

EFFECT OF GALLIC ACID AND TANNIC ACID
ON THE ANTIOXIDANT ACTIVITY OF WHITE WINESZ. L. GRIGORYAN ^{1,2*}, H. A. SHILAJYAN ^{2,3**}, S. G. DEHERYAN ^{1***},
K. R. GRIGORYAN ^{1,2****}¹ Chair of Physical and Colloid Chemistry, YSU, Armenia² Laboratory of Physical Chemistry, Chemistry Research Center, YSU, Armenia³ Faculty of Chemistry, YSU, Armenia

The effect of gallic acid (GA) and tannic acid (TA) on the antioxidant activity of white wines was studied based on sensory, physicochemical and DPPH assay. It was shown that GA exhibits pronounced antioxidant activity ($R_s = 22.78\%$), while TA, at the same concentration, demonstrates a significantly stronger antioxidant effect ($R_s = 68.21\%$) without altering the sensory properties of the wine. These findings suggest that both phenolic acids, GA and TA, may serve as promising natural antioxidant additives for enhancing the oxidative stability and preserving the quality of white wines.

<https://doi.org/10.46991/PYSUB.2026.60.2.129>

Keywords: DPPH radical, antioxidant capacity, white wine, gallic acid, tannic acid.

Introduction. Foods and drinks rich in antioxidants (such as nuts, berries, citrus fruits, grapes, dark chocolate, brandy, and green tea) help to protect the body and brain against oxidative damage caused by free radicals. Aging and pathological conditions, including neurodegenerative disorders, cardiovascular diseases, cancer, and rheumatoid arthritis, are strongly associated with the oxidative stress, and the harmful effects of free radicals [1–5].

Among dietary sources of antioxidants, wines occupy a prominent position. Their antioxidant capacity primarily attributes to phenolic compounds, including both flavonoids and non-flavonoids, which also play a crucial role in determining the sensorial properties of wine, such as appearance, aroma taste and texture [6–8].

In recent years, interest in phenolic compounds in the wine industry has increased due to their significant influence on sensory characteristics (color, astringency, and bitterness), as well as their recognized health-promoting antioxidant activity. Polyphenols are present in both red and white wines; however, their concentrations are considerably higher in red wines. Consequently, red wines are generally considered to exert a greater protective effect on human health than white wines, largely due to the higher levels of antioxidant compounds extracted during the maceration process [9–12]. The enhancement of antioxidant and other quality-

* E-mail: zara.grigoryan@ysu.am

** E-mail: hshilajyan@ysu.am

*** E-mail: shushan.deheryan@ysu.am

**** E-mail: kara@ysu.am

related properties of premium wines, particularly dry white wines, using additives such as fining agents, preservatives, yeast derivatives, nutrients, and oak alternatives becomes especially critical when low levels of sulfur dioxide are applied [13–15].

Gallic acid (GA) and tannic acid (TA) can act as effective antioxidants that contribute to the astringency, bitterness and overall antioxidant capacity of wines. The molecular structure of these phenolic acids are presented in Fig. 1. These phytochemicals are mainly present in grape seeds and skins and can be recovered from grape pomace. In addition, they exhibit inhibitory effects against some microorganisms [16–18]. GA is a low-molecular-weight phenolic acid naturally occurring in tea, grapes, berries, oak bark, and many other plants. It contains three hydroxyl groups per molecule. TA is a considerably larger polyphenolic compound consisting of multiple GA units esterified to a glucose core and containing approximately 25 hydroxyl groups per molecule.

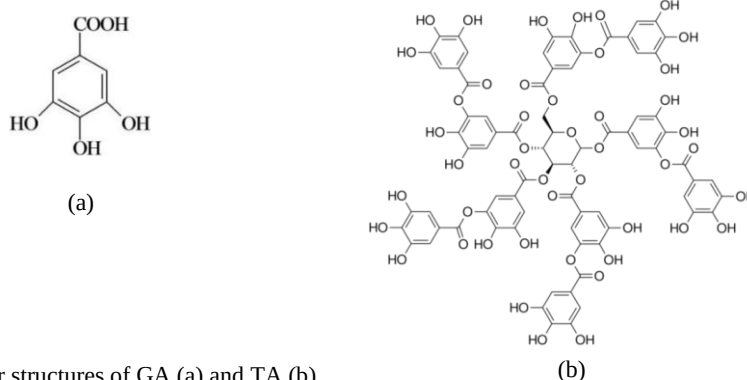


Fig. 1. Molecular structures of GA (a) and TA (b).

