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STILBENOIDS - ASTRINGIN AND ASTRINGININ OF SAPERAVI GRAPE VARIETY (*VITIS VINIFERA* L.) AND WINE

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Abstract

It was identified and determined the stilbenoids – trans-astringinin (piceatannol) and its glucoside trans- astringin in the Saperavi grape variety and dry wine. The study shows that the grape juice is reach with trans-astringin and from the solid parts of grapes (skins, seeds and stems) - grape skin. Trans-astringin and trans-astringinin found in the Saperavi grapes and wine approved their biological activity: they possess the antiradical activity manifested to inhibit the 2, 2-diphenyl-picryl-hydrazyl. From the studied stilbenoids -stilbene tetramers were the most active. Trans-astringin and other stilbenoids do not inhibit the activity of lactobacteria during the process of malolactic fermentation in Saperavi wine. The identification of trans-astringin and trans-astringinin is a novelty for the stilbene profile of Saperavi grapes and wine and important data for substantiating the functional (therapeutic-preventive) purpose of the Saperavi wine.

Key words: stilbenoids; grape; wine

Introduction

Phenolic substances of the red varieties grapes and the wines made of them are presented with the flavonoids (anthocyans, procyanidins – oligomers and polymers, flavonols, flavanols, etc.) and nonflavonoids (stilbenoids, phenolic aldehydes, phenolic acids, etc.) (Valuiko *et al.,* 1973; Ribeiro de Lima *et al*., 1999; Bezhuashvili *et al*., 2009). The above-mentioned groups of substances participate actively in oxidative- redox processes during a making wines and highly determine the quality of it. Due to their high biological activity, the phenolic substances determine the functional purpose of red wines with their therapeutic-preventive properties (Klatsky *et al*., 1997; Szmitsko *et al*., 2005; Balestrieri *et al*., 2008).

Among the phenolic compounds, stilbenoids of red grapes and wine are significantly distinguished with their high biological activity. They are presented as an isomeric forms of resveratrol monomers and the derivatives of resveratrol – glucosides and oligomeric stilbenoids: cis-, trans-piceid; resveratrol dimers - cis-, trans-ε-viniferin, cis-, trans-δ-viniferin, pallidol; resveratrol trimer - α-viniferin and trimer - R-viniferin; resveratrol metabolite – astringinin (piceatannol) and its glucoside - astringin (Vitrac *et al.,* 2005; Boutegrabet *et al.,* 2011; Moreno-Labanda *et al.,* 2004; Guebailia *et al.,* 2006; Baderschneider *et al.,* 2000; He *et al.,* 2009; Nougler *et al.,* 2007). The concentration of stilbenoids in wines depends on many factors: varietal features of grapes, a place of vine propagation – climatic conditions, vineyard location, wine production process, etc. (Bavaresco *et al*., 2002; Sun *et al*., 2006; Surguladze *et al*., 2016; Guerreroa *et al.,* 2010). Taking into consideration all these factors, the fact is that the wines of different countries contain different concentrations of stilbenoids.

Stilbenoids have a variety of biological activities: they are phytoalexins and are characterized by antioxidant, bacteriocidal and anticarcinogenic effects. They have a preventive effect against cardiovascular, ischemic and other diseases (Jeandet *et al*., 2002; Langcake *et al.,* 1981; Bavaresco *et al*., 2008; Billard *et al.,* 2002; Piver *et al*., 2003; Privat *et al*., 2002; Yang *et al*., 1997; Piotrowska *et al*., 2012; Kim *et al.,* 2009; Son *et al*., 2013; Santos *et al.,* 2013; Waffo-Teguo *et al.,* 2009).

