Tsirkvalis Tetri, Muradouli, Tsitska, Chitistvala Bodburi

content represents the sum of extractable polyphenols of the skin and seeds evaluated as in mg per kg of grape. Most of the studied varieties have quite high content of total polyphenolics, within the range of 546.7 mg·kg^{-1} ('Jvari') to 2818.4 mg·kg^{-1} ('Saperavi Budeshuriseburi'). Among white grape varieties the highest content of total phenolics (above the 1500 mg·kg^{-1}) was found in 'Chitistvala Bodburi', 'Tsitska', 'Muradouli', 'Tsirkvalis Tetri' (Tab. 3) and among colored grape varieties in 'Gvinis Tsiteli', 'Saperavi Atenis', 'Mujuretuli', 'Partala Shavi', 'Buza', 'Aspindzura', 'Ikaltos Tsiteli', 'Saperavi Budeshuriseburi' (Tab. 3).

Conclusions

Georgian grapevine varieties (15 white and 21 colored) showed a significant variability in the carpological and enological characteristics. This evaluation would help a better technological characterization of the winemaking potential of particular rarely distributed varieties. However, reported values should be generalized with caution since the concentration of phenolic compounds may vary upon the grape maturity, environmental conditions, vineyard management and analytical methods. As all studied varieties were planted within the same collection site, with the same climatic and soil conditions and subjected to the same viticultural practices, we may think that the differences in total polyphenol and total anthocyanin contents could be mainly due to genetic differences among the varieties. In order to assess the full range of variation in polyphenolic compounds for Georgian grape germplasm, it is indispensable to study several year yields of more varieties.

Acknowledgements

This study was done in the framework of the project "Conservation, Research and Breeding Usage of Local Grape Germplasm" of the Agricultural University of Georgia in 2012 and 2013. The article is a joint publication of the COST Action FA1003 "East-West Collaboration for Grapevine Diversity Exploration and Mobilization of Adaptive Traits for Breeding".

References

García-Beneytez, E.; Revilla, E.; Cabello, F.; 2002: Anthocyanin pattern of several red grape cultivars and wines made from them. Eur. Food Res. Technol. **215**, 32-3.

Glonti, T.; 2010: Traditional technologies and history of Georgian wine. Materials of 33rd World Congress of Vine and Wine. OIV, Tbilisi, Georgia.

Ketskhoveli, N.; Ramishvili, M.; Tabidze, D.; 1960: Ampelography of Georgia. Georgian Academy of Science, Tbilisi, Georgia (In Georgian and Russian).

Maghradze, D.; Failla, O.; Imazio, S.; Rossoni, M.; Scienza, A.; 2009a: Georgian native grapevine cultivars 'Alexandrpouli', 'Dzveli Alexandrpouli' and 'Mujuretuli': description, genetic relationship and hypotheses about their origin. J. Am. Pomol. Soc. **63**, 181-191 .

Maghradze, D.; Rossoni, M.; Imazio, S.; Maitti, C.; Failla, O.; Del Zan, F.; Chkhartishvili, N.; Scienza, A.; 2009b: Genetic and phenetic exploration of Georgian grapevine germplasm. ISHS Acta Hortic. **827**, 107-114.

Maghradze, D.; Rustioni, L.; Scienza, A.; Turok, J.; Failla, O.; 2012: Caucasus and Northern Black Sea Region Ampelography. Vitis (special issue), 177-239.

OIV; 2007: Descriptors for grapevine cultivars and *Vitis* species. O. I. V. (Off. Int. Vigne Vin), Paris, France.

Rossoni, M.; Maghradze, D.; Bregant, F.; Failla, O.; Scienza, A.; 2007: Uso del profilo antocianico per la valutazione del potenziale qualitativo del germoplasma Georgiano. Italus Hortus **14**, 63-67.

Rustioni, L.; Maghradze, D.; Popescu, C. F.; Cola, G.; Abashidze, E.; Aroutiounian, R.; Brazão, J.; Coletti, S.; Cornea, V.; Dejeu, L.; Dinu, D.; Eiras Dias, J. E.; Fiori, S.; Goryslavets, S.; Ibáñez, J.; Kocsis, L.; Lorenzini, F.; Maletic, E.; Mamasakhlisashvili, L.; Margaryan, K.; Mdinaradze, I.; Memetova, E.; Montemayor, M. I.; Muñoz-Organero, G.; Nemeth, G.; Nikolaou, N.; Raimondi, S.; Risovanna, V.; Sakaveli, F.; Savin, G.; Savvides, S.; Schneider, A.; Schwander, F.; Spring, J. L.; Pastore, G.; Preiner, D.; Ujmajuridze, L.; Zioziou, E.; Maul, E.; Bacilieri, R.; Failla, O.; 2014: First results of the European Grapevine collections' collaborative network: validation of a standard eno-carpological phenotyping method. Vitis **53**, 219-226.

Teixeira, A.; Eiras-Dias, José.; Castellarin, D. S.; Gerós, H.; 2013: Berry phenolics of grapevine under challenging environments. Int. J. Mol. Sci. **14**, 18711-18739.

Vacca,V.; Del Caro, A.; Millela, G. G.; Nieddu, G.; 2009: Preliminary characterisation of Sardinian red grape cultivars (*Vitis vinifera* L.) according to their phenolic potential. S. Afr. J. Enol. Vitic. **30**, 93-100.