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Review

The High Dispersion of Phenolic Concentration in the Seeds, Skins and Wines of *Vitis vinifera* L. Cultivars Limits Comparative Analysis and Varietal Categorization Under Heterogeneous Conditions

Remigio López-Solís [1], Eliana Seguel-Rubio [2], Claudio Muñoz-Pérez [2], Mónica Vergara-López [3], Rocío Belmar-Díaz [2], Marcela Medel-Marabolí [2], Danilo Aros-Orellana [2], Jaime Laqui-Estaña [4,5] and Elías Obreque-Slier [2,*]

[1] Interdisciplinary Group of Cell Biology and Genetics, Faculty of Medicine–ICBM, University of Chile, Independencia 1027, Santiago 8380453, Chile; rlopez@med.uchile.cl
[2] Department of Agro–Industry and Enology, Faculty of Agronomical Sciences, University of Chile, Santa Rosa 11315, Santiago 8820808, Chile; eliseguel@gmail.com (E.S.-R.); claudio.munoz.perez@ug.uchile.cl (C.M.-P.); rociobelmardiaz@gmail.com (R.B.-D.); mmedel@uchile.cl (M.M.-M.); daros@uchile.cl (D.A.-O.)
[3] School of Technical Education, Faculty of Agricultural Sciences, University of Talca, Ramón Sanfurgo 980, Santa Cruz 3130000, Chile; movergara@utalca.cl
[4] Sensory Analysis and Consumer Study Group, Escuela Profesional de Ingeniería Agroindustrial, Universidad Nacional de Moquegua, Prolongación Calle Ancash s/n, Moquegua 18001, Peru; j272329@dac.unicamp.br
[5] Department of Food Science and Nutrition, School of Food Engineering, University of Campinas, Monteiro Lobato Street 80, Campinas 13083-862, São Paulo, Brazil
* Correspondence: eobreque@uchile.cl; Tel.: +562-229785730

Abstract

This comparative literature review evaluated the polyphenolic profiles in seeds, skins, and wines of nine *Vitis vinifera* L. cultivars. The data compilation revealed that total tannins and catechin exhibited comparatively more homogeneous phenolic profiles in seeds than skins, suggesting differential tissue regulation of specific phenolic biosynthetic pathways within the berry. However, this pattern did not extend to total phenols or epicatechin. Furthermore, the results confirmed wide inter- and intra-cultivar polyphenolic variations, with intra-cultivar dispersion frequently reaching a magnitude comparable to, or exceeding, that observed between cultivars. These variations are likely related to the multifactorial effect of environmental, genetic, and cultural contexts on polyphenol concentration in grapes and wines due to methodological differences (extraction protocols, various quantification techniques and winemaking practices) and biological factors (edaphic and climatic conditions). Furthermore, this high inter- and intra-cultivar variability leads to overlapping concentration ranges, preventing strict varietal categorization. This demonstrates that each study represents only a snapshot of specific environmental and agricultural conditions. Consequently, this review underscores that standardized analytical protocols, rigorous experimental designs, and robust biological replication are essential to distinguish between experimental noise and biological variability, reinforcing the value of comprehensive phenolic profiles for genotypic characterization and targeted winemaking decisions.

Keywords: tannin; anthocyanin; flavanol; grape seed; grape skin

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1. Introduction

Phenolic compounds are a group of secondary metabolites derived from plants that influence the chemical characteristics of *Vitis vinifera* grapes and have consequently been linked to wine quality [1,2]. The polyphenols present in the skins, seeds and stems (and even in the pulp of some red grape varieties) are extracted during the winemaking process [3,4] and contribute to various sensory characteristics of wines, such as color, aroma, astringency, and bitterness [1,3,5,6]. Furthermore, phenolic compounds are classified into two major groups: non-flavonoids (phenolic acids, cinnamic acids and stilbenes) and flavonoids (flavonols, anthocyanins, and flavanols or proanthocyanidins) [3,5]. Anthocyanins are the compounds responsible for the color of skins and wines, while flavanols are associated with astringency and bitterness. Finally, flavonols are thought to contribute to the color and bitterness of wines. Beyond their sensory relevance, these compounds are also widely recognized as major contributors to the antioxidant capacity of grapes and wine, a property inherent to their chemical structure, particularly the hydroxyl groups on the aromatic rings, which confer high free-radical scavenging and reducing capacity [1–10].

