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TRANS-RESVERATROL CONTENT IN VITIS VINIFERA L CULTIVATED IN THE SÃO FRANCISCO RIVER VALLEY - BRAZIL AND POSSIBLE USE AS A FUNCTIONAL INGREDIENT IN FOODS

TEOR DE TRANS-RESVERATROL EM VITIS VINÍFERA L CULTIVADA NO VALE DO RIO SÃO FRANCISCO-BRASIL E POSSÍVEL USO COMO INGREDIENTE FUNCIONAL EM ALIMENTOS

CONTENIDO DE TRANS-RESVERATROL EN VITIS VINIFERA L CULTIVADA EN EL VALLE DEL RÍO SÃO FRANCISCO-BRASIL Y POSIBLE USO COMO INGREDIENTE FUNCIONAL EN ALIMENTOS

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ABSTRACT

The trans-resveratrol is a polyphenol not flavonoid present in grape, especially in the skin and many studies proved its efficiency in human health. That is why there is a huge necessity of quantifying it in skins of grapes in nature consumed by the population. The proposal of this study was to quantify the content of trans-resveratrol by High-Performance Liquid Chromatography – HPLC in the skins of varieties (Vitis vinifera L) cultivated in the Northeast region of Brazil, in the São Francisco River valley in 2024 and propose the development of a functional ingredient obtained from these skins. The varieties analyzed were: “Red globe”; “Rubi”; Italia” and Patricia” bought in a Central market. After manual separation of the skin, pulp and seed, drying and the extraction of the active components of the skin, the latter was analyzed by HPLC. The major contents found were in the varieties" Rubi"(28,14ppm) and “Red Globe” (27,59ppm) followed by lesser values in ”Patricia” (14,97ppm) and "Italia"(3,77ppm) suggesting that the red coloration indicates a bigger quantity of trans-resveratrol. Comparing with the values obtained in the literature it was observed that in the skins of red grapes produced in the Valley of São Francisco have content of resveratrol equivalent or superior to grapes produced in other regions of the world. The levels of resveratrol can be sufficient to use them as functional ingredients, aggregating value to the residue of food processing. These discoveries reinforce the importance of investigating the composition of skins of grape from the São Francisco Valley and its relevance to the food industry and for the consumption as a source of trans-resveratrol.

Keywords: Grapes. Trans-resveratrol. Quantification. HPLC. Functional ingredient.

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RESUMO
O trans-resveratrol é um polifenol não flavonoide presente na uva, especialmente na casca, e muitos estudos comprovaram sua eficiência na saúde humana. Por isso, há uma enorme necessidade de quantificá-lo em cascas de uvas in natura consumidas pela população. A proposta deste estudo foi quantificar o teor de trans-resveratrol por Cromatografia Líquida de Alta Eficiência – CLAE nas cascas de variedades (Vitis vinifera L) cultivadas na região Nordeste do Brasil, no vale do Rio São Francisco, em 2024 e propor o desenvolvimento de um ingrediente funcional obtido a partir dessas cascas. As variedades analisadas foram: “Red Globe”; “Rubi”; “Itália” e “Patricia” adquiridas em um mercado Central. Após a separação manual da casca, polpa e semente, secagem e extração dos componentes ativos da casca, esta última foi analisada por CLAE. Os maiores teores encontrados foram nas variedades "Rubi" (28,14 ppm) e "Red Globe" (27,59 ppm), seguidos por valores menores em "Patricia" (14,97 ppm) e "Italia" (3,77 ppm), sugerindo que a coloração vermelha indica maior quantidade de trans-resveratrol. Comparando com os valores obtidos na literatura, observou-se que as cascas de uvas tintas produzidas no Vale do São Francisco apresentam teor de resveratrol equivalente ou superior às uvas produzidas em outras regiões do mundo. Os níveis de resveratrol podem ser suficientes para utilizá-las como ingredientes funcionais, agregando valor ao resíduo do processamento de alimentos. Essas descobertas reforçam a importância de investigar a composição das cascas de uvas do Vale do São Francisco e sua relevância para a indústria alimentícia e para o consumo como fonte de trans-resveratrol.

Palavras-chave: Uvas. Trans-resveratrol. Quantificação. HPLC. Ingrediente funcional.

