JAP&T
TPA-Timişoara

Available online at http://journal-of-agroalimentary.ro

Journal of Agroalimentary Processes and Technologies 2020, *26* (4), 429-440

Journal of Agroalimentary Processes and Technologies

A critical review on the antioxidant analysis and composition of *Vitis* species

Claudia Oprinescu [1], Daniel Ioan Hădărugă [1,2]*, Nicoleta Gabriela Hădărugă [3]

[1] *Doctoral School "Engineering of Vegetable and Animal Resources", Banat's University of Agricultural Sciences and Veterinary Medicine "King Michael I of Romania" from Timişoara, Calea Aradului 119, 300645-Timişoara, Romania*

[2] *Department of Applied Chemistry, Organic and Natural Compounds Engineering, Polytechnic University of Timişoara, Carol Telbisz 6, 300001-Timişoara, Romania*

[3] *Department of Food Science, Banat's University of Agricultural Sciences and Veterinary Medicine "King Michael I of Romania" from Timişoara, Calea Aradului 119, 300645-Timişoara, Romania*

Abstract

Fruits of *Vitis* species (grapes) are one of the most consumed, even as fresh or processed products (such as juices and wines). Among organoleptic characteristics of these products (e.g., taste, aroma and freshness), the antioxidant capacity is well known. The review focuses on the classification of biologically active compounds having antioxidant activity, their analyses and pharmaceutical properties. *Vitis* species such as *V. vinifera*, *V. riparia*, *V. aestivalis*, *V. rotundifolia*, *V. rupestris*, *V. coignetiae*, or *V. amurensis* have been reviewed. Moreover, possible valorization of these antioxidant compounds, that also includes wastes from the wine industry, was emphasized and critically discussed.

Keywords: *Vitis* species, grapes, food quality and authenticity, antioxidants, resveratrol

1. Introduction

The most known grape species used for wine production is *Vitis vinifera* L., which have many varieties. However, other *Vitis* species, such as *V. amurensis* or *V. rupestris* are also used [1, 2]. There are many factors influencing the quality of grapes and wine products. Some of them are: climate (low humidity and moderate temperature of about 25-30 °C), soils (sandy, not alkaline and good drainage), cultivation techniques etc. [3, 4]. The winemaking process includes many steps that can differ according to the wine type (white or red). Shortly, the main steps for white wine production involves the extraction of the juice and fermentation under controlled temperature. On the other hand, red wines requires the previous maceration of the grape skin and seeds with the juice [5]. However, all winemaking techniques involves the crushing, maceration and pressing, resulting in must and pomace fractions. Sulphiting the must using SO_2, amelioration if necessary, when the sugar content and acidity are corrected. The fermentation step involves the development of the yeast, "bubbling" and "quiet fermentation", sometimes with the second fermentation step. The last steps are the drying off the wine and storage, as well as maturating and ageing [1, 6]. Finally, the alcoholic content is in the range 9-15%, total acidity 3.5-5.5 g/L of sulfuric acid, volatile acidity of <0.5 g/L for white wine and <0.9 g/L for red wine, pH of 2.8-3.8, total and free SO_2 content of 70-120 mg/L and 25-40 mg/L, respectively [1, 7-11].

Regarding the surface area of the vineyards, it is about 7.5 millions of ha in the world. The largest area is cultivated in Spain, France and Italy (~16%, 11% and 10.3%, respectively). Romania is the seventh country from this point of view, with a cultivated area of 2.46% from the world's area. The wine production is generally above 700 millions of liters, of about 27 000 millions of liters all over the world [1, 2, 12].

There are many grape varieties, even in Europe or in America. Moreover, grape hybrids are also developed. From this point of view, the most known

Corresponding authors: daniel.hadaruga@upt.ro

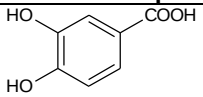
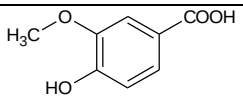
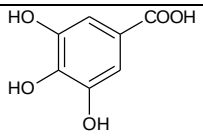
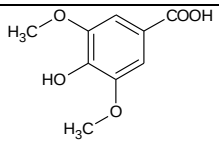
native American grape varieties, derived from *V. labrusca*, are "Concorde" for red wine varieties, "Catawba" and "Delaware" for white wine varieties [4]. Many of wine grape varieties belong to French-American grape hybrids (derived from native *V. vinifera* and *V. rupestris*, *V. lincecumii*, *V. riparia*, respectively), such as "Chancellor", "Maréchal Foch", "Chardonel", or "Seyval Blanc" [4]. European grape varieties belong to the species *V. vinifera* and some of the most known are "Cabernet Sauvignon", "Merlot", "Pinot Noir", or "Syrah" for the red wines, as well as "Chardonnay", "Gewürztraminer", "Pinot Blanc", "Riesling", or "Sauvignon Blanc" for white wines [4].

The chemical composition of grapes, especially from the antioxidant compounds point of view, is very important for the quality of these fruits, as well as for the final product – wine. The composition of various grape species and varieties, the stability and degradation of these compounds during processing, as well as the composition and quality of wine products are systematically presented.

2. Antioxidants from *Vitis* species

Vitis species and their varieties, even native in Europe or in America, are used for obtaining wines, as well as other products. Consequently, grapes and other parts of the plant and fruits (peel or skin, juice, stem and leaves) have been extensively studied from the antioxidant activities and antioxidant compound contents point of views. The main antioxidant compound classes are hydroxybenzoic acids, hydroxycinnamic acids, flavanols, flavonols, hydroxylated stilbenes, procyanidins and anthocyanins [13-19]. The presence of these antioxidants in various *Vitis* species are summarized in Tables 1-6, where the specie/variety, part of the fruit/plant and the corresponding reference are presented.

Table 1. The main antioxidant compounds from hydroxybenzoic acid class, identified in *Vitis* species

Antioxidant compound	Source
 Protocatechuic acid	*V. vinifera* L. – different varieties, juices [13] *V. vinifera* L. – different varieties, skin [20] *V. vinifera* L. – skin, pulp [21] *V. labrusca* L. – peel, pulp, seed [22] *V. labrusca* L. – organic & conventional, juice [23] *V. labrusca* L. – juice [24] *V. rotundifolia* – wine [11]
 Vanillic acid	*V. vinifera* L. – different varieties, juices [13] *V. vinifera* L. – different varieties, skin [20] *V. vinifera* L. – skin, pulp [21] *V. labrusca* L. – peel, pulp, seed [22] *V. labrusca* L. – juice [24] *V. aestivalis* – wine [25] *V. rotundifolia* – wine [11]
 Gallic acid	*V. vinifera* L. – different varieties, juices [13] *V. vinifera* L. – different varieties, skin [20] *V. vinifera* L. – vegetative parts [26] *V. vinifera* L. – skin, pulp [21] *V. vinifera* L. – leaves [27] *V. vinifera* L. – red wines [9] *V. labrusca* L. – juice & wine [28] *V. labrusca* L. – peel, pulp, seed [22] *V. labrusca* L. – varieties, juice [29] *V. labrusca* L. – organic & conventional, juice [23] *V. labrusca* L. – juice & wine [30] *V. labrusca* L. – juice [24] *V. aestivalis* – wine [25] *V. rotundifolia* – skin, seeds [31] *V. rotundifolia* – wine [11]
 Syringic acid	*V. vinifera* L. – different varieties, juices [13] *V. vinifera* L. – different varieties, skin [20] *V. vinifera* L. – skin, pulp [21] *V. vinifera* L. – leaves [27] *V. labrusca* L. – juice & wine [28] *V. labrusca* L. – peel, pulp, seed [22] *V. labrusca* L. – organic & conventional, juice [23] *V. labrusca* L. – juice & wine [30] *V. labrusca* L. – juice [24] *V. aestivalis* × *V. vinifera* – wine extract [32] *V. rotundifolia* – wine [11]

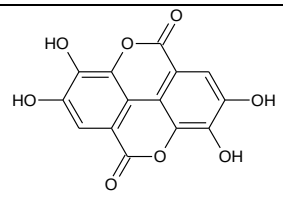
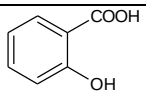
 Ellagic acid	*V. vinifera* L. – different varieties, juices [13] *V. labrusca* L. – peel, pulp, seed [22] *V. labrusca* L. – juice [24] *V. rotundifolia* – skin [33] *V. rotundifolia* – skin, seeds [31] *V. rotundifolia* – wine [11]
 Salicylic acid	*V. vinifera* L. – different varieties, skin [20]