Various reports have highlighted the numerous factors that modulate the development and availability of polyphenols in grape skins, seeds, and wines [3,7–10]. A factor frequently reported in the literature links the effect of wine grape variety to the concentration of these polyphenols in grape tissues and, consequently, in wine [11–14]. Numerous studies have been designed under strict experimental and methodological conditions to comparatively evaluate the varietal factor, thereby controlling for other countless factors that could influence the concentration of this group of metabolites. Despite the above, comparative phenolic analysis of *Vitis vinifera* grapes and wines is not free of challenges, since, as previously noted, these vegetal metabolites are quantitatively modulated by multiple environmental and technological factors. This particular condition means that any variation in the experimental design affects the availability of these analytes and, consequently, makes it difficult to compare the phenolic profiles of the same variety grown at different growing latitudes and/or under various environmental and technological conditions. For this reason, this study proposes a comparative analysis of the phenolic composition in seeds, skins, and wines from nine *Vitis vinifera* L. varieties to determine the phenolic variability exhibited by these cultivars under broadly diverse conditions, which would consequently contribute to a better understanding of the behavior of these important secondary metabolites. Unlike previous reviews on grape and wine phenolics, this study integrates seed, skin, and wine data within the same analytical framework across nine internationally relevant cultivars, enabling direct cross-matrix comparisons that are rarely addressed jointly in the existing literature.

2. Materials and Methods

2.1. Literature Search and Study Selection

This study utilized various bibliographic resources obtained from Web of Science and Scopus (2005–2025). The search keywords were "phenolic," "polyphenols," "grape seeds," "grape skins," and "wines" combined with each cultivar name. For cultivars with recognized international synonyms, both the primary name and its synonym were used as search terms: 'Mourvèdre' OR 'Monastrell', 'Syrah' OR 'Shiraz', and 'Grenache' OR 'Garnacha'. No additional synonyms were searched for the remaining cultivars (Cabernet Sauvignon, Carménère, Malbec, Merlot, Sangiovese, and Tannat). Retrieved records were screened by title and abstract to identify studies reporting quantitative phenolic data (mean and standard deviation, or equivalent) for at least one of the three plant matrices (seeds, skins, or wine) in each of the nine cultivars. Claude Haiku 5.5 was used by some co-authors to help distinguish, among the retrieved scientific records, those that reported quantitative phenolic data for at least one of the three plant matrices. The AI-assisted screening results were

independently verified by the authors, and the final decisions regarding study inclusion and data extraction were made by the authors. Given the exploratory, comparative nature of this narrative review, database sources and inclusion/exclusion criteria described above are reported in full to support transparency and reproducibility. The methodology involved an initial stage of gathering information relevant to the stated objective. Next, studies were selected that had exclusively examined the phenolic content of the cultivars' seeds, skins, and wines. The selection of the nine cultivars included in this study, relative to a broader initial pool of candidate varieties considered during the literature search, was based on two combined criteria: (i) their recognized relevance and wide geographical distribution across major wine-producing countries, and (ii) the availability of a sufficient number of studies reporting quantitative phenolic data across all three plant matrices (seeds, skins, and wines) for the same cultivar. Other internationally relevant varieties were excluded from the final analysis due to an insufficient number of studies reporting data across all three matrices simultaneously, which would have precluded a balanced cross-matrix comparison for these cultivars. The final set of included studies was restricted to sources indexed in Web of Science and/or Scopus. Unpublished theses and other non-indexed grey literature were excluded from the final dataset to ensure methodological consistency with the stated search strategy.

2.2. Data Extraction

After conducting a thorough review of the available sources of information, the material was selected and classified. Quantitative data were obtained from articles that reported the mean ± standard deviation. Prior to compilation, all reported values were normalized to a common expression basis (fresh weight, whole-berry equivalent) and reference standard for each compound class to ensure comparability of the concentration ranges across studies employing different original units and calibration standards. Studies that did not report sufficient information to allow this conversion (e.g., lacking mean berry or seed weight, moisture content, or a clearly specified reference standard) were excluded from the final dataset; consequently, all values retained in the compiled dataset (Tables S1–S3, Supplementary Material) are expressed on a common, directly comparable basis. For articles that presented different treatments for the same variety and reported more than one mean ± standard deviation, the minimum and maximum values reported across the treatments were considered. In articles that reported only one mean ± standard deviation, the minimum value (mean − standard deviation) and the maximum value (mean + standard deviation) were calculated.