RESUMEN
El trans-resveratrol es un polifenol no flavonoide presente en la uva, especialmente en la cáscaras, y muchos estudios han demostrado su eficacia en la salud humana. Por este motivo, existe una gran necesidad de cuantificarlo en las cáscaras de uva fresca consumidos por la población. El objetivo de este estudio fue cuantificar el contenido de trans-resveratrol por cromatografía líquida de alta resolución (HPLC) en hollejos de variedades (Vitis vinifera L) cultivadas en la región nordeste de Brasil, en el valle del río São Francisco, en 2024 y proponer el desarrollo de un ingrediente funcional obtenido a partir de estos cáscaras. Las variedades analizadas fueron: «Red Globe»; «Rubi»; «Itália» y «Patricia», adquiridas a un sector Central. Tras separar manualmente la cáscara, la pulpa y las semillas, secar y extraer los componentes activos de la cáscara, ésta se analizó mediante CLAE. Los niveles más altos se encontraron en las variedades «Rubi» (28,14 ppm) y «Red Globe» (27,59 ppm), seguidas de valores más bajos en “Patricia” (14,97 ppm) e «Italia» (3,77 ppm), lo que sugiere que el color rojo indica una mayor cantidad de trans-resveratrol. En comparación con los valores obtenidos en la bibliografía, se observó que las cáscaras de las uvas tintas producidas en el Valle de São Francisco tienen un contenido de resveratrol equivalente o superior al de las uvas producidas en otras regiones del mundo. Los niveles de resveratrol pueden ser suficientes para utilizarlos como ingredientes funcionales, añadiendo valor a los residuos del procesado de alimentos. Estos resultados refuerzan la importancia de investigar la composición de las cáscaras de uva del Valle de São Francisco y su relevancia para la industria alimentaria y para el consumo como fuente de trans-resveratrol.

Palabras clave: Uvas. Trans-resveratrol. Cuantificación. HPLC. Ingrediente funcional.

INTRODUCTION

The association of habits of healthy life and the consumption of certain kinds of food having bioactive compounds with the health is an old finding, that only in the last decades have gained a major impulse, directing the research to a search of scientifical evidence that can explain the mechanism of action of food compounds that contribute to the improvement of the general state of health of individuals. Among these bioactive compounds are the polyphenols, that promote benefits to the health of your consumers, including prevention and treatment of chronical not transmissible diseases (Stringheta *et al.*, 2024).

Belonging to the group of polyphenols not flavonoids the resveratrol (3,5,4'-trans-tri-hydroxystilbene) is a phytoalexin belonging to the family of stilbene, it is synthesized by more than 70 species of plants in response to an infection, stress, injury, bacterial or fungal infection and UV radiation. It is a natural dietary vegetal compound that occurs mainly in the skin and in the seeds of grape, but also it is found in wines and many other kinds of vegetal food, especially peanut, red fruits and tea (Malaguarnera, 2019). Its chemical structure is composed of two benzenic rings, one carrying two hydroxyls and the other only one, molecular mass 228,24 g/mol, it is found in solid state at standard temperature, being a whitish dust and presents the point of fusion of 253-255ºC. It is a lipophilic molecule that easily dissolves in organic solvents like ethanol and DSMO, it is slightly soluble in water. In humans, they are bind to plasmatic proteins as lipoproteins, albumin and hemoglobin (Cabra *et al.*, 2024).

The resveratrol is a photosensitive substance that before the ultraviolet light presents two isoform, cis and trans (Figure 1), in which the more active form of the compound is the trans-resveratrol and its natural occurrence in the skin of grapes happens as a response to the stress caused by a fungal attack (*Botrytis cinerea, Plasmopora vitcula*), mechanical damage and irradiation of ultraviolet light (Henz *et al*., 2020) These isomers can be bond to a glucose molecule, under the form of a glycoside, known as piceid (3,4',5-trihydroxystilbene-3-β-mono-D-glucoside). (Figure 1).

Figure 1 – Representation of chemical structure of the isomers of trans-resveratrol, *cis*-resveratrol, glycoside *trans*-piceid and *cis*-piceid(*trans*-resveratrol-O-β-glycoside).