Table 2. The main antioxidant compounds from hydroxycinnamic acid class, identified in *Vitis* species

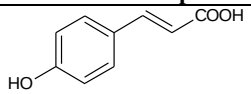
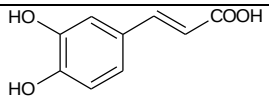
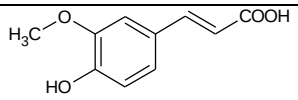
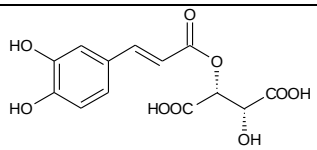
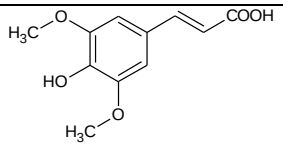
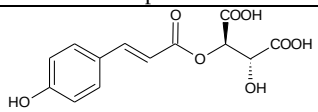
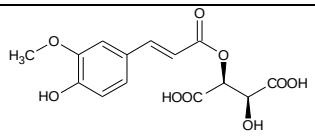
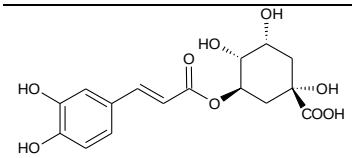
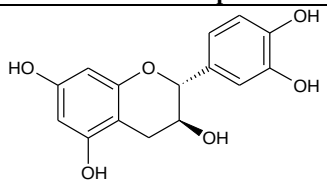
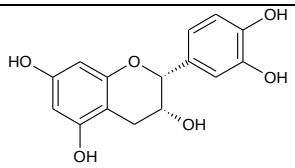
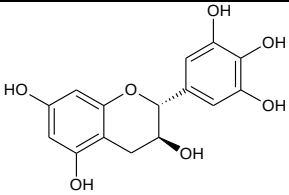
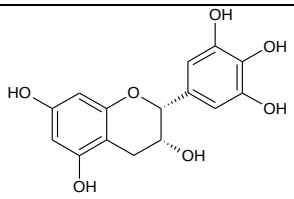
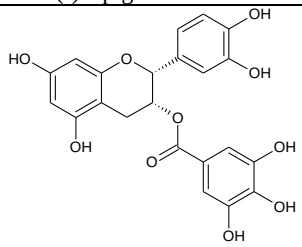
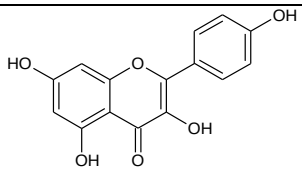
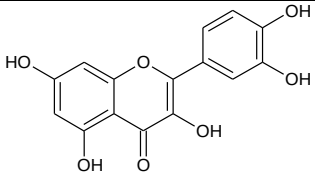
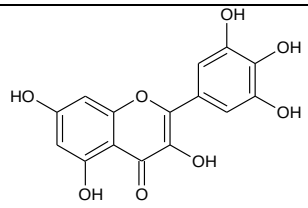
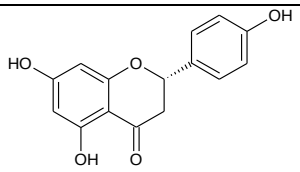
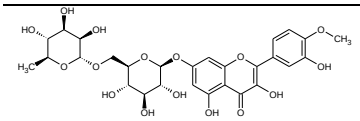
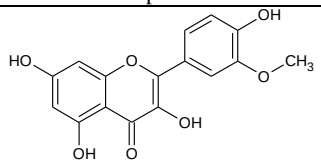
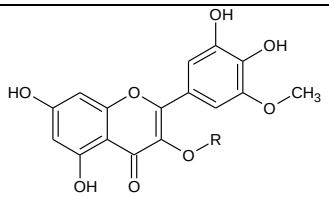
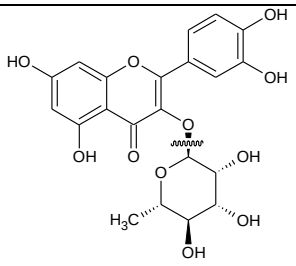
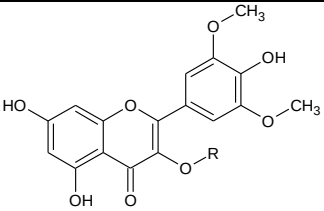
Antioxidant compound	Source
 *p*-Coumaric acid	*V. vinifera* L. – different varieties, juices [13] *V. vinifera* L. – different varieties, skin [20] *V. vinifera* L. – vegetative parts, also *o*- and *m*-coumaric acids [26] *V. vinifera* L. – leaves [34] *V. vinifera* L. – skin, pulp [21] *V. labrusca* L. – juice & wine [28] *V. labrusca* L. – peel, pulp, seed [22] *V. labrusca* L. – varieties, juice [29] *V. labrusca* L. – organic & conventional, juice [23] *V. labrusca* L. – juice & wine [30] *V. labrusca* L. – juice [24] *V. aestivalis* × *V. vinifera* – wine extract [32] *V. rotundifolia* – wine [11]
 Caffeic acid	*V. vinifera* L. – different varieties, juices [13] *V. vinifera* L. – different varieties, skin [20] *V. vinifera* L. – leaves [34] *V. vinifera* L. – skin, pulp [21] *V. vinifera* L. – leaves [27] *V. vinifera* L. – red wines [9] *V. vinifera* L. – red wines [9] *V. labrusca* L. – juice & wine [28] *V. labrusca* L. – peel, pulp, seed [22] *V. labrusca* L. – varieties, juice [29] *V. labrusca* L. – organic & conventional, juice [23] *V. labrusca* L. – juice & wine [30] *V. labrusca* L. – juice [24] *V. aestivalis* × *V. vinifera* – wine extract [32] *V. rotundifolia* – wine [11]
 Ferulic acid	*V. vinifera* L. – different varieties, juices [13] *V. vinifera* L. – different varieties, skin [20] *V. vinifera* L. – leaves [34] *V. labrusca* L. – peel, pulp, seed [22] *V. labrusca* L. – organic & conventional, juice [23] *V. labrusca* L. – juice [24] *V. aestivalis* – wine [25] *V. aestivalis* × *V. vinifera* – wine extract [32] *V. rotundifolia* – wine [11]
 *trans*-Caftaric acid	*V. vinifera* L. – different varieties, juices [13] *V. vinifera* L. – different varieties, stems [35] *V. vinifera* L. – skin, pulp [21] *V. vinifera* L. – red wines [9] *V. vinifera* L. – stem [36] *V. labrusca* L. – peel, pulp, seed [22] *V. labrusca* L. – juice & wine [30] *V. labrusca* L. – juice [24]
 Sinapic acid	*V. vinifera* L. – different varieties, skin [20] *V. labrusca* L. – juice & wine [28] *V. rotundifolia* – wine [11]
 *trans*-Coutaric acid	*V. vinifera* L. – different varieties, skin [20]
 *trans*-Fertaric acid	*V. vinifera* L. – different varieties, skin [20]
 Chlorogenic acid	*V. labrusca* L. – juice & wine [28] *V. labrusca* L. – varieties, juice [29] *V. labrusca* L. – organic & conventional, juice [23]

Table 3. The main antioxidant compounds from flavanol and flavonol classes, identified in *Vitis* species