Under these conditions, protecting wine against oxidative spoilage using alternative additives remains a significant challenge. The aim of this study was to enhance the antioxidant activity of white wines through the addition GA and TA additives.

Materials and Methods.

Wines. Six commercial dry white wines bottled in 750 mL wine bottles and originated from different regions of Armenia, aged 3–5 years, were randomly selected for 1,1-diphenyl-2-picrylhydrazyl radicals (DPPH[•]) assays and stored at 4°C during the analysis. Prior to analysis, the wines were degassed with CO₂ (3 mL·min⁻¹) to remove free SO₂, as sulfites can react with DPPH[•] and artificially contribute to the measured antioxidant capacity of white wines [19] and filtered through a 450 nm syringe filter.

GA, TA, and DPPH[•] were purchased from “Sigma-Aldrich” (USA) and used without further purification. All other chemicals were of analytical grade.

UV/Vis Measurements. Electronic absorption spectra were registered using a Specord 50PC spectrophotometer (Germany) over the wavelength range of 200–600 nm at 25°C. The radical scavenging capacity (*R_s*, %) toward DPPH[•] was calculated by the following equation:

$$R_s = \frac{A_0 - A_s}{A_0} \cdot 100\%,$$

where A_0 represents the absorbance of the control (in the absence of antioxidant), and A_s is the absorbance in the presence of antioxidant.

Preparation of DPPH[•] Stock Solution. A stock solution of DPPH[•] was prepared in ethanol and the initial concentration of DPPH[•] was determined spectrophotometrically by measuring the absorbance at $\lambda = 515 \text{ nm}$ using UV/Vis spectroscopy and applying the molar absorption coefficient $\varepsilon = 12509 \text{ M}^{-1} \cdot \text{cm}^{-1}$ [20].

Preparation of the Stock Solutions of GA and TA and Samples. Stock solutions of antioxidants GA and TA were freshly prepared by dissolving accurately weighted amounts (0.02 g) of each compound in wine (20 mL). The samples were stirred for 30 min on a magnetic stirrer until a clear solution was obtained. The solutions were filtered, degassed, and stored at 4°C until use.

Sensory Analysis. Ten students (6 women and 4 men) from the fourth year of the Food Safety bachelor's program, aged 20–25 years, participated in the study. All participants were healthy, with no known chronic diseases or food allergies that could interfere with the experimental procedures. The study was conducted in accordance with the ethical guidelines for research involving human subjects.

Statistical Analysis. Six dry white wines for different vintages (3–5 years old) and regions of Armenia were selected for the analysis. All measurements were performed in triplicate, and the results were expressed as mean $\pm$ standard deviation.

The density (ρ) of wine solutions were measured using an Anton Paar DMA 4500 densimeter (Austria). Electroconductivity (κ) and pH were determined using a JENWAY 4330 instrument (Great Britain), while the refractive index (n) was measured using an IPR refractometer at 25°C.

Results and Discussion.

Sensory, Organoleptic, and Physicochemical Properties of Wine. The sensory and organoleptic properties of wine include appearance, aroma, taste, and texture (mouthfeel). These characteristics arise from the physicochemical properties of the wine, such as density, refractive index, conductivity and pH, which contribute to its overall quality, balance, and consumer acceptance [21]. The results of sensory analysis of wines in the presence of GA and TA are presented in Tab. 1, while the physicochemical parameters are summarized in Tab. 2.

Table 1

Sensory properties of white wines in the presence of GA and TA:
 $[GA] = [TA] = 0.5\text{--}4.8 \cdot 10^{-4} \text{ mol} \cdot \text{L}^{-1}$. Characteristics (GOST 32051-2013)

Sample	Sensory properties of white wines			
	appearance (color, clarity and intensity)	smell (smell, bouquet, fruit/floral/spicy notes)	taste (sweet, sour, bitter, salty)	texture/mouthfeel (body, viscosity, astringency, warmth from alcohol)
Wine	transparent, light yellow	floral	vanilla, caramel	slightly astringency
Wine-GA	reserved	reserved	reserved	reserved
Wine-TA	reserved	reserved	reserved	reserved
$GA > 6.0 \cdot 10^{-4} \text{ mol} \cdot \text{L}^{-1}$	not reserved	not reserved	not reserved	not reserved
$TA > 6.0 \cdot 10^{-4} \text{ mol} \cdot \text{L}^{-1}$	not reserved	not reserved	not reserved	not reserved