In the grapes of red varieties growing in Georgia and wines made of them, the following stilbenoids were identified and quantified: cis-, trans-resveratrol, cis-, trans-piceid, trans-ε-viniferin, and two stilbenoid tetramers, one of which was hopeaphenol (Bezhuashvili *et al.,* 1991; Bezhuashvili *et al*., 1997; Kokhtashvili *et al.*, 2002;

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Bezhuashvili *et al*., 2013; Bezhuashvili *et al*., 2011; Bezhuashvili *et al*., 2013; Bezhuashvili *et al*., 2014; Bezhuashvili *et al*., 2005; Bezhuashvili *et al*., 2010; Surguladze *et al*., 2017; Bezhuashvili *et al*., 2016). From this point of view we studied the following technical grape varieties: Saperavi, Cabernet Sauvignon, Otskhanuri Sapere, Odzhaleshi, Aladasturi, Dzelshavi, Alexandrouli, Mudzhuretuli, Chkhaveri, Shavkapito and Asuretuli Shavi. On basis of our study the antioxidant activity of the determined vine stilbenoids in the form of their inhibiting ability of produced of malondialdehyde in blood serum "*in vitro*" experiments, we revealed the following sequence: trans-resveratrol (105%) < trans-ε-viniferin (118%) < stilbene tetramer-I (169%) < stilbene tetramer-II (178%) (Bezhuashvili *et al*., 2005; Bezhuashvili *et al*., 2010). Trans-resveratrol selectively affects on the microorganisms. It is determined impact of trans-resveratrol on intensive developing of wine yeasts (*Sacch. vini, Sacch. chodati* and *Sacch. uvarum*) during alcoholic fermentation of grape juice. (Bezhuashvili *et al*., 2010). Trans-resveratrol inhibits the reproduction of bacteria *Agrobacterium tumefaciens*, producer of vine cancer (Bezhuashvili *et al*., 2010). Trans-resveratrol and trans-ε-viniferin do not inhibit the activity of lactobacteria during the process of malolactic fermentation process in Saperavi wine material and do not support the formation of secondary products (Bezhuashvili *et al*., 2011).

Based on the variety of biological activities of stilbenoids, determined stilbenoid spectrum of the grapes of red varieties growing in Georgia and wines made of them is a topical issue. Regarding to this, investigation and determination of two new representatives of stilbenoids, astringinin and astringin, in Saperavi wine and grape is very important.

Materials and Methods

1. Materials The objects of our investigation were a) the skins, stems, seeds and juice of the Saperavi grape variety; b) dry red wines made from the Saperavi grape variety ; c) commercial dry red Georgian wines made from the Saperavi grape variety by several wine companies : Teliani Valley, Telavi wine cellar and Badagoni. d) as standards were used Astringin and Astringinin delivered by ChemFaces Co., Ltd., China, e) For model malolactic fermentation and determination of the antiradical activity, were used authentic stilbenoids, isolated from the vine.

2. Processing of the materials The grapes were harvested during the period of technical maturity in Kakheti (Eastern Georgia). The stems, skins, seeds and juice were separated by scheme given below Fig. 1. The solid parts were air-dried, ground and used for investigation. To isolate the stilbenoid-containing fractions and individual stilbenoids, we processed the studying objects by the scheme given below Fig. 1. The eluent was chosen according to the procedure (Ribeiro de Lima *et al*., 1999).

Wine stilbenoid-containing fraction receiving scheme. It was taken 1 l wine material. After that wine was dealcoholized on the rotary evaporator under pressure at the 40^{0}C. Dealcoholized compound was placed for separate column and solved out three times by ethilacetate at the room temperature. Received fractions were messed up and concentrated in rotary avaporator and then received concentrate was processed on the Sephadex G50.As an eluent was used MeOH:H_2O (3:2). Stilbenoids containing fraction was analyzed by HPLC method.

Juice stilbenoid-containing fraction receiving scheme. It was taken 1 l saperavi grape juice and placed in separate column and solved out three times by ethilacetate at the room temperature. Received fractions were messed up and concentrated in rotary evaporator and then received concentrate was processed on the Sephadex G50. As an eluent was used MeOH:H_2O (3:2). Stilbenoids containing fraction was analyzed by HPLC method.

Grape strong parts stilbenoids- containing fraction receiving scheme. We took grape skin, seeds and stems. Dried on the air and grounded. We passed hot extraction by ethilacetate in three steps. Received fractions were missed up on the rotary evaporator and the received concentrate was processed on the Sephadex G50.As an eluent was used MeOH:H_2O (3:2). Stilbenoids containing fraction was analyzed by HPLC method.