2.3. Cultivars

Data analysis and discussion were conducted on the phenolic composition (general and detailed) of nine *Vitis vinifera* L. varieties included in the study: Cabernet Sauvignon (CS), Merlot (ME), Carménère (CA), Syrah (SY), Malbec (MB), Sangiovese (SG), Tannat (TA), Mourvèdre (MV), and Grenache (GA). The selection of these nine cultivars, relative to a broader initial pool of candidate varieties considered during the literature search, was based on two combined criteria: (i) their recognized relevance and wide geographical distribution across major wine-producing countries, and (ii) the availability of a sufficient number of studies reporting quantitative phenolic data across all three plant matrices (seeds, skins, and wines) for the same cultivar. Other internationally relevant varieties were excluded from the final analysis due to an insufficient number of studies reporting data across all three matrices simultaneously, which would have precluded a balanced cross-matrix comparison for these cultivars. Finally, Mendeley software (version 1.19.8) was used to organize bibliographic references.

2.4. Statistical and Graphical Analysis

Box plots were constructed based on the individual data collected from the literature review for each cultivar (Figures 1–3). Each box represents the interquartile range (IQR), spanning from the first quartile (Q1) to the third quartile (Q3), which contains the central 50% of the data. The inner horizontal line represents the median, which was used as a measure of central tendency due to the asymmetry of the data. Potential outliers were identified using Tukey's criterion, with the lower and upper limits of the whiskers set at Q1 − 1.5 × IQR and Q3 + 1.5 × IQR, respectively. All analyses were performed using R software version 2026.05.0. To complement the graphical dispersion analysis, the coefficient of variation (CV) was calculated for each cultivar–compound combination as CV (%) = (standard deviation/mean) × 100, using the same set of individual compiled values from the literature underlying the box plots (Table S4, Supplementary Materials). Because these values originate from independent studies employing heterogeneous analytical protocols, extraction methods, and normalization procedures, the resulting CV reflects the combined contribution of true biological variability and inter-study methodological variability, and should be interpreted as a descriptive measure of overall dispersion rather than a precise estimate of intrinsic biological variance.

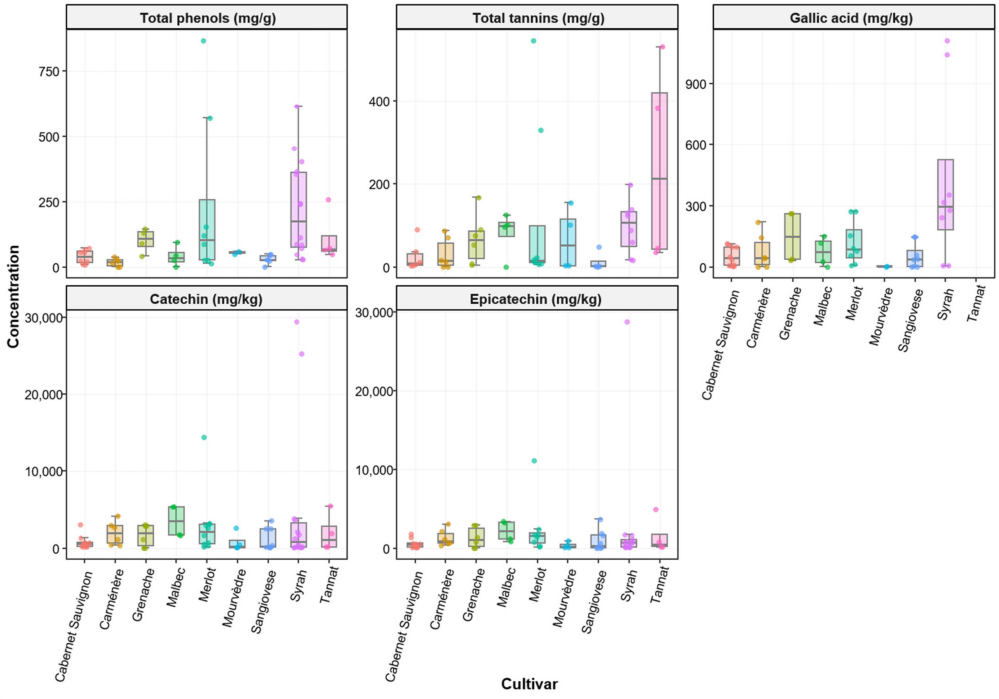


Figure 1. Box plots showing phenolic compound concentrations in the seeds of nine *Vitis vinifera* L. cultivars: total phenols, total tannins, and gallic acid (**upper** panels), and catechin and epicatechin (**lower** panels). Each box represents the interquartile range (IQR), the horizontal line indicates the median, and whiskers extend to 1.5 × IQR (Tukey's criterion). Points represent individual values from each compiled study. Color denotes cultivar only and carries no additional statistical information.