Antioxidant compound	Source
 (+)-Catechin	*V. vinifera* L. – different varieties, juices [13, 37] *V. vinifera* L. – juices [6] *V. vinifera* L. – vegetative parts [26] *V. vinifera* L. – red wines [38] *V. vinifera* L. – red grape seeds [39] *V. vinifera* L. – skin, pulp [21] *V. vinifera* L. – red wines [9] *V. vinifera* L. – grape cane [40] *V. labrusca* var. Bordo – organic and conventional, leaves, juice [41, 42] *V. labrusca* L. – juice & wine [28] *V. labrusca* L. – peel, pulp, seed [22] *V. labrusca* L. – varieties, juice [29] *V. labrusca* L. – juice & wine [30] *V. labrusca* L. – juice [24] *V. rotundifolia* – skin, seeds [31]
 (-)-Epicatechin	*V. vinifera* L. – different varieties, juices [13, 37] *V. vinifera* L. – juices [6] *V. vinifera* L. – red wines [38] *V. vinifera* L. – red grape seeds [39] *V. vinifera* L. – skin, pulp [21] *V. vinifera* L. – red wines [9] *V. vinifera* L. – grape cane [40] *V. labrusca* L. – peel, pulp, seed [22] *V. labrusca* L. – varieties, juice [29] *V. labrusca* L. – juice [24] *V. rotundifolia* – skin, seeds [31]
 (+)-Gallocatechin	*V. vinifera* L. – juices [6] *V. vinifera* L. – red wines [38]
 (-)-Epigallocatechin	*V. vinifera* L. – juices [6] *V. vinifera* L. – red wines [38] *V. labrusca* L. – juice & wine [30]
 (-)-Epicatechin gallate	*V. vinifera* L. – red wines [38] *V. vinifera* L. – red wines [9] *V. labrusca* L. – juice & wine [28] *V. labrusca* L. – varieties, juice [29] *V. labrusca* L. – juice & wine [30] *V. rotundifolia* – skin, seeds [31]
 Kaempferol	*V. vinifera* L. – different varieties, juices [13] *V. vinifera* L. – vegetative parts [26] *V. vinifera* L. – skin, pulp [21] *V. labrusca* var. Bordo – organic and conventional, leaves, juice [41, 42] *V. labrusca* L. – peel, pulp, seed [22] *V. labrusca* L. – varieties, juice [29] *V. labrusca* L. – juice [24] *V. rotundifolia* – skin [33]
Kaempferol-3-*O*-Glu / Gal / glucuronide Kaempferol-3-*O*-Rut	*V. vinifera* L. – different varieties, stems [35] *V. vinifera & V. riparia / V. labrusca / V. lincecumii / V. rupestris* – hybrids, juice [43] *V. labrusca* L. – juice & wine [28] *V. vinifera, V. candicans, V. champinii, V. amurensis, V. cinerea, V. doaniana* – berry [44]
 Quercetin	*V. vinifera* L. – different varieties, juices [13] *V. vinifera* L. – vegetative parts [26] *V. vinifera* L. – red grape skin [39] *V. vinifera* L. – leaves [27] *V. vinifera* L. – red wines [9] *V. labrusca* var. Bordo – organic and conventional, leaves [41] *V. labrusca* L. – peel, pulp, seed [22] *V. labrusca* L. – varieties, juice [29]

	V. labrusca L. – juice [24] *V. rotundifolia* – skin [33] *V. rotundifolia* – skin, seeds [31] *V. amurensis* – leaf, stem [45]
Quercetin-3-*O*-glucuronide	*V. vinifera* L. – stem [36] *V. vinifera, V. candicans, V. champinii, V. amurensis, V. cinerea, V. doaniana* – berry [44]
Quercetin-3-*O*-Glu / Gal	*V. vinifera & V. riparia / V. labrusca / V. lincecumii / V. rupestris* – hybrids, juice [43] *V. labrusca* L. – juice & wine [28] *V. vinifera, V. candicans, V. champinii, V. amurensis, V. cinerea, V. doaniana* – berry [44]
Rutin (quercetin-3-*O*-Rha-Glu)	*V. vinifera* L. – red grape skin [39] *V. vinifera* L. – skin, pulp [21] *V. vinifera* L. – leaves [27] *V. labrusca* var. Bordo – organic and conventional, leaves, juice [41, 42] *V. vinifera & V. riparia / V. labrusca / V. lincecumii / V. rupestris* – hybrids, juice [43] *V. labrusca* L. – juice & wine [28] *V. labrusca* L. – varieties, juice [29] *V. vinifera, V. candicans, V. champinii, V. amurensis, V. cinerea, V. doaniana* – berry [44]
Isoquercitrin (quercetin-3-*O*-Glu)	*V. vinifera* L. – skin, pulp [21]
 Myricetin	*V. vinifera* L. – different varieties, juices [13] *V. vinifera* L. – leaves [27] *V. vinifera* L. – red wines [9] *V. labrusca* L. – peel, pulp, seed [22] *V. labrusca* L. – varieties, juice [29] *V. labrusca* L. – juice [24] *V. rotundifolia* – skin [33]
Myricetin-3-*O*-Glu / Gal / glucuronide / Rha	*V. vinifera & V. riparia / V. labrusca / V. lincecumii / V. rupestris* – hybrids, juice [43] *V. vinifera, V. candicans, V. champinii, V. amurensis, V. cinerea, V. doaniana* – berries [44]

 Naringenin	*V. vinifera* L. – vegetative parts [26] *V. labrusca* L. – juice & wine [28]
Naringin	*V. labrusca* var. Bordo – organic and conventional, leaves, juice [41, 42]
 Hesperidin	*V. labrusca* L. – juice & wine [28]
 Isorhamnetin	*V. vinifera* L. – different varieties, stems [35] *V. vinifera* L. – red wines [9] *V. labrusca* L. – varieties, juice [29]
Isorhamnetin-3-*O*-glucuronide / Glu	*V. vinifera & V. riparia / V. labrusca / V. lincecumii / V. rupestris* – hybrids, juice [43] *V. vinifera, V. candicans, V. champinii, V. amurensis, V. cinerea, V. doaniana* – berries [44]
Isorhamnetin-3-*O*-(6-*O*-feruloyl)-Glu	*V. vinifera* L. – different varieties, stems [35]
 Laricitrin-3-*O*-glucuronide / Glu / Gal	*V. vinifera & V. riparia / V. labrusca / V. lincecumii / V. rupestris* – hybrids, juice [43] *V. vinifera, V. candicans, V. champinii, V. amurensis, V. cinerea, V. doaniana* – berries [44]
 Quercitrin Quercitrin-3-*O*-Rut / glucuronide	*V. vinifera* L. – different varieties, stems [35]
 Syringetin-3-O-Glu/Gal (R: Glu / Gal)	*V. vinifera & V. riparia / V. labrusca / V. lincecumii / V. rupestris* – hybrids, juice [43]

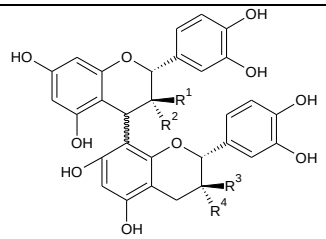
 Procyanidins B1-B4 (R^{1-4}: H or OH)	*V. vinifera* L. – juices [6] *V. vinifera* L. – grape cane [40] *V. labrusca* L. – juice & wine [28] *V. labrusca* L. – peel, pulp, seed [22] *V. labrusca* L. – varieties, juice [29] *V. labrusca* L. – juice & wine [30]

Table 4. The main antioxidant compounds from stilbene derivative class, identified in *Vitis* species