3. Identification and Determination of Stilbenoids. We identified the individual isolated compounds by spectral and chromato-mass-spectral data and melting temperatures in comparison with the standards. The UV spectra were detected using Varian Cary 100 UV-Vis Spectrometer. The melting temperature was measured using the MEL – TEMP 3.0 Apparatus. Astringin and astringinin were determined by the method of high-performance liquid chromatography (HPLC). For this purpose, we used the Varian chromatograph, SUPELCOSIL™ LC18 Column, 250×4.6 mm; eluents: A. 0.025% trifluoroacetic acid, B. Acetonitrile A80/20. Gradient mode: 0-35 min, 20-50% B; 35-40 min, 50-100% B; 41-46 min, 100% B; 46-48 min, 100-20% B; 48-53 min, 200% B. Flow rate of the eluent – 1 ml/min; wavelength – 306 and 324 nm. Analyzed samples – the

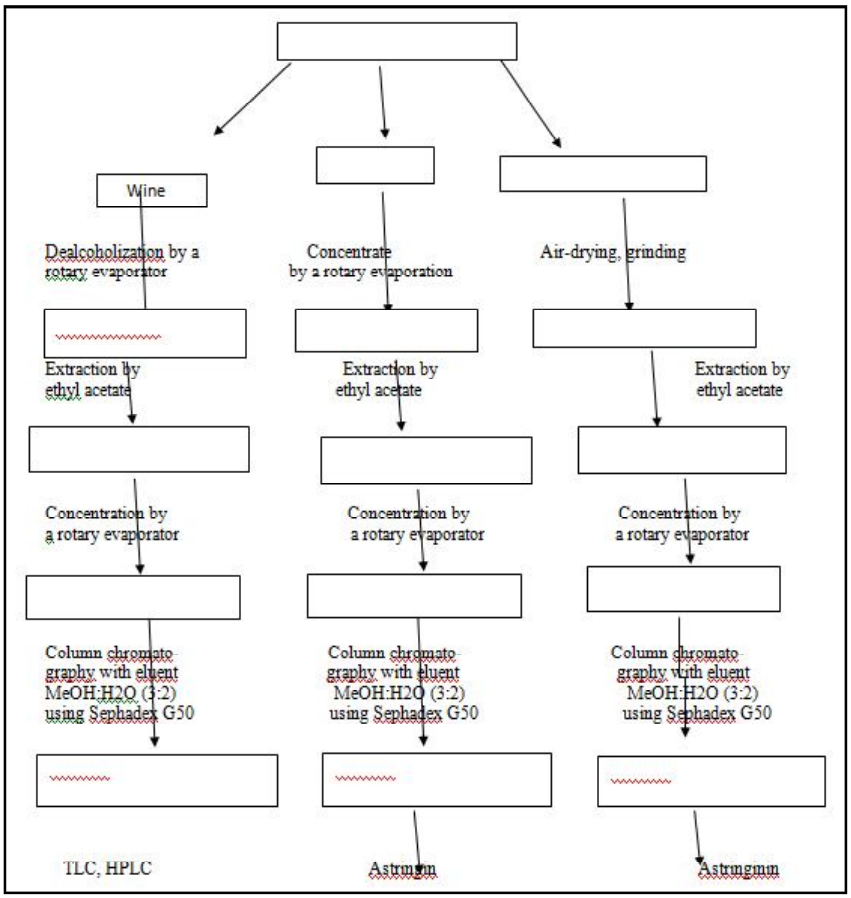


Fig. 1: The scheme of processing of the objects and isolation of stilbenoids.

isolated stilbenoid-containing fractions were filtrated using a membrane filter (0.45μ) before the chromatographic procedure. The chromato-mass-spectral investigations were carried out to the above-mentioned conditions; the mass-spectra were detected with obtaining of positive and negative ions.

The qualitative analysis of stilbenoid-containing fractions was carried out by the method of thin-layer chromatography (TLC) on silufol plates in the following system of solvents: chloroform:methanol (80:20); the chromatograms were developed by diazed sulfanilic acid.