Table 2

Physicochemical parameters of the wines in the presence of GA and TA

White wine – Antioxidant			
Property	wine	GA	TA
Concentration, mol/L	0	$5.9 \cdot 10^{-2}$	$5.9 \cdot 10^{-3}$
Alcoholic strength	12.5%	12.5%	12.5%
Wine strength	12.5%	12.5%	12.5%
pH (± 0.01)	3.76	3.69	3.74
Refractive index, n_{25}	1.342	1.344	1.346
Density, $g \cdot cm^{-3}$ ($\pm 1 \cdot 10^{-5}$)	0.98897	0.98999	0.99892
κ , $mS \cdot cm^{-1}$ ($\pm 1 \cdot 10^{-4}$)	0.9220	1.8530	1.8380

From the results presented in Tab. 1, the sensory and organoleptic properties of the wine did not change in the presence of GA and TA at antioxidant concentrations $\leq 6.0 \cdot 10^{-4} \text{ mol} \cdot L^{-1}$. However, at higher concentrations of GA and TA, these properties were no longer reserved. As can be seen from Tab. 2, the physicochemical parameters of the white wines in the presence of GA and TA did not change noticeably, indicating that the overall properties of wines were reserved. The observed decrease in solution conductivity in the presence of GA and TA can be explained by the increased of chelating properties of these compounds.

Radical-Scavenging Activity. The DPPH $\cdot$ scavenging activity of antioxidants was monitored according to the method described in [22]. The absorbance of the DPPH $\cdot$, with an odd electron delocalized over the molecule, shows a strong absorption band at 515 nm in ethanol. The scavenging of free radicals by antioxidants is achieved by donating H-atom to form the stable DPPH-H molecule, which causes the decrease of absorbance due to color change from purple to yellow. The antioxidant activity of polyphenols largely depends on their ability to donate hydrogen atoms or electrons to neutralize free radicals. Owing to its multiple GA moieties and higher number of hydroxyl groups, TA generally exhibits greater antioxidant capacity than GA.

Table 3

Antioxidant activity values of white wine in the presence of GA and TA:
 $[DPPH\cdot] = 6.5 \cdot 10^{-5} \text{ mol} \cdot L^{-1}$, $V_{\text{sample}} = 3 \text{ mL}$

Wine, μL	C(GA/TA), $mol \cdot L^{-1}$	R_s , %	
		GA	TA
60	0	-15.66	-15.66
60	3.3	17.78	37.51
60	5.0	19.55	44.67
60	6.7	20.21	52.41
60	8.3	21.74	56.39
60	10.0	22.78	68.21

The results presented in Tab. 3 demonstrate that both GA and TA enhanced the radical scavenging activity of the wine, confirming their significant antioxidant potential. At lower additive concentrations, both compounds increased the antioxidant activity of the wine; however, TA exhibited a substantially greater effect

than GA throughout the entire concentration range studied. The stronger antioxidant activity of TA can be attributed to its molecular structure and higher number of hydroxyl groups. The larger number of hydroxyl groups in TA enhances its ability to donate hydrogen atoms or electrons to free radicals, thereby improving its radical scavenging capacity.

However, stronger antioxidant activity *in vitro* does not necessarily mean stronger biological activity. Due to its smaller molecular size, GA is more readily adsorbed and exhibits bioavailability than TA. Consequently, despite of its lower intrinsic antioxidant capacity, GA may exert greater antioxidant effects in biological systems, because it can more easily penetrate tissues and reach target sites. As it was shown in [22], duration of antioxidant action of GA and TA can be prolonged, when these phenolic acids form complexes with transport proteins.

Conclusion. Both GA and TA improved the antioxidant activity of white wines by enhancing their radical scavenging capacity without significantly affecting the sensory, organoleptic, or physicochemical properties of the wines. Among the studied additives, TA demonstrated significantly higher antioxidant effectiveness than GA, which can be attributed to its polyphenolic structure and greater number of hydroxyl groups. These findings indicate that TA, in particular, may serve as a promising natural antioxidant additive for improving the oxidative stability and quality preservation of white wines, especially under conditions of reduced sulfur dioxide application.

This work was supported by the Higher Education and Science Committee of the MESCS RA, in the frames of the research studies of the Chemical Research Center, Laboratory of Physical Chemistry (Research project YSU-CHEM).