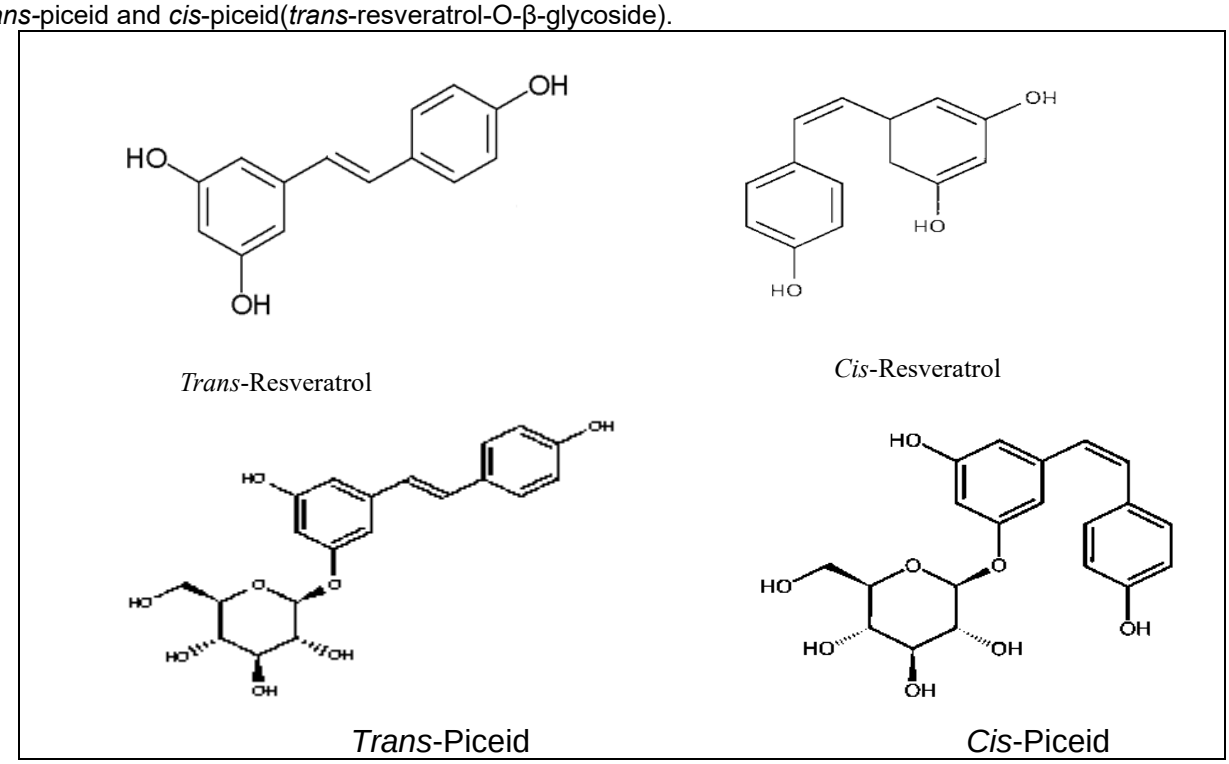


Image from: Authors, 2024.

Among the known effects of resveratrol, it is highlighted the potent antioxidant activity, that is associated with the presence of its three hydroxyl groups in its structure, which has an inhibitory effect in the production of Reactive Oxygen Species–ROS and for the rise of indoleamine 3-dioxygenase activity and in the lipid peroxidation by inhibition of lipoxygenase (Gualdoni,2016; Doiphode *et al.*, 2023, Galianiak *et al.*,2019).

Besides proven the anti-inflammatory effect, through the inhibition of biomarkers to activate the deacetylase enzyme Sirtuina- Sirt1 that inhibits inflammatory factors as Nuclear Factor kappa B (NF-κB), Tumor Necrosis Factor alpha (TNF-α), Interleukin-1 beta (IL-1β) e Interleukin -6, metalloprotease (MMP 1 e MMP3) and the cyclooxygenase-2 enzyme that are related to metabolism, cancer, immunological tolerance, embryonic development, (Malaguarnera, 2019). Its effects are being associated to an improvement in the oxidative stress with the reduction of risks of development of cardiovascular diseases, chronic kidney disease, diabetes, and neurodegenerative diseases (Galianiak *et al.*, 2019).

The studies demonstrate important chemotherapeutic effect in prostate, breast, pancreas and pulmonary cancer, of chancre and colorectal through the apoptotic induction and anti-androgenic action as well as reducing the course of various stages of carcinogenesis by resveratrol (Balasubramanian, Girigoswami, Girigoswami, 2023; Talib *et al.*, 2020), as also display evidences of radioprotective action of isomer trans, through alteration of cell response to ionizing radiation. There is proof of suppression of metastasis

of cervical cancer through resveratrol by deactivating the phosphorylation of STAT3 as well as its way of signaling (Sun, 2020).

The resveratrol has also been related in the prevention of atherosclerosis, by its vasorelaxant and vasodilating property, as by means of additional actions involving the reduction of chemical and enzymatic reactions measured by peroxidases, inhibiting this way the oxidation of low density lipoprotein (LDL), in the suppression of platelet aggregation and rising the current concentration of high density lipoprotein (HDL) with this provides protection to the vascular endothelium against disfunctions and damages caused by inadequate diets (Cabra *et al.*, 2024).

This way, it is realized that the consume of this chemical compound presented in the husk of grape, in human diet can bring many benefits to health, like the prevention of diseases or as coadjuvant in the treatment of comorbidities.

In the Valley of São Francisco in the northeast of Brazil, the technological improvement permitted the production of fine table grapes with quality that meets market niches inside the country and the demands of different importers (EMBRAPA, 2024).

Even though there are studies in many countries of the world about resveratrol and its biological properties, there are still few that quantify the content of this polyphenol in table grapes produced in Brazil, mainly in the Northeast region, in the region of Valley of São Francisco, where this is the second major producer of wine from Brazil and the biggest exporter of grapes, according to the Brazilian Association of Exporting Producers of Fruits and Derivatives (ABRAFRUTAS, 2023). In this region, it is produced the *Vitis vinífera* L, representing the European grapes being known as fine grapes, destined to the in nature consumption or in the production of fine wines, according to Bernardi et al., (2019).