4. Determination of the Biological Activity. The biological activity of astrinngin and astringinin was determined in the form of their antiradical activity in respect to 2, 2-diphenyl-picryl-hydrazyl (Moreno *et al*., 1998). At the same time for comparing we used also several stiolbenoids: Trans-resveratrol, Cis-resveratrol, Trans-piceid, Cis-piceid, Trans-ε-viniferin, Cis-δ-viniferiin, α-Viniferin, Hopeaphenol (Stilbene tetramer I), Stilbene tetramer II. All stilbenoids was solved out by us from grape and wine. Effect of astringin , was determined on the process of malolactic fermentation in the wine material. To compare we used δ- viniferin and α-viniferin, which were isolated from grape. The model malolactic fermentation proceeded in dry wine material prepared from Saperavi grape variety using the preparation of lactobacteria Lactoenos 450 PreAc. Experiment simples were: The quantity of malic and lactic acid was determined by HPLC (M111 OIV-MA-AS313-04: R., 2009).

Results and Discussion

1. Identification of astringin and astringinin. Based on the qualitative analysis of the total stilbenoid-containing preparations, we isolated two standard-like individual compounds: substance I (corresponding to astringinin) and substance II (corresponding to astringin). Substance I was isolated from the total preparation of the g, and substance II - from the total preparation of grape juice. Their identity with standard stilbenoids was supported by spectral and chromatographic indicators (Table 1).

2. Concentration of Astringin and Astringinin in grape and wine.

Generally the concentration off astringin in grapes exceeds the concentration of its aglycone – astringinin. Grape juice contains a high concentration of glucoside – astringin, while there was not found astringinin in it. Of the solid parts of grapes, the crests are distinguished by a high content of astringinin (Table 2).

Both experimental and commercial wines from the Saperavi grape variety contain more astringin than astringinin. Of commercial wines, Teliani Valley is istinguihed (Table 3).

Stilbenoids are characterized by different antiradical

Table 1: Indicators of studied and standard compounds.

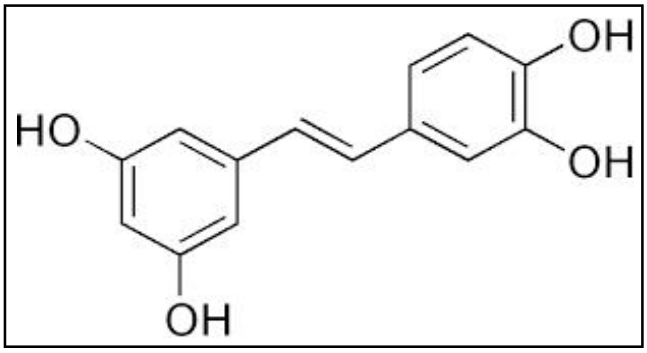
Indicators					
N.	**Compound**	**Rf(chloroform: methanol 80:20)**	**UV λ_{max} (MeOH), nm**	**Melting temperature ^{0}C**	**$[M+H]^+$**
1.	Substance I trans-astringinin	0,63	323	229	245,2
2.	Studied standard	0,62	324	230	245,2
3.	Substance II trans-astringin	0,28	309	232	407,3
4.	Studied standard	0,28	311	231	407,3

Table 2: The content of astringin and astringinin in the solid parts (mg/100 g) and juice (mg/l) of the Saperavi grape variety.

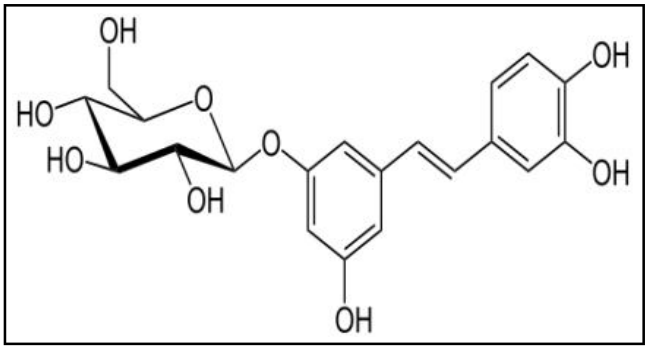
Object	Astringinin	Astringin
Skins	0,68	5,37
Crests	1,16	2,11
Seeds	0,39	1,12
Juice	-----	9,31

Table 3: The content (mg/l) of astringin and astringinin in dry red Saperavi wines.