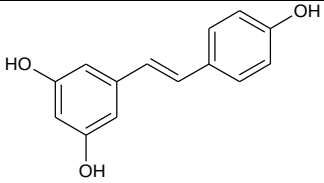
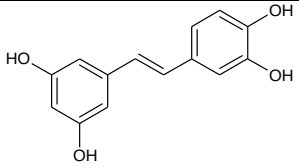
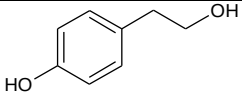
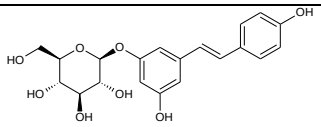
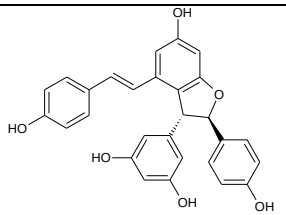
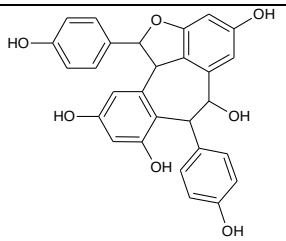
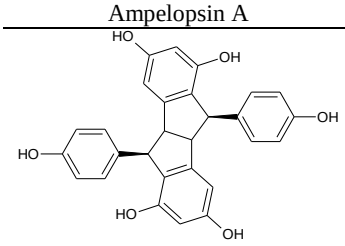
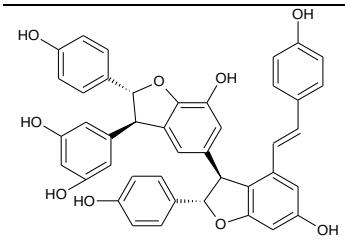
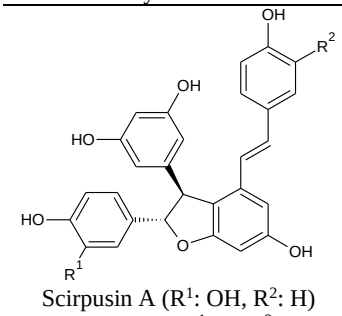
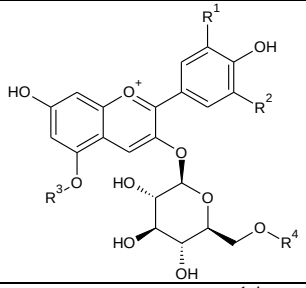
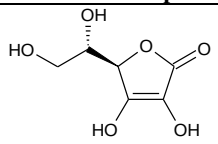
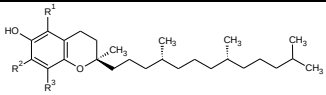
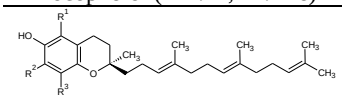
Antioxidant compound	Source
 *trans*-Resveratrol	*V. vinifera* L. – different varieties, juices [13, 37] *V. vinifera* L. – different varieties, skin [20] *V. vinifera* L. – red grape skin [39] *V. vinifera* L. – skin, pulp [21] *V. vinifera* L. – leaves [27] *V. vinifera* L. – red wines [9] *V. vinifera* L. – grape cane [40] *V. labrusca* var. Bordo – organic and conventional, leaves, juice [41, 42] *V. labrusca* L. – juice & wine [28] *V. labrusca* L. – peel, pulp, seed [22] *V. labrusca* L. – pulp, seed, exocarp [46] *V. labrusca* L. – varieties, juice [29] *V. labrusca* L. – juice [24] *V. rotundifolia* – skin, seeds [31] *V. amurensis* – juice [47] *V. amurensis* – leaf, stem [45]
cis-Resveratrol	*V. labrusca* L. – juice & wine [28] *V. amurensis* – juice [47]
 Piceatannol	*V. vinifera* L. – grape cane [40] *V. amurensis* – leaf, stem [45]
 Tyrosol	*V. vinifera* L. – different varieties, juices [13] *V. labrusca* L. – peel, pulp, seed [22] *V. labrusca* L. – juice [24]
 Piceid	*V. vinifera* L. (Cabernet Sauvignon) – juices [37] *V. vinifera* L. – different varieties, skin [20] *V. vinifera* L. – leaves [27] *V. amurensis* – juice [47] *V. amurensis* – leaf, stem [45]
 ε-Viniferin	*V. vinifera* L. – different varieties, skin [20] *V. vinifera* L. – different varieties, stems [35] *V. vinifera* L. – stem [36] *V. vinifera* L. – grape cane [40] *V. amurensis* – leaf, stem [45]
 Ampelopsin A	*V. vinifera* L. – grape cane [40] *V. amurensis* – leaf, stem [45]
 Pallidol	*V. vinifera* L. – grape cane [40]
 Miyabenol C	*V. vinifera* L. – grape cane [40]
 Scirpusin A (R^1: OH, R^2: H) Isoscirpusin A (R^1: H, R^2: OH)	*V. vinifera* L. – grape cane [40]

Table 5. The main antioxidant compounds from anthocyanin class, identified in *Vitis* species

Antioxidant compound	Source
	
Pelargonidin-3-*O*-Glu (R^{1-4}: H)	*V. vinifera* L. (red varieties) – juices [6] *V. vinifera* L. – red wines [9] *V. labrusca* L. – juice & wine [28] *V. labrusca* L. – varieties, juice [29] *V. vinifera*×*V. labrusca* hybrid – wine [48]
Petunidin-3-*O*-Glu (R^1: OH, R^2: OMe, $R^{3,4}$: H)	*V. vinifera* L. (red varieties) – juices [6] *V. labrusca* L. – juice & wine [28] *V. vinifera*×*V. labrusca* hybrid – wine [48] *V. aestivalis* – wine [25]
Petunidin-3,5-*O*-diGlu (R^1: OH, R^2: OMe, R^3: Glu, R^4: H)	*V. vinifera* L. – hybrids, skin [49] *Vitis labrusca* L. – red wines [12] *V. vinifera*×*V. labrusca* hybrid – wine [48] *V. rotundifolia* – skin [33]
Petunidin-3-*O*-(6-*O*-acetyl)-Glu-5-*O*-Glu (R^1: OH, R^2: OMe, R^3: Glu, R^4: Ac)	*Vitis labrusca* L. – red wines [12] *V. vinifera*×*V. labrusca* hybrid – wine [48]
Petunidin-3-*O*-(6-*O*-*c*/*t*-*p*-coumaroyl)-Glu-5-*O*-Glu (R^1: OH, R^2: OMe, R^3: Glu, R^4: *cis*/*trans*-*p*-coumaroyl)	*Vitis labrusca* L. – red wines [12] *V. vinifera*×*V. labrusca* hybrid – wine [48]
Peonidin-3-*O*-Glu (R^1: OMe, R^{2-4}: H)	*V. vinifera* L. (red varieties) – juices [6] *V. vinifera* L. – hybrids, skin [49] *V. vinifera* L. – red wines [9] *Vitis labrusca* L. – red wines [12] *V. labrusca* L. – juice & wine [28] *V. labrusca* L. – peel, pulp, seed [22] *V. labrusca* L. – varieties, juice [29] *V. vinifera*×*V. labrusca* hybrid – wine [48] *V. labrusca* L. – juice & wine [30] *V. labrusca* L. – juice [24] *V. aestivalis* – wine [25]
Peonidin-3,5-*O*-diGlu (R^1: OMe, R^3: Glu, $R^{2,4}$: H)	*V. vinifera* L. (red varieties) – juices [6] *Vitis labrusca* L. – red wines [12] *V. vinifera*×*V. labrusca* hybrid – wine [48] *V. rotundifolia* – skin [33]
Peonidin-3-*O*-(6-*O*-acetyl)-Glu (R^1: OMe, $R^{2,3}$: H, R^4: Ac)	*V. vinifera* L. – hybrids, skin [49] *V. vinifera*×*V. labrusca* hybrid – wine [48]
Peonidin-3-*O*-(6-*O*-acetyl)-Glu-5-*O*-Glu (R^1: OMe, R^2: H, R^3: Glu, R^4: Ac)	*Vitis labrusca* L. – red wines [12]
Peonidin-3-*O*-(6-*O*-*cis*-cumaroyl)-Glu (R^1: OMe, $R^{2,3}$: H, R^4: *cis*-cumaroyl)	*V. vinifera* L. – hybrids, skin [49] *V. vinifera*×*V. labrusca* hybrid – wine [48]
Peonidin-3-*O*-(6-*O*-*trans*-cumaroyl)-Glu (R^1: OMe, $R^{2,3}$: H, R^4: *trans*-cumaroyl)	*V. vinifera* L. – hybrids, skin [49]
Peonidin-3-*O*-(6-*O*-*c*/*t*-*p*-cumaroyl)-Glu-5-*O*-Glu (R^1: OMe, R^2: H, R^3: Glu, R^4: *cis*/*trans*-*p*-cumaroyl)	*Vitis labrusca* L. – red wines [12] *V. vinifera*×*V. labrusca* hybrid – wine [48]
Malvidin-3-*O*-Glu ($R^{1,2}$: OMe, $R^{3,4}$: H)	*V. vinifera* L. (red varieties) – juices [6] *V. vinifera* L. – different varieties, stems [35] *V. vinifera* L. – hybrids, skin [49] *V. vinifera* L. – red wines [9] *V. vinifera* L. – stem [36] *Vitis labrusca* L. – red wines [12] *V. labrusca* L. – juice & wine [28] *V. labrusca* L. – peel, pulp, seed [22] *V. labrusca* L. – varieties, juice [29] *V. labrusca* L. – juice & wine [30] *V. labrusca* L. – juice [24] *V. aestivalis* – wine [25]
Malvidin-3,5-*O*-diGlu ($R^{1,2}$: OMe, R^3: Glu, R^4: H)	*V. vinifera* L. – different varieties, stems [35] *V. vinifera* L. – hybrids, skin [49] *Vitis labrusca* L. – red wines [12] *V. labrusca* L. – juice & wine [28] *V. labrusca* L. – peel, pulp, seed [22] *V. labrusca* L. – varieties, juice [29] *V. vinifera*×*V. labrusca* hybrid – wine [48] *V. labrusca* L. – juice & wine [30] *V. labrusca* L. – juice [24]