This way, considering the importance of resveratrol to the human nutrition and its performance in the prevention of diverse diseases, this study has by its main objective determine the content of trans-resveratrol in varieties of table grapes *(Vitis vinífera* L*)* cultivated in the Valley of River São Francisco by the method of Liquid Chromatography of High Efficiency (HPLC) and propose the use of freeze-dried skins as functional ingredient in foods.

MATERIAL AND METHODS

SAMPLES

The varieties *Vitis vinífera* L analyzed was acquired in a Central market of the city of Fortaleza, Ceará-Brazil. The varieties of the fruit analyzed were: grape Red Globe (RG),

grape Patricia (PA), grape Rubi (RU) e grape Itália (IT), in the period of August to December of 2024.

The varieties analyzed exhibit the following characteristics: RG: they are of big size and have pinkish to reddish coloration, known by its smooth sweetness, tones slightly acid, produced only in Valley of São Francisco. IT: The grapes from the Italian group, are valued by its big size, intense yellow-straw color with green-yellow hues and aromatic sweetness or muscat. These grapes have a profile of musky and delicate flavor when compared to tropical fruits. RU: derived grape from Italy, kept the general characteristics of Italian grape, but exhibiting uneven light pink coloration (Maia, Ritschel, Lazzarotto, 2018). The Patrician grape is a hybrid variety, its berry are small, round, dark red, crispy texture, neutral flavor slightly herbaceous, thick skin that ensures great resistance to cracking (EMBRAPA, 2024).

SAMPLE PREPARING

The fruits were washed in running water after it was manually separated its components in pulp, seeds and kins, this last went frozen at -50°C and was lyophilized under a vacuum of 5 Mtorr (9.67x10-5 psi) in an EDWARDS-brand banch-top freeze-dry for 48 hours. After dried and crushed the samples were stored under refrigeration until the moment of the analysis. In figure 2 is represented the process of preparing of samples, taking as example the variety of grape Red Globe.

Figure 2: Representation of process to the preparing of skins of grape variety Red Globe to analyze: a) Grape *in nature* variety Red Globe, b) separation of pulps from the humid skins and seeds, c) Skins after freeze drying, d) Dried skins after crushing.

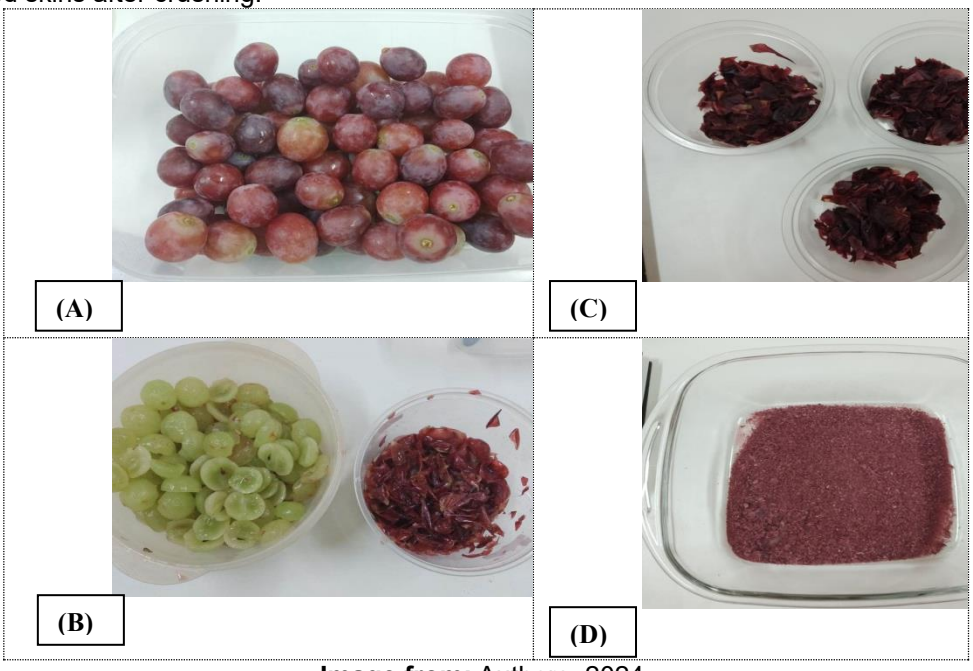


Image from: Authors, 2024.

The resveratrol present in grape was extracted from the dried extract of its components following the adapted methodology proposed by Silva *et al.*,(2014). The dried skin (2,5g) of each sample was extracted in 60mL of solution Ethanol- H_2O (1:1, v/v), submitted to heating for 30 minutes at 70ºC and filtered in filter paper. After that, it was repeated the process with the residue from extraction. The solution resulted from the two extractions was reduced and concentrated at vacuum at 70ºC using a rotary evaporator (Buchi R-210 Rotavap, Buchi Co., New Castel, DE) and the concentrated solubilized in 5 mL of methanol and analyzed by HPLC.