Received 16.05.2026

Reviewed 19.06.2026

Accepted 03.07.2026

REFERENCES

1. Balakrishna R., Bjørnerud T., et al. Consumption of Nuts and Seeds and Health Outcomes Including Cardiovascular Disease, Diabetes and Metabolic Disease, Cancer, and Mortality. *An Umbrella Review Advances in Nutrition* **13** (2022), 2136–2148.
<https://doi.org/10.1093/advances/nmac077>
2. Zou Z., Xi W., et al. Antioxidant Activity of Citrus Fruits. *Food Chemistry* **196** (2015), 885–896.
<http://dx.doi.org/10.1016/j.foodchem.2015.09.072>
3. Kharadze M., Japaridze I., et al. Anthocyanins and Antioxidant Activity of Red Wines Made from Endemic Grape Varieties. *Annals of Agrarian Science* **16** (2018) 181–184.
<https://doi.org/10.1016/j.aasci.2018.04.006>
4. Aune D. Plant Foods, Antioxidant Biomarkers, and the Risk of Cardiovascular Disease, Cancer, and Mortality. A Review of the Evidence. *Adv. Nutr.* **10** (2019), 404–421.
<https://doi.org/10.1093/advances/nmz042>
5. Shilajyan H.A., Grigoryan K.R. The Impact of Aging on the Antioxidant Properties of Armenian Grape Brandies. *Proc. of the YSU. Chem. and Biol. Sci.* **58** (2024), 107–113 .
<https://doi.org/10.46991/PYSU:B.2024.58.2.107>

6. Ivanova-Petropulos V., Hermosin-Gutierrez I., et al. Phenolic Compounds and Antioxidant Activity of Macedonian Red Wines. *J. Food Comp. Anal.* **41** (2015), 1–14.
<https://doi.org/10.1016/j.jfca.2015.01.002>
7. López-Vélez M., Martínez-Martínez F., Del Valle-Ribes C. The Study of Phenolic Compounds as Natural Antioxidants in Wine. *Crit. Rev. Food Sci. Nutr.* **43** (2003), 233–244.
<https://doi.org/10.1080/10408690390826509>
8. Jakabová S., Fikselová M., Mendelová A., et al. Chemical Composition of White Wines Produced from Different Grape Varieties and Wine Regions in Slovakia. *Appl. Sci.* **11** (2021), 11059.
<https://doi.org/10.3390/app112211059>
9. Zanette T., Sant’Ana D. R., et al. Determination of the Antioxidant Activity of Red and White Wines Produced in Rio Grande do Sul, Brazil. *Inter. J. Current Res.* **8** (2016), 36710–36713.
10. Banc R., Loghin F., et al. Phenolic Composition and Antioxidant Activity of Red, Rosé and White Wines Originating from Romanian Grape Cultivars. *Notulae Botanicae Horti Agrobot Cluj-Napoca* **48** (2020), 716–734.
<https://doi.org/10.15835/nbha48211848>
11. Tekos F., Makri S., et al. Assessment of Antioxidant. and Antimutagenic Properties of Red and White Wine Extracts *in vitro*. *Metabolites* **11** (2021), 436.
<https://doi.org/10.3390/metabo11070436>
12. Radeka S., Rossi S., et al. Bioactive Compounds and Antioxidant Activity of Red and White Wines Produced from Autochthonous Croatian Varieties: Effect of Moderate Consumption on Human Health. *Food* **11** (2022), 1804.
<https://doi.org/10.3390/foods11121804>
13. Comuzzo P., Battistutta F., et al. Antioxidant Properties of Different Products and Additives in White Wine. *Food Chemistry* **168** (2015), 107–114.
<http://dx.doi.org/10.1016/j.foodchem.2014.07.028>
14. Romanet R., Coelho C., et al. The Antioxidant Potential of White Wines Relies on the Chemistry of Sulfur-Containing Compounds an Optimized DPPH Assay. *Molec.* **24** (2019), 1353.
<https://doi.org/10.3390/molecules24071353>
15. Seong H., Heo J., et al. Enhancing the Antioxidant Activities of Wines by Addition of White Rose Extract. *J. Microbiol. Biotech.* **27** (2017), 1602–1608.
<https://doi.org/10.4014/jmb.1704.04034>
16. Lopes J.C., Madureira J., et al. Grape Pomace: A Review of Its Bioactive Phenolic Compounds, Health Benefits, and Applications. *Molec.* **30** (2025), 362.
<https://doi.org/10.3390/molecules30020362>
17. Meini M-R., Cabezudo I., et al. Production of Grape Pomace Extracts with Enhanced Antioxidant and Prebiotic Activities Through Solid-State Fermentation by *Aspergillus niger* and *Aspergillus oryzae*. *Food Biosci.* **42** (2021), 101168.
<https://doi.org/10.1016/j.fbio.2021.101168>
18. Mohammed H.S. Inhibitory Effect of Tannic Acid Extracted from Grape Seeds and Pomegranate Peels on Some Microorganisms. *Mesop. J. Agric.* **36** (2008), 12–18.
<https://doi.org/10.33899/magrj.2008.26578>
19. Pegram Z., Kwasniewski M.T., Sacks G.L. Simplified Method for Free SO₂ Measurement Using Gas Detection Tubes. *Am. J. Enol. Vitic.* **64** (2013), 405–410.
<https://doi.org/10.5344/ajev.2013.13003>
20. Brand-Williams W., Cuvelier M.E., Berset C. Use of a Free Radical Method to Evaluate Antioxidant Activity. *LWT – Food Science and Technology* **28** (1995), 25–30.
<https://doi.org/0023-6438/95/010025>
21. Pérez-Navarro J., Izquierdo-Cañas P. M., et al. Comprehensive Chemical and Sensory Assessment of Wines Made from White Grapes of *Vitis vinifera* Cultivars Albillo Dorado and Montonera del Casar: A Comparative Study with Airén. *Foods* **9** (2020), 1282.
<https://doi.org/10.3390/foods9091282>
22. Grigoryan K., Shilajyan H., et al. Effect of Bovine Serum Albumin on Gallic Acid and Tannic Acid Radical Scavenging Properties and Binding Kinetics with 2,2-diphenyl-1-picrylhydrazyl. *Proc. Biochem.* **141** (2024), 30–38.
<https://doi.org/10.1016/j.procbio.2024.02.009>