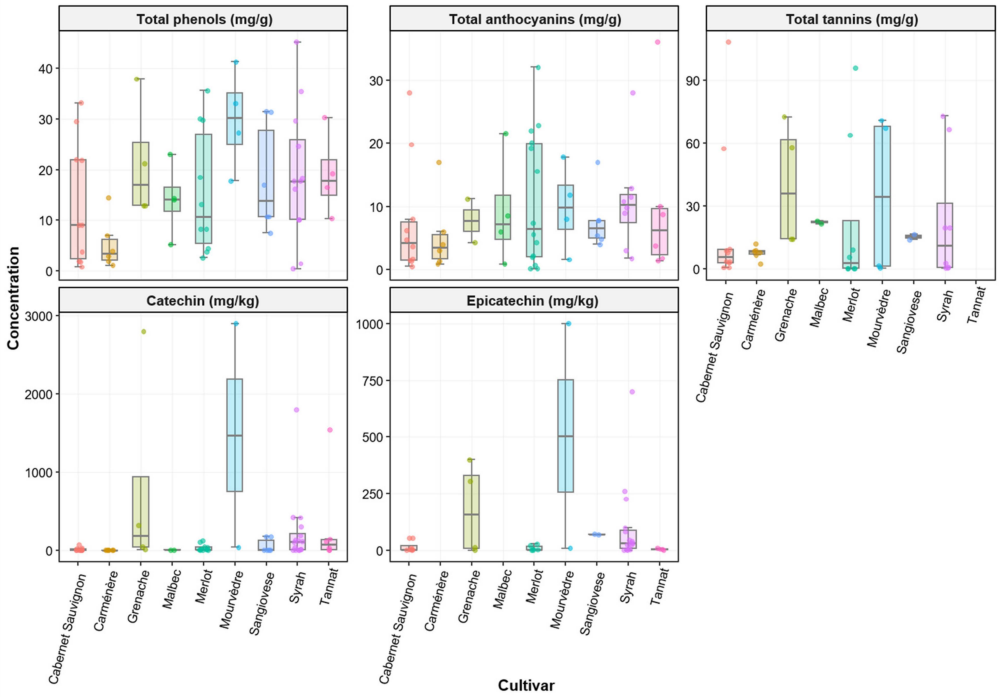


Figure 2. Box plots showing the phenolic compound concentrations in the skins of nine *Vitis vinifera* L. cultivars: total phenols, total anthocyanins, and total tannins (**upper** panels), and catechin and epicatechin (**lower** panels). Each box represents the interquartile range (IQR), the horizontal line indicates the median, and whiskers extend to 1.5 × IQR (Tukey's criterion). Points represent individual values from each compiled study. Color denotes cultivar only and carries no additional statistical information.