PREPARING THE STANDARD SOLUTION FOR THE CURVE OF CALIBRATION, DETECTION LIMITS AND QUANTIFICATION

For the preparing of the standard solution it was utilized 5 mg of standard trans-resveratrol of kind ALDRICH® dissolved to 10 mL of methanol (standard solution), after it was carried out the dilutions presented in table 1.

Table 1 – Dilutions for the preparing of the curve of calibration

Solution	Concentration (mg/mL)	Dilution
A	0,25	5mL standard solution to 10mL of methanol
B	0,1	1 mL solution A to 5 mL de metanol
C	0,05	5 mL solution A to 10 mL de metanol
D	0,025	5 mL solution C to 10 mL de metanol
E	0,0025	1 mL solution D to 10 mL de metanol
F	0,00025	1 mL solution E to 10 mL de metanol

Source: Data collected by the authors, 2024.

From each dilution, after filtration, it was removed 1 mL and it was injected in the loop of 20µL from the minor to the major concentration. The total time of execution was 15min for dilution. A curve of calibration with external pattern was generated from the injections in triplicate of each dilution.

DETERMINATION OF THE CONTENT OF RESVERATROL

The trans-resveratrol was quantified by High-Performance Liquid Chromatography (HPLC), according to Silva *et al.,* (2014) with adaptations. It was utilized a liquid chromatograph Shimadzu® equipped with bomb model LC-10AD operating in isocratic mode, a degasser model DGU-14A, in oven CTO-10AS, loop of injection with volume of 20µl, detector UV/VIS with arrange of photodiode (DAD) coupled to a system CLASS-VP®. The analytic column utilized was HIBAR® C-18 (250 mm x 4,6mm, 5µm) preceded to a guard column of same composition. The mobile phase consisting of deionized water acidified to pH 3,0 with phosphoric acid (H_3PO_4) (Solution A) and acetonitrile (Solution B) in

the proportion of 75:25 (A:B), with output of 1,5 mL/min and total time of 15min for sample at 40ºC. The trans-resveratrol was detected at 306nm.

The identification of trans-resveratrol was based in the time of retention, in the maximum of absorption, and the purity of peaks was confirmed through DAD. The quantification was made by external standardization, with pattern of trans-resveratrol of kind ALDRICH®, after the acquisition of the curve of calibration.

RESULT AND DISCUSSION

CURVE OF CALIBRATION, AND LIMITS OF DETECTION AND QUANTIFICATION

The determination of linearity was made through the construction of the curve of calibration with standard solution of *trans*-resveratrol in six concentrations. The values obtained for the construction of the curve of calibration by HPLC are presented in table 2. The parameters of validation of chromatography analysis of trans-resveratrol are described in table 3.

Table 2. Absolute areas obtained in the determination of the curve of calibration of the pattern of *trans*-resveratrol by HPLC.

Concentration mg/mL	Absolute Area *Average ± DP*	Dif. %
0,00025	31981 ± 674	4,146
0,0025	294893,5 ± 5749,5	3,98
0,025	2894076 ± 13117,5	0,90
0,05	4910252 ± 15564,5	0,63
0,1	11187040 ± 235532,5	4,12
0,25	3246461 ± 114265,5	0,71

Source: Data collected by the authors, 2024.

Table 3. Parameters of validation by chromatography analysis of *trans*-resveratrol

Parameters	Trans-Resveratrol Results
Limit of detection (mg/mL)	$2,5x10^{-9}$
Limit of quantification (mg/mL)	$2,5x10^{-8}$
Linearity	$y=10^{8}x + 4604,6$
Coef. of correlation (R^2)	0,998
Time of retention (min)	5,8 minutes

x= Concentration; y= area of peak (absorbance x length of wave). **Source:** Data collected by the authors, 2024.

The varieties of grapes analyzed (PA, RG, RU e IT) are said table grape, are diary consumable fruits by the population for low cost and are more accessible than the fine grapes, that normally are destined to the production of fine wines.

The varieties of grape from the Valley of river São Francisco analyzed in the present study exhibit the content of trans-resveratrol between 3,778 to 28,148 ppm in its skins, showed in Table 4. The highlight is given to the grapes of variety “Rubi” that presented

28,148 ppm followed by “Red Globe” with 27,593 ppm, the lesser value was detected in “Italia” with 3,778ppm.