2. Լ. ԳՐԻԳՈՐՅԱՆ, Հ. Ա. ՇԻԼԱԶՅԱՆ, Շ. Գ. ԴԵՀԵՐՅԱՆ, Կ. Ռ. ԳՐԻԳՈՐՅԱՆ

**ԳԱԼԱԹԹՎԻ ԵՎ ԴԱԲԱՂԱԹԹՎԻ ԱԶԴԵՑՈՒԹՅՈՒՆԸ
ՍՊԻՏԱԿ ԳԻՆԻՆԵՐԻ ՀԱԿԱՕՔՍԻԴԱՆՏԱՅԻՆ ԱԿՏԻՎՈՒԹՅԱՆ ՎՐԱ**

Գալաթթվի (ԳԹ) և դաբաղաթթվի (ԴԹ) ազդեցությունը սպիտակ գինիների հակաօքսիդանտային ակտիվության վրա ուսումնասիրվել է զգայական, ֆիզիկաքիմիական և DPPH անալիզների հիման վրա: Ցույց է տրվել, որ ԳԹ-ն ցուցաբերում է արտահայտված հակաօքսիդանտային ակտիվություն ($R_s = 22,78\%$), մինչդեռ նույն կոնցենտրացիայի դեպքում ԴԹ-ն ցուցաբերում է զգալիորեն ավելի ուժեղ հակաօքսիդանտային ակտիվություն ($R_s = 68,21\%$)՝ առանց գինու զգայական հատկությունների փոփոխության: Ստացված արդյունքները վկայում են, որ ԳԹ-ն և ԴԹ-ն կարող են ծառայել որպես խոստումնալից բնական հակաօքսիդանտային հավելանյութ՝ սպիտակ գինիների օքսիդատիվ կայունությունը և որակի պահպանումը բարելավելու համար:

3. Л. ГРИГОРЯН, А. А. ШИЛАДЖЯН, Ш. Г. ДЕГЕРЯН, К. Р. ГРИГОРЯН

**ВЛИЯНИЕ ГАЛЛОВОЙ И ДУБИЛЬНОЙ КИСЛОТ
НА АНТИОКСИДАНТНУЮ АКТИВНОСТЬ БЕЛЫХ ВИН**

Влияние галловой кислоты (ГК) и таниновой кислоты (ДК) на антиоксидантную активность белых вин было изучено с использованием сенсорного, физико-химического анализа и анализа DPPH. Было показано, что ГК проявляет выраженную антиоксидантную активность ($R_s = 22,78\%$), в то время как ДК при той же концентрации демонстрирует значительно более сильный антиоксидантный эффект ($R_s = 68,21\%$), не изменяя при этом органолептические свойства вина. Эти результаты указывают на то, что данные фенольные кислоты могут служить перспективной природной антиоксидантной добавкой для повышения окислительной стабильности и сохранения качества белых вин.