	V. aestivalis – wine [25] *V. rotundifolia* – skin [33]
Malvidin-3-*O*-(6-*O*-acetyl)-5-*O*-Glu ($R^{1,2}$: OMe, R^3: Glu, R^4: Ac)	*Vitis labrusca* L. – red wines [12] *V. vinifera*×*V. labrusca* hybrid – wine [48]
Malvidin-3-*O*-(6-*O*-cumaroyl)-Glu ($R^{1,2}$: OMe, R^3: H, R^4: cumaroyl)	*V. vinifera* L. – hybrids, skin [49] *V. vinifera*×*V. labrusca* hybrid – wine [48]
Malvidin-3-*O*-(6-*O*-caffeoyl)-Glu ($R^{1,2}$: OMe, R^3: H, R^4: caffeoyl)	*V. vinifera* L. – stem [36] *V. vinifera*×*V. labrusca* hybrid – wine [48]
Malvidin-3-*O*-(6-*O*-caffeoyl)-Glu-5-*O*-Glu ($R^{1,2}$: OMe, R^3: Glu, R^4: caffeoyl)	*Vitis labrusca* L. – red wines [12]
Malvidin-3-*O*-(6-*O*-feruloyl)-Glu ($R^{1,2}$: OMe, R^3: H, R^4: feruloyl)	*V. vinifera* L. (red varieties) – juices [6]
Malvidin-3-*O*-(6-*O*-acetyl)-Glu ($R^{1,2}$: OMe, R^3: H, R^4: Ac)	*V. vinifera* L. – hybrids, skin [49] *V. vinifera*×*V. labrusca* hybrid – wine [48]
Malvidin-3-*O*-(6-*O*-*c/t*-*p*-coumaroyl)-Glu-5-*O*-Glu ($R^{1,2}$: OMe, R^3: Glu, R^4: *cis/trans*-p-coumaroyl)	*Vitis labrusca* L. – red wines [12] *V. vinifera*×*V. labrusca* hybrid – wine [48]
Cyanidin-3-*O*-Glu (R^1: OH, R^{2-4}: H)	*V. vinifera* L. (red varieties) – juices [6] *V. vinifera* L. – red wines [9] *V. labrusca* L. – juice & wine [28] *V. labrusca* L. – peel, pulp, seed [22] *V. labrusca* L. – varieties, juice [29] *V. vinifera*×*V. labrusca* hybrid – wine [48] *V. labrusca* L. – juice [24]
Cyanidin-3,5-*O*-diGlu (R^1: OH, R^3: Glu, $R^{2,4}$: H)	*V. vinifera* L. – hybrids, skin [49] *Vitis labrusca* L. – red wines [12] *V. labrusca* L. – juice & wine [28] *V. labrusca* L. – peel, pulp, seed [22] *V. labrusca* L. – varieties, juice [29] *V. vinifera*×*V. labrusca* hybrid – wine [48] *V. labrusca* L. – juice & wine [30] *V. labrusca* L. – juice [24] *V. aestivalis* – wine [25] *V. rotundifolia* – skin [33]
Cyanidin-3-*O*-(6-*O*-acetyl)-Glu (R^1: OH, $R^{2,3}$: H, R^4: Ac)	*V. vinifera* L. – hybrids, skin [49]
Cyanidin-3-*O*-(6-*O*-coumaroyl)-Glu-5-*O*-Glu (R^1: OH, R^2: H, R^3: Glu, R^4: *p*-coumaroyl)	*Vitis labrusca* L. – red wines [12] *V. vinifera*×*V. labrusca* hybrid – wine [48]
Delphinidin-3-*O*-Glu ($R^{1,2}$: OH, $R^{3,4}$: H)	*V. vinifera* L. (red varieties) – juices [6] *V. vinifera* L. – hybrids, skin [49] *V. vinifera* L. – red wines [9] *V. labrusca* L. – juice & wine [28] *V. labrusca* L. – peel, pulp, seed [22] *V. labrusca* L. – varieties, juice [29] *V. vinifera*×*V. labrusca* hybrid – wine [48] *V. labrusca* L. – juice [24]
Delphinidin-3,5-*O*-diGlu ($R^{1,2}$: OH, R^3: Glu, R^4: H)	*V. vinifera* L. – hybrids, skin [49] *Vitis labrusca* L. – red wines [12] *V. vinifera*×*V. labrusca* hybrid – wine [48] *V. rotundifolia* – skin [33]
Delphinidin-3-*O*-(6-*O*-cumaroyl)-Glu ($R^{1,2}$: OH, R^3: H, R^4: cumaroyl)	*V. vinifera* L. – hybrids, skin [49] *V. vinifera*×*V. labrusca* hybrid – wine [48]
Various pyranoanthocyanins (e.g., 3-*O*-Glu/(6-*O*-*p*-coumaroyl)-Glu-10-(3-hydroxy/3,4-dihydroxy-phenyl-pyrano-petunidin / peonidin / malvidin / dephinidin)	*Vitis labrusca* L. – red wines [12]

Table 6. The main antioxidant compounds from vitamin classes (tocopherol and tocotrienol, ascorbic acid), identified in *Vitis* species

Antioxidant compound	Source
	*V. labrusca* L. – pulp, seed, exocarp [46] *V. labrusca* L. – varieties, juice [29] *V. labrusca* L. – organic & conventional, juice [23]
Ascorbic acid	
 α-Tocopherol (R^{1-3}: Me) β-Tocopherol ($R^{1,3}$: Me, R^2: H) γ-Tocopherol (R^1: H, $R^{2,3}$: Me) δ-Tocopherol ($R^{1,2}$: H, R^3: Me)	*V. vinifera* L. – seed oil [50] *V. labrusca* L. – pulp, seed, exocarp [46] *V. amurensis* – leaf, stem [45]
 α-Tocotrienol (R^{1-3}: Me) β-Tocotrienol ($R^{1,3}$: Me, R^2: H) γ-Tocotrienol (R^1: H, $R^{2,3}$: Me)	*V. vinifera* L. – seed oil [50]

3. Antioxidant activity evaluation for *Vitis* species

There are many methods and techniques used for antioxidant activity evaluation of various samples. These are classified as *in vitro* and *in vivo* methods, but other techniques such as electrochemical and chemiluminescent methods have also been used. Among these, *in vitro* methods are frequently used for antioxidant activity evaluation of *Vitis* species. The antioxidant mechanisms are generally based on electron transfer reactions or hydrogen atom transfer reactions. In the first class, the total phenols quantification (Folin-Ciocalteu), Trolox equivalent antioxidant capacity (TEAC), ferric ion reducing antioxidant power (FRAP), cupric ion reducing antioxidant capacity (CUPRAC), and 2,2-diphenyl-1-picrylhydrazyl (DPPH·) methods are widely used. On the other hand, the second class involves oxygen radical absorbance capacity (ORAC) or total radical-trapping antioxidant parameter (TRAP) methods were applied [51, 52].

Vitis specie juices, wines and extracts from various plant parts were evaluated by Folin-Ciocalteu, DPPH·, ABTS, TEAC, FRAP methods [8, 9, 11, 14, 15, 19, 21, 26-28, 30, 35, 36, 40, 47, 49, 53-58]. There are many studies dealing with the antioxidant activity evaluation of *Vitis* species and only the most recent ones are cited in the present review, such in the cases of *V. vinifera*, *V. labrusca*, *V. rotundifolia*, *V. coignetiae* and *V. amurensis*.