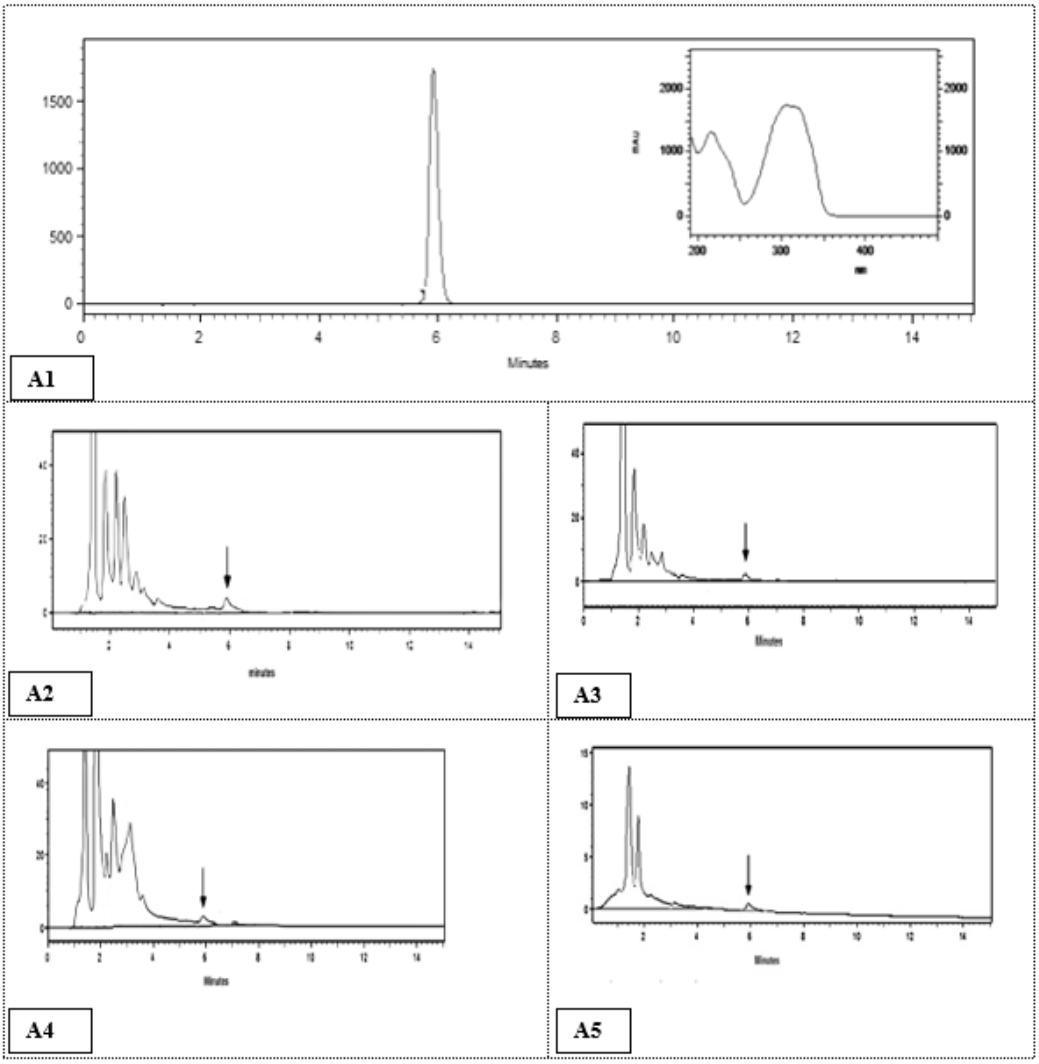
Table 4. Content of trans-resveratrol of varieties of grape of Valley of São Francisco

Varieties of Grape	Trans-resveratrol* (mg/kg)
Patricia	14,97
Red Globe	27,59
Rubi	28,15
Italia	3,78

*mg/kg= ppm. **Source:** Authors, 2024

See below the chromatogram obtained from the injection of the standard of the *Trans*- Resveratrol and the respective samples cited, figure 3.

Figura3. Chromatograms obtained from the injections of the standard of *Trans*-resveratrol and extracts from skins of grape lyophilized, showing the correspondent peak of the *trans*-resveratrol in 5,8min. (A1) Chromatogram obtained by injecting the Trans-resveratrol standard with the corresponding peak at a retention time of 5.8 minutes and its absorption curve in the UV region. (A2) Rubi, (A3) Patricia, (A4) Red Gobe, (A5) Italia.



Source: Authors, 2024

The study done by Lago-Vanzela and collaborators (2011a) utilizing HPLC for analysis in skins of grapes cultivated in São Paulo from species *Vitis vinífera* L genetically modified codified by EMPRABA for BRS Morena and BRS Clara it was identified 3,91ppm of resveratrol for the first species, not being found in the second. Such value is close to the minor value found in this experiment, in variety "Italia". Another study done by the same authors (2011b) evaluated the content of trans-resveratrol of species *Vitis labrusca,* presented in the South region of Brazil; in this one it was found 10,91 ppm, approximately value to the one found in this study by variety "Patricia". Although, it is still under the values found by the variety "Rubi" of our study.