Wine	Astringin	Astringinin
Experimental:		
1. of 2014	7, 5	0, 45
2. of 2015	6, 8	0, 52
3. Commercial: Teliani Valley	4, 24	0, 33
Telavi Marani	2, 26	0, 17
Badagoni	2, 84	0, 14



I. Astringinin $C_{20}H_{22}O_9$



II. Astringin $C_{14}H_{12}O_4$

Table 4: Effective concentration of stilbenoids with inhibition of 50% 2,2-diphenyl-picryl-hydrazyl

N	Stilbenoid	Cc50, µg	TEc50, min
1	Trans-resveratrol	38,5	8,3
2	Cis-resveratrol	41,0	9,0
3	Trans-astringinin	34,0	8,0
4	Trans-astringin	39,2	9,0
5	Trans-piceid	49,1	10,0
6	Cis-piceid	58,8	10,8
7	Trans-ε-viniferin	30,8	8,0
8	Cis-δ-viniferiin	35,7	8,5
9	α-Viniferin	28,3	8,0
10	Hopeaphenol (Stilbene tetramer I)	26,6	7,7
11	Stilbene tetramer II	28,5	8,0

activity, which is reflected in the effective concentration that inhibits the 50% of the radical 2, 2 diphenyl-picryl-hydrazyl. Inhibition of the radical by a more active stilbenoid is achieved with a relatively less amount of stilbenoid. From this point of view, of stillbenoids, stilbene tetramers possess high antiradical activity. Trans-astringin and trans-piceid turned out to be less active than anglycones – trans-astringinin and trans-resveratrol. The antiradical activity of trans-isomeric forms of stilbenoids exceeded that of cis-isomeric ones (Table 4).

It is interesting the effect of stilbenoids on lactobacteria during malolactic fermentation in the Saperavi wine material. Wine material containing the natural concentration of stilbenoids- the concentration of residual malic acid made up 0.0080 g/l with formation of 2.0937 g/l lactic acid. It was observed that in the wine materials with added stilbenoids, certain intensification of conversion of malic acid decreased compare to the concentration of lactic acid. This was more clearly seen with addition of α-viniferin.

Thus, the determination of biologically active stilbenoids trans-astringinin and its glucoside trans-astringin is a novelty for the stilbenoid spectrum of Saperavi grapes and wine. The obtained results are a practical and scientific interest , as they enrich significantly the biochemical base of Saperavi grapes and wine. That

Table 5: The results of malolactic fermentation in the presence of stilbenoids.

Stilbenoid, mg/l	Acid, g/l	Acid, g/l
	Malic	Lactic
Reference wine material (trans-astrriingin 7.0 mg/l; δ-viniferin 0.85 mg/l; α-viniferin 0.67 mg/l) + Lactoenos 450PreAC^R	0.0080	2.0937
Wine material+trans- astringin (14 mg/l)+ Lactoenos 450PreAC^R	0.0078	1.9498
Wine material+ δ-viniferin (10.85 mg/l)+ Lactoenos 450PreAC^R	0.0076	1.9347
Wine material+ α-viniferin (10.67 mg/l)+ Lactoenos 450PreAC^R	0.0075	1.8646

definitely explain the functional (therapeuttic-preventive) purpose of the Saperavi wine.

Conclusion

It was identified and determined at first time the resveratrol metabolite trans-astringinin and its glucoside trans-astringin. Their biological activity was established with antiradical activity depending of 2, 2-diphenyl-picryl-hydrazyl. Also their noninhibited reaction on lactic bacteria during the malolactic fermentation process in wine. Above mentioned compounds are important for Saperavi wine to explain it functional purpose.

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