4. Conclusions

In this review, a comprehensive survey on the antioxidant compounds found in *Vitis* species was emphasized. Various parts of the plant have been considered in this regard. It is the case of whole fruit or its juice, skin (pericarp) and pulp, as well as stems and leaves. Antioxidants identified and quantified in these parts of *Vitis* species were presented and summarized according to organic compound classes. Thus, hydroxybenzoic and hydroxycinnamic acids, flavanols, flavonols, and their glycosides, hydroxystilbenes, their glycosides, di- and trimers, anthocyanidins and the corresponding anthocyanins, as well as some antioxidant vitamins were considered. Finally, a short presentation of the methods and techniques that were applied for the evaluation of antioxidant activity of *Vitis* species was presented, with focusing on the most recent studies.

Compliance with Ethics Requirements. Authors declare that they respect the journal's ethics requirements. Authors declare that they have no conflict of interest and all procedures involving human or animal subjects (if exist) respect the specific regulation and standards.

References

1. ***. Grapes Wine. Agribusiness Handbook. Rome: Food and Agriculture Organization of the United Nations FAO; **2009**. 39 p.
2. Gutiérrez-Gamboa, G.; Liu, S.-Y.; Sun, X.; Fang, Y. Oenological potential and health benefits of Chinese non-*Vitis vinifera* species: An opportunity to the revalorization and to breed new varieties. Food Research International. **2020**, *137*, 109443. https://doi.org/10.1016/j.foodres.2020.109443.
3. Ferreira, P.A.A.; Marchezan, C.; Ceretta, C.A.; Tarouco, C.P.; Lourenzi, C.R.; Silva, L.S.; Soriani, H.H.; Nicoloso, F.T.; Cesco, S.; Mimmo, T.; Brunetto, G. Soil amendment as a strategy for the growth of young vines when replanting vineyards in soils with high copper content. *Plant Physiology and Biochemistry*. **2018**, 152-162. https://doi.org/10.1016/j.plaphy.2018.03.003.
4. Goldammer, T. Grape Grower's Handbook. A *Guide to Viticulture for Wine Production*. Centreville, WV: Apex Publishers, **2018**. 28 p.
5. Granato, D.; Carrapeiro, M.d.M.; Fogliano, V.; van-Ruth, S.M. Effects of geographical origin, varietal and farming system on the chemical composition and functional properties of purple grape juices: A review. *Trends in Food Science & Technology*. **2016**, *52*, 31-48. http://dx.doi.org/10.1016/j.tifs.2016.03.013.
6. Cosme, F.; Pinto, T.; Vilela, A. Phenolic Compounds and Antioxidant Activity in Grape Juices: A Chemical and Sensory View. *Beverages*. **2018**, *4*, 22. http://dx.doi.org/10.3390/beverages4010022.
7. de-Souza, V.B.; Fujita, A.; Thomazini, M.; da-Silva, E.R.; Lucon-Jr., J.F.; Genovese, M.I.; Favaro-Trindade, C.S. Functional properties and stability of spray-dried pigments from Bordo grape (*Vitis labrusca*) winemaking pomace. *Food Chemistry*. **2014**, *164*, 380-386. http://dx.doi.org/10.1016/j.foodchem.2014.05.049.
8. Nagai, T.; Tanoue, Y.; Kai, N.; Suzuki, N. Characteristics of strained lees of wines made from crimson glory vine (*Vitis coignetiae* Pulliat ex Planch.) berries as low economic waste by-product. *Sustainable Chemistry and Pharmacy*. **2019**, *14*, 100180. https://doi.org/10.1016/j.scp.2019.100180.
9. Osrečak, M.; Karoglan, M.; Kozina, B. Influence of leaf removal and reflective mulch on phenoliccomposition and antioxidant activity of Merlot, Teran and Plavac maliwines (*Vitis vinifera* L.). *Scientia Horticulturae*. **2016**, *209*, 261-269. http://dx.doi.org/10.1016/j.scienta.2016.07.005.

10. Rockenbach, I.I.; Gonzaga, L.V.; Rizelio, V.M.; Gonçalves, A.E.d.S.S.; Genovese, M.I.; Fett, R. Phenolic compounds and antioxidant activity of seed and skin extracts of red grape (*Vitis vinifera* and *Vitis labrusca*) pomace from Brazilian winemaking. *Food Research International*. **2011**, *44*, 897-901. http://dx.doi.org/10.1016/j.foodres.2011.01.049.
11. Zhang, Y.; Chang, S.K.C.; Stringer, S.J.; Zhang, Y. Characterization of titratable acids, phenolic compounds, and antioxidant activities of wines made from eight mississippi-grown muscadine varieties during fermentation. L*WT - Food Science and Technology*. **2017**, *86*, 302-311. http://dx.doi.org/10.1016/j.lwt.2017.07.038.
12. de-Castilhos, M.B.M.; Corrêa, O.L.d.S.; Zanus, M.C.; Maia, J.D.G.; Gómez-Alonso, S.; García-Romero, E.; Del-Bianchi, V.L.; Hermosín-Gutiérrez, I. Pre-drying and submerged cap winemaking: Effects on polyphenolic compounds and sensory descriptors. Part II: BRS Carmem and Bordô (*Vitis labrusca* L.). *Food Research International*. **2015**, *76*, 697-708. http://dx.doi.org/10.1016/j.foodres.2015.07.033.
13. Burin, V.M.; Ferreira-Lima, N.E.; Panceri, C.P.; Bordignon-Luiz, M.T. Bioactive compounds and antioxidant activity of *Vitis vinifera* and *Vitis labrusca* grapes: Evaluation of different extraction methods. *Microchemical Journal*. **2014**, *114*, 155-163. http://dx.doi.org/10.1016/j.microc.2013.12.014.
14. Barreales, D.; Malheiro, R.; Pereira, J.A.; Verdial, J.; Bento, A.; Casquero, P.A.; Ribeiro, A.C. Effects of irrigation and collection period on grapevine leaf (*Vitis vinifera* L. var. Touriga Nacional): Evaluation of the phytochemical composition and antioxidant properties. *Scientia Horticulturae*. **2019**, *245*, 74-81. https://doi.org/10.1016/j.scienta.2018.09.073.
15. Cheng, J.; Wei, L.; Mei, J.; Wu, J. Effect of rootstock on phenolic compounds and antioxidant propertiesin berries of grape (*Vitis vinifera* L.) cv. 'Red Alexandria'. *Scientia Horticulturae*. **2017**, *217*, 137-144. http://dx.doi.org/10.1016/j.scienta.2017.01.037.
16. Devi, S.; Singh, R. Evaluation of antioxidant and anti-hypercholesterolemic potential of *Vitis vinifera* leaves. *Food Science and Human Wellness*. **2017**, 6, 131-136. https://doi.org/10.1016/j.fshw.2017.07.002.
17. González-Centeno, M.R.; Comas-Serra, F.; Femenia, A.; Rosselló, C.; Simal, S. Effect of power ultrasound application on aqueous extraction of phenolic compounds and antioxidant capacity from grape pomace (*Vitis vinifera* L.): Experimental kinetics and modeling. *Ultrasonics Sonochemistry*. **2015**, *22*, 506-514. http://dx.doi.org/10.1016/j.ultsonch.2014.05.027.
18. Kőrösi, L.; Bouderias, S.; Csepregi, K.; Bognár, B.; Teszlák, P.; Scarpellini, A.; Castelli, A.; Hideg, É.; Jakab, G. Nanostructured TiO2-induced photocatalytic stress enhances the antioxidant capacity and phenolic content in the leaves of *Vitis vinifera* on a genotypedependent manner. *Journal of Photochemistry & Photobiology, B: Biology*. **2019**, *190*, 137-145. https://doi.org/10.1016/j.jphotobiol.2018.11.010.
19. Peron, D.V.; Fraga, S.; Antelo, F. Thermal degradation kinetics of anthocyanins extracted from juçara (*Euterpe edulis* Martius) and ''Italia" grapes (*Vitis vinifera* L.), and the effect of heating on the antioxidant capacity. *Food Chemistry*. **2017**, *232*, 836-840. http://dx.doi.org/10.1016/j.foodchem.2017.04.088.
20. Biniari, K.; Xenaki, M.; Daskalakis, I.; Rusjan, D.; Bouza, D.; Stavrakaki, M. Polyphenolic compounds and antioxidants of skin and berry grapes of Greek *Vitis vinifera* cultivars in relation to climate conditions. *Food Chemistry*. **2020**, *307*, 125518. https://doi.org/10.1016/j.foodchem.2019.125518.
21. Li, F.-x.; Li, F.-h.; Yang, Y.-x.; Yin, R.; Ming, J. Comparison of phenolic profiles and antioxidant activities in skins and pulps of eleven grape cultivars (*Vitis vinifera* L.). *Journal of Integrative Agriculture*. **2019**, *18*(5), 1148-1158. https://doi.org/10.1016/S2095-3119(18)62138-0.
22. Gomes, T.M.; Toaldo, I.M.; Haas, I.C.d.S.; Burin, V.M.; Caliari, V.; Luna, A.S.; de-Gois, J.S.; Bordignon-Luiz, M.T. Differential contribution of grape peel, pulp, and seed to bioaccessibility of micronutrients and major polyphenolic compounds of red and white grapes through simulated human digestion. *Journal of Functional Foods*. **2019**, *52*, 699-708. https://doi.org/10.1016/j.jff.2018.11.051.
23. Margraf, T.; Santos, É.N.T.; de-Andrade, E.F.; van-Ruth, S.M.; Granato, D. Effects of geographical origin, variety and farming system on the chemical markers and in vitro antioxidant capacity of Brazilian purple grape juices. *Food Research International*. **2016**, *82*, 145-155. http://dx.doi.org/10.1016/j.foodres.2016.02.003.
24. Toaldo, I.M.; Cruz, F.A.; Alves, T.d.L.; de-Gois, J.S.; Borges, D.L.G.; Cunha, H.P.; da-Silva, E.L.; Bordignon-Luiz, M.T. Bioactive potential of *Vitis labrusca* L. grape juices from the Southern Region of Brazil: Phenolic and elemental composition and effect on lipid peroxidation in healthy subjects. *Food Chemistry*. **2015**, *173*, 527-535. http://dx.doi.org/10.1016/j.foodchem.2014.09.171.
25. Hogan, S.; Zhang, L.; Li, J.; Zoecklein, B.; Zhou, K. Antioxidant properties and bioactive components of Norton (*Vitis aestivalis*) and Cabernet Franc (*Vitis vinifera*) wine grapes. *LWT - Food Science and Technology*. **2009**, *42*, 1269-1274. http://dx.doi.org/10.1016/j.lwt.2009.02.006.
26. Eftekhari, M.; Yadollahi, A.; Ford, C.M.; Shojaeiyan, A.; Ayyari, M.; Hokmabadi, H. Chemodiversity evaluation of grape (*Vitis vinifera*) vegetative parts during summer and early fall. *Industrial Crops & Products.* **2017**, *108*, 267-277. http://dx.doi.org/10.1016/j.indcrop.2017.05.057.