The Chile is a country from South America that has great participation in the production of grapes, mainly of species *Vitis vinífera* L. In analysis done in skins of grape from the varieties: "Red Globe"; "Autunm Royal", "Crimson seedless" and "Ribier" to the quantification of content of trans-resveratrol in grapes of the cited country, Lutz *et al.,* (2011) found the following values: 0,77 ppm, 1,76 ppm, 0,98 ppm e 2,66 ppm, respectively. Values that, are below the ones found in this study.

The Canada produces grapes of variety "seedless" whose content of resveratrol found by Huang e Mazza (2011) was of: 0,034ppm. This content is still below the one quantified by our analysis.

In 2009, Santos together with other researchers identified in the skin of species *Vitis labrusca* of varieties: "Isabel"; "Benitaka", "Niágora", e "Brasil", values below the ones found in skins of grape cultivated in the riverbank of River São Francisco. The values observed in the varieties of *V. labrusca* were respectively: 12,9ppm; 1,17ppm; 2,21ppm e 2,84ppm.

Other study done in Minas Gerais by Aber and other scholars (2007) identified in varieties of the species of *Vitis labrusca and Vitis vinífera* L in the varieties: "Niagora rosada", "Shyrah" and "Merlot" the respective values: 0,22ppm, 6ppm and 5ppm such quantifications were done having as parameter the humid weight.

Fan and collaborators (2008) analyzing fresh skins of grape cultivated in China of variety "Merlot" and "Carbenet sauvignon" identified 6,77ppm and 3,92 ppm of trans-resveratrol.

In countries of Europe there are significant differences in the quantity analyzed of the compound in skins of grape. In Portugal Sun *et al.,*(2006) analyzed species of *Vitis vinífera* L of variety: "Castelão", "Shyrah" e "Tinta Roriz", detecting respectively: 18ppm, 22ppm and 12ppm of trans-resveratrol. These values are below the ones found in varieties "Rubi" and "Red Globe" of varieties of the present study. In Spain, Piñeiro, Palma e Barroso (2006) identified in the whole lyophilized grape of variety "Viura" and "Tempranilho" medium values

of 2,18ppm, value still below of the quantities identified in grapes of Valley of São Francisco.

In United States in 2020, Rathburn and other researchers quantified by HPLC the content of resveratrol in grapes produced in the vineyards of center of Texas and found in grapes Lenoir and “Cabernet Souvignon” quantities related to this compound of 52,3 ppm e 49,6 ppm respectively.

The researchers Hua, Inbaraj and Chen (2021), quantified the content of *trans*-resveratrol in grape of variety “Kyoho” by HPLC and found a total of 1,54 ppm in extract of dry skins.

Studying the dynamic of resveratrol from the beginning of the period of maturation of grapes until technological maturation in winegrowing of Simnico from Romenia by HPLC, Căpruciu et al., (2022), observed that the compound trans-resveratrol was better quantified in varieties “Merlot” (0,699 to 0,675 ppm) and “Cabernet” (0,633 to 0,430 ppm) studied in relation to other present compounds. Besides, this component tends to decrease with the process of maturation of fruits being the Merlot grape the one that better keeps the content of trans-resveratrol throughout the process of maturation.

Making a comparison between the varieties of grape produced in Valley of São Francisco and the fine grapes produced in other places in the world (Table 5), it is observed that the contents of trans-resveratrol found are much closer. This indicates that the ingestion of this chemical compound is accessible through the consumption of skin of grape in nature. Once the fine grapes, normally destined to the production of fine wines, are of high cost.

Table 5. Resume of contents of *trans*-resveratrol found in varieties of grapes in the world.

Varieties of grape	Contents of trans-resveratrol in ppm	Reference
BRS Morena e BRS Clara	3,91	Vanzela *et al.*, (2011a)
Vittis Labrusca	10,91	Vanzela *et al.*,(2011b)
Red Globe	0,77	Lutz *et al.*, (2011) and Huang, Mazza, (2011)
Cutem Royal	1,76	
Crimson Sedless	0,98 e 0,034	
Ribier	2,66	
Isabel	12,90	Santos *et al.*, (2009) and Aber *et al.*, (2007)
Benitaka	1,17	
Niagora	2,21	
Niágora Rosada	0,22	

Brasil	2,84	
Shyrah	6,00 e 22,00	Aber *et al.*, (2007) and Fan *et al.*, (2008)
Merlot	5,00 e 6,77	
Cabernet Souvignon	3,92 e 49,6	Fan *et al.*, (2008) and Rathburn, *et al.*, (2020)
Castelão	18,00	Sun *et al.*, (2006)
Tinta Roriz	12,00	
Viura	2,18	Pinero, Palma, Barroso (2006)
Trampilho	2,18	
Lenoir	52,3	Rathburn *et al.*, (2020)
Kyoho	1,54	Hua, Inbaraj, Chen, (2021)

Source: Data collected by the authors, 2024.