27. Loizzo, M.R.; Sicari, V.; Pellicanò, T.; Xiao, J.; Poiana, M.; Tundis, R. Comparative analysis of chemical composition, antioxidant and antiproliferative activities of Italian *Vitis vinifera* by-products for a sustainable agro-industry. *Food and Chemical Toxicology*. **2019**, *127*, 127-134. https://doi.org/10.1016/j.fct.2019.03.007.
28. Dutra, M.d.C.P.; Rodrigues, L.L.; de-Oliveira, D.; Pereira, G.E.; Lima, M.d.S. Integrated analyses of phenolic compounds and minerals of Brazilian organic and conventional grape juices and wines: Validation of a method for determination of Cu, Fe and Mn. *Food Chemistry*. **2018**, *269*, 157-165. https://doi.org/10.1016/j.foodchem.2018.07.014.
29. Lima, M.d.S.; Dutra, M.d.C.P.; Toaldo, I.M.; Corrêa, L.C.; Pereira, G.E.; de-Oliveira, D.; Bordignon-Luiz, M.T.; Ninow, J.L. Phenolic compounds, organic acids and antioxidant activity of grape juices produced in industrial scale by different processes of maceration. *Food Chemistry*. **2015**, *188*, 384-392. http://dx.doi.org/10.1016/j.foodchem.2015.04.014.
30. Padilha, C.V.d.S.; Miskinis, G.A.; de-Souza, M.E.A.O.; Pereira, G.E.; de-Oliveira, D.; Bordignon-Luiz, M.T.; Lima, M.d.S. Rapid determination of flavonoids and phenolic acids in grape juices and wines by RP-HPLC/DAD: Method validation and characterization of commercial products of the new Brazilian varieties of grape. *Food Chemistry*. **2017**, *228*, 106-115. http://dx.doi.org/10.1016/j.foodchem.2017.01.137.
31. Xu, C.; Yagiz, Y.; Borejsza-Wysocki, W.; Lu, J.; Gu, L.; Ramírez-Rodrigues, M.M.; Marshall, M.R. Enzyme release of phenolics from muscadine grape (*Vitis rotundifolia* Michx.) skins and seeds. *Food Chemistry*. **2014**, *157*, 20-29. http://dx.doi.org/10.1016/j.foodchem.2014.01.128.
32. Panico, A.M.; Cardile, V.; Avondo, S.; Garufi, F.; Gentile, B.; Puglia, C.; Bonina, F.; Santagati, N.A.; Ronsisvalle, G. The in vitro effect of a lyophilized extract of wine obtained from Jacquez grapes on human chondrocytes. *Phytomedicine*. **2006**, *13*, 522-526. http://dx.doi.org/10.1016/j.phymed.2005.06.009.
33. Sandhu, A.K.; Gray, D.J.; Lu, J.; Gu, L. Effects of exogenous abscisic acid on antioxidant capacities, anthocyanins, and flavonol contents of muscadine grape (*Vitis rotundifolia*) skins. *Food Chemistry*. **2011**, *126*, 982-988. http://dx.doi.org/10.1016/j.foodchem.2010.11.105.
34. Król, A.; Amarowicz, R.; Weidner, S. The effects of cold stress on the phenolic compounds and antioxidant capacity of grapevine (*Vitis vinifera* L.) leaves. *Journal of Plant Physiology*. **2015**, *189*, 97-104. http://dx.doi.org/10.1016/j.jplph.2015.10.002.
35. Gouvinhas, I.; Santos, R.A.; Queiroz, M.; Leal, C.; Saavedra, M.J.; Domínguez-Perles, R.; Rodrigues, M.; Barros, A.I.R.N.A. Monitoring the antioxidant and antimicrobial power of grape (*Vitis vinifera* L.) stems phenolics over long-term storage. *Industrial Crops & Products*. **2018**, *126*, 83-91. https://doi.org/10.1016/j.indcrop.2018.10.006.
36. Queiroz, M.; Oppolzer, D.; Gouvinhas, I.; Silva, A.M.; Barros, A.I.R.N.A.; Domínguez-Perles, R. New grape stems' isolated phenolic compounds modulate reactive oxygen species, glutathione, and lipid peroxidation *in vitro*: Combined formulations with vitamins C and E. *Fitoterapia*. **2017**, *120*, 146-157. http://dx.doi.org/10.1016/j.fitote.2017.06.010.
37. Acuña-Avila, P.E.; Vásquez-Murrieta, M.S.; Hernández, M.O.F.; López-Cortéz, M.d.S. Relationship between the elemental composition of grapeyards and bioactive compounds in the Cabernet Sauvignon grapes *Vitis vinífera* harvested in Mexico. *Food Chemistry*. **2016**, *203*, 79-85. http://dx.doi.org/10.1016/j.foodchem.2016.02.031.
38. Gris, E.F.; Mattivi, F.; Ferreira, E.A.; Vrhovsek, U.; Pedrosa, R.C.; Bordignon-Luiz, M.T. Proanthocyanidin profile and antioxidant capacity of Brazilian *Vitis vinifera* red wines. *Food Chemistry*. **2011**, *126*, 213-220. https://doi.org/10.1016/j.foodchem.2010.10.102.
39. Iacopini, P.; Baldi, M.; Storchi, P.; Sebastiani, L. Catechin, epicatechin, quercetin, rutin and resveratrol in red grape: Content, in vitro antioxidant activity and interactions. *Journal of Food Composition and Analysis*. **2008**, *21*, 589-598. https://doi.org/10.1016/j.jfca.2008.03.011.
40. Sáez, V.; Pastene, E.; Vergara, C.; Mardones, C.; Hermosín-Gutiérrez, I.; Gómez-Alonso, S.; Gómez, M.V.; Theoduloz, C.; Riquelme, S.; von-Baer, D. Oligostilbenoids in *Vitis vinifera* L. Pinot Noir grape cane extract: Isolation, characterization, *in vitro* antioxidant capacity and anti-proliferative effect on cancer cells. *Food Chemistry*. **2018**, *265*, 101-110. https://doi.org/10.1016/j.foodchem.2018.05.050.
41. Dani, C.; Oliboni, L.S.; Agostini, F.; Funchal, C.; Serafini, L.; Henriques, J.A.; Salvador, M. Phenolic content of grapevine leaves (*Vitis labrusca* var. Bordo) and its neuroprotective effect against peroxide damage. *Toxicology in Vitro*. **2010**, *24*, 148-153. http://dx.doi.org/10.1016/j.tiv.2009.08.006.
42. Dani, C.; Oliboni, L.S.; Vanderlinde, R.; Bonatto, D.; Salvador, M.; Henriques, J.A.P. Phenolic content and antioxidant activities of white and purple juices manufactured with organically- or conventionally-produced grapes. *Food and Chemical Toxicology*. **2007**, *45*, 2574-2580. http://dx.doi.org/10.1016/j.fct.2007.06.022.
43. De-Rosso, M.; Tonidandel, L.; Larcher, R.; Nicolini, G.; Dalla-Vedova, A.; De-Marchi, F.; Gardiman, M.; Giust, M.; Flamini, R. Identification of new flavonols in hybrid grapes by combined liquid chromatography-mass spectrometry approaches. *Food Chemistry*. **2014**, *163*, 244-251. http://dx.doi.org/10.1016/j.foodchem.2014.04.110.

44. Hilbert, G.; Temsamani, H.; Bordenave, L.; Pedrot, E.; Chaher, N.; Cluzet, S.; Delaunay, J.-C.; Ollat, N.; Delrot, S.; Mérillon, J.-M.; Gomès, E.; Richard, T. Flavonol profiles in berries of wild *Vitis* accessions using liquid chromatography coupled to mass spectrometry and nuclear magnetic resonance spectrometry. *Food Chemistry*. **2015**, *169*, 49-58. http://dx.doi.org/10.1016/j.foodchem.2014.07.079.
45. Ha, D.T.; Kim, H.; Thuong, P.T.; Ngoc, T.M.; Lee, I.; Hung, N.D.; Bae, K. Antioxidant and lipoxygenase inhibitory activity of oligostilbenes from the leaf and stem of *Vitis amurensis*. *Journal of Ethnopharmacology*. **2009**, *125*, 304-309. https://doi.org/10.1016/j.jep.2009.06.019.
46. Güder, A.; Korkmaz, H.; Gökce, H.; Alpaslan, Y.B.; Alpaslan, G. Isolation, characterization, spectroscopic properties and quantum chemical computations of an important phytoalexin resveratrol as antioxidant component from *Vitis labrusca* L. and their chemical compositions. *Spectrochimica Acta Part A: Molecular and Biomolecular Spectroscopy*. **2014**, *133*, 378-395. http://dx.doi.org/10.1016/j.saa.2014.05.056.
47. Chen, Q.; Diao, L.; Song, H.; Zhu, X. *Vitis amurensis* Rupr: A review of chemistry and pharmacology. *Phytomedicine*. **2018**, *49*, 111-122. https://doi.org/10.1016/j.phymed.2017.08.013.
48. Nixdorf, S.L.; Hermosín-Gutiérrez, I. Brazilian red wines made from the hybrid grape cultivar Isabel: Phenolic composition and antioxidant capacity. *Analytica Chimica Acta*. **2010**, *659*, 208-215. http://dx.doi.org/10.1016/j.aca.2009.11.058.
49. Maurer, L.H.; Bersch, A.M.; Santos, R.O.; Trindade, S.C.; Costa, E.L.; Peres, M.M.; Malmann, C.A.; Schneider, M.; Bochi, V.C.; Sautter, C.K.; Emanuelli, T. Postharvest UV-C irradiation stimulates the non-enzymatic and enzymatic antioxidant system of 'Isabel' hybrid grapes (*Vitis labrusca* × *Vitis vinifera* L.). *Food Research International*. **2017**, *102*, 738-747. http://dx.doi.org/10.1016/j.foodres.2017.09.053.
50. Mohamed, H.B.; Duba, K.S.; Fiori, L.; Abdelgawed, H.; Tlili, I.; Tounekti, T.; Zrig, A. Bioactive compounds and antioxidant activities of different grape (*Vitis vinifera* L.) seed oils extracted by supercritical CO2 and organic solvent. *LWT - Food Science and Technology*. **2016**, *74*, 557-562. http://dx.doi.org/10.1016/j.lwt.2016.08.023.
51. Miguel, M.G. Antioxidant activity of medicinal and aromatic plants. A review. *Flavour and Fragrance Journal*. **2010**, *25*, 291-312. http://dx.doi.org/10.1002/ffj.1961.
52. Shahidi, F.; Ambigaipalan, P. Phenolics and polyphenolics in foods, beverages and spices: Antioxidant activity and health effects – A review. *Journal of Functional Foods*. **2015**, *18*, 820-897. http://dx.doi.org/10.1016/j.jff.2015.06.018.
53. da-Silva, M.J.R.; Padilha, C.V.d.S.; Lima, M.d.S.; Pereira, G.E.; Filho, W.G.V.; Moura, M.F.; Tecchio, M.A. Grape juices produced from new hybrid varieties grown on Brazilian rootstocks – Bioactive compounds, organic acids and antioxidant capacity. *Food Chemistry*. **2019**, *289*, 714-722. https://doi.org/10.1016/j.foodchem.2019.03.060.
54. Demirkol, M.; Tarakci, Z. Effect of grape (*Vitis labrusca* L.) pomace dried by different methods on physicochemical, microbiological and bioactive properties of yoghurt. *LWT - Food Science and Technology*. **2018**, *97*, 770-777. https://doi.org/10.1016/j.lwt.2018.07.058.
55. Mesquita, T.C.; Schiassi, M.C.E.V.; Lago, A.M.T.; Careli-Gondim, Í.; Silva, L.M.; Lira, N.d.A.; Carvalho, E.E.N.; Lima, L.C.d.O. Grape juice blends treated with gamma irradiation evaluated during storage. *Radiation Physics and Chemistry*. **2020**, *168*, 108570. https://doi.org/10.1016/j.radphyschem.2019.108570.
56. Pertuzatti, P.B.; Mendonça, S.C.; Alcoléa, M.; Guedes, C.T.; Amorim, F.d.E.; Beckmann, A.P.S.; Gama, L.A.; Américo, M.F. Bordo grape marc (*Vitis labrusca*): Evaluation of bioactive compounds *in vitro* and *in vivo*. *LWT - Food Science and Technology*. **2020**, *129*, 109625. https://doi.org/10.1016/j.lwt.2020.109625.
57. Shahkoomahally, S.; Sarkhosh, A.; Richmond-Cosie, L.M.; Brecht, J.K. Physiological responses and quality attributes of muscadine grape (*Vitis rotundifolia* Michx) to CO2-enriched atmosphere storage. *Postharvest Biology and Technology*. **2021**, 173, 111428. https://doi.org/10.1016/j.postharvbio.2020.111428.
58. Xu, C.; Yagiz, Y.; Zhao, L.; Simonne, A.; Lu, J.; Marshall, M.R. Fruit quality, nutraceutical and antimicrobial properties of 58 muscadine grape varieties (*Vitis rotundifolia* Michx.) grown in United States. *Food Chemistry*. **2017**, *215*, 149-156. http://dx.doi.org/10.1016/j.foodchem.2016.07.163.