The effects of trans-resveratrol can be sensed with doses between 2,5 mg a 1 g, measure in which it is well tolerated, other studies with doses above 1g already refer to gastrointestinal disorders. (Brown *et al*., 2024). The supplements of trans-resveratrol can include contents less than 1 milligram(mg) to 500(mg) of resveratrol by pill or capsule, but it doesn't know if there is an efficient and safe dosage for the prevention of chronical diseases in human (Linus Pauling Institute, 2024).

Based in this study and comparing the values found in literature, to obtain a dose of 1 mg of resveratrol would be necessary the supplementation of 36 to 38 g of dust from skin of grape "Rubi" lyophilized (approximately 6 half tablespoon**)**). The dried dust crushed from the skin of grape lyophilized produced in Valley of São Francisco in Brazil, can be added to the preparing of diverse types of food like bread, pizza, cakes, cookies and smoothies.

The values of resveratrol found in skins of grape lyophilized from Valley of São Francisco have higher contents when compared with other natural forms of the compound like, for example, in wines and peanuts. In tables 6 and 7 it is presented the content of resveratrol in these foods and compared to the content equivalent of resveratrol found in skins of grape lyophilized.

Table 6. Comparing of the total content of resveratrol in selected foods with the skins of grape lyophilized of major content of resveratrol produced in São Francisco-Northeast-Brazil (variety Rubi)

Food	Quantity	Resveratrol total in mg	Equivalent in skin of dry grape and lyophilized content of RSV referenced(g)
Peanut (raw)	1 cup (146 g)	0,14	**4,97 (3 teaspoon)**
Peanut (baked)	1 cup (180 g)	0,80	**28,41 (6 half tablespoon)**
Butter of Peanut	1 cup (258 g)	0,09	**3,20 (2 teaspoon)**
Red grapes	1 cup (160 g)	0,75	**26,64 (5 half tablespoon)**

Source: Linus Pauling Institute adaptated, 2015.

Table 7. Comparing the total content of resveratrol in red wine with the skins of grape lyophilized of major content of resveratrol produced in São Francisco-Northeast- Brazil (variety Rubi)

Variety	Concentration of Resveratrol		
	Average (mg/100ml)	Cup of 150 mL (mg)	**Equivalent in skins of dry grape and lyophilized (g) in relation to concentration media.**
Pinot Noir	**0,36 ± 0,29**	0,5	**13,05 (3** tablespoon**)**
Vinho Merlot	**0,28 ± 0,26**	0,4	**10,15 (2** half tablespoon)
Shyrah	**0,18 ± 0,09**	0,3	**6,52 (4** half teaspoon**)**
Cabernet Sauvignon	**0,17 ± 0,17**	0,2	**6,16 (4** teaspoon**)**
Vinhos tintos (globais)	**0,19 ± 0,17**	0,3	**6,89 (4** half teaspoon**)**

Source: Linus Pauling Institute adaptated, 2015

The wine industry generates a lot of grape skin waste that can be reused by the food and pharmaceutical industry as a nutraceutical or food supplement to increase the nutritional value of food products. The method proposed in this work allows waste obtained from the grape production process to be processed in an accessible, cheap and reproducible way. In addition, the use of waste generated by the food industry can reduce environmental pollution and, consequently, guarantee better food and nutritional safety.

CONCLUSION

The result found in the skins of the variety *Vitis vinífera* L of Valley of São Francisco, indicates that the *trans*-resveratrol is present in a major quantity in skin of grape of the variety of color red. Highlighting still that in the study done it was identified a major quantity of this compound in variety “Rubi”, followed in a descending way by the following varieties: “Red globe”, “Patrícia” e “Itália”.

Comparing to other values obtained in this study and data from literature, it was observed that red grape produced in the Valley of São Francisco have content of resveratrol equivalent or superior to grapes produced in other regions of the world and it can indicate the use of skin of grape lyophilized as functional ingredient in foods in the portion of 36 to 38g of skins lyophilized, the equivalent of 1 mg of resveratrol.

As limitation of study, we can highlight that the extraction can not have removed all the trans-resveratrol from the skins of the varieties studied and that factors such as the weather, the composition of the soil, the presence of glycosides and the conditioning of the plant to infections and aggressions, can influence in the quantity of resveratrol.

This study points to the use of by-products from different grape varieties as sources of resveratrol and can be used to produce a functional ingredient. This means the exploration of resources of low cost, providing a positive economic and environmental impact. Using small amounts of grape skins can provide the recommended daily intake of these substances.

The variety of grape “Rubi” excelled by the presence of great quantities of resveratrol in its skin, highlighting the importance of detailed individual characterization of bioactive compounds, given that research in this format is scarce, especially in Brazil. More studies are necessary to verify the content of these substances in by-products of fruits and vegetables, encourage its use and analyze its effects on human health. Besides, tests on cells and animals can be necessary to verify its functional properties. The data obtained in this study add valuable information to the current knowledge about flavonoids in residues of Brazilian fruits and vegetables.

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