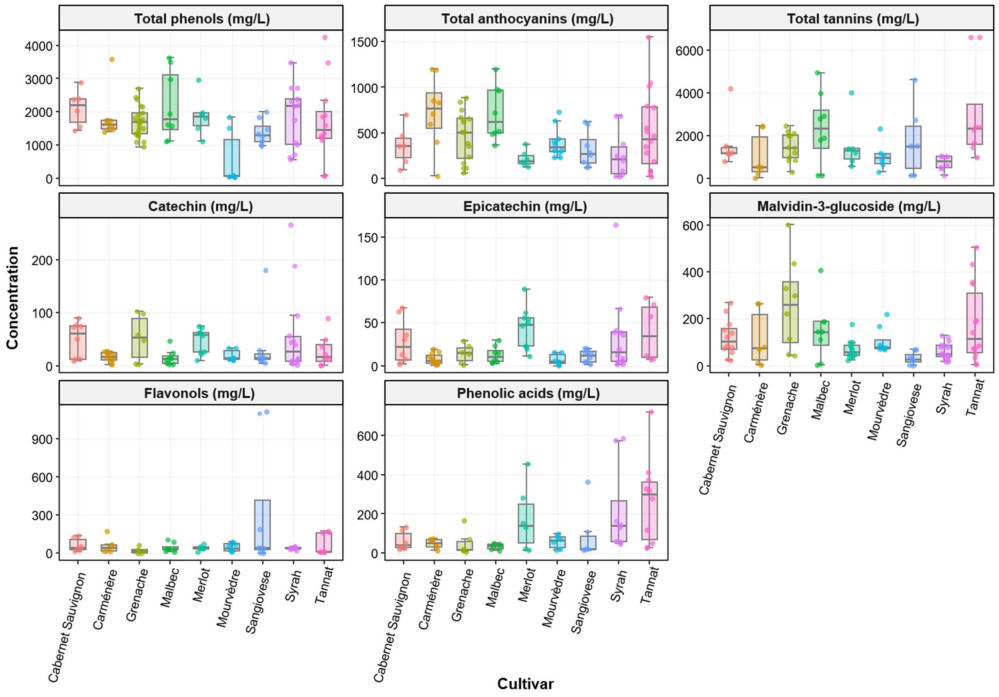


Figure 3. Box plots showing the phenolic compound concentrations in wines from nine *Vitis vinifera* L. cultivars: total phenols, anthocyanins, and tannins (**upper** panels); catechin, epicatechin, and malvidin-3-glucoside (**middle** panels); and flavonols and phenolic acids (**lower** panels). Each box represents the interquartile range (IQR), the horizontal line indicates the median, and whiskers extend to 1.5 × IQR (Tukey's criterion). Points represent individual values from each compiled study. Color denotes cultivar only and carries no additional statistical information.

3. Results and Discussion

This study conducted a comparative literature review of the concentrations of various phenolic compounds present in seeds, skins, and wines. To this end, we reviewed research conducted on nine wine grape varieties, which were selected for their iconic status and/or high relevance to the wine industry in wine-producing countries, such as France (Merlot), Spain (Grenache and Mourvèdre), Australia (Syrah), Argentina (Malbec), Italy (Sangiovese), Uruguay (Tannat), and Chile (Carménère). Cabernet Sauvignon, meanwhile, has traditionally been considered one of the most widely cultivated varieties in the world. Tables S1–S3 show (Supplementary Material) the content of the various phenolic compounds reported in seeds, skins, and wines from the different varieties considered in this study. Each Table indicates the phenolic parameter studied and the minimum and maximum levels reported by the various studies. Concurrently, the individual concentrations reported in different studies were plotted as box plots as previously described (Figures 1–3). Four central ideas emerged from this analytical study.

3.1. Polyphenol Biosynthesis Undergoes Compound-Specific Tissue Regulation

An initial observation derived from this study showed that compounds associated with condensed tannins exhibited comparatively more homogeneous profiles in seeds than in skins—total tannins (Coefficient of variation = 101.6% in seeds versus 125.2% in skins) and catechin (Coefficient of variation = 97.4% versus 124.9%)—consistent with a biosynthesis confined to the early stages of berry development (Table S4, Supplementary Material). However, this pattern was not observed for other compounds: total phenols showed slightly greater dispersion in seeds than in skins (Coefficient of variation = 65.9% versus 58.6%), as did epicatechin (Coefficient of variation = 101.9% versus 76.3%), while total anthocyanins could not be evaluated in seeds given their trace or absence in this tissue (Table S4, Supplementary Material). This suggests that tissue regulation of phenolic biosynthesis is not a uniform phenomenon across all polyphenol classes, but rather depends on the specific biosynthetic pathway and its activation timing during berry development, and that the biosynthesis and accumulation of these specific compounds may be subject to differential tissue regulation in the berry.

This phenomenon could be attributed to three non-mutually exclusive explanations: (1) The seed is an embryonic tissue whose phenolic composition may be primarily determined by genetically controlled developmental dynamics and less subject to the direct influence of external climatic factors. Conversely, the berry skin is in direct contact with the environment, serving as the main protective interface against solar radiation, ambient temperature, humidity, and fungal diseases, among other factors [15–17]. (2) The synthesis of condensed tannins in seeds occurs predominantly during the early stages of berry development and ceases prior to veraison [18,19], whereas phenolic synthesis in skins is modulated during late ripening [18,20–22]. (3) Genetic variability may exert a less pronounced phenotypic expression in seed phenolic biosynthesis if this pathway is governed by regulatory mechanisms that are more evolutionarily conserved. It should be noted that the number of independent studies (n) contributing to each cultivar–compound estimate ranged from 1 to 11, and CV estimates based on a low number of studies ($n \leq 2$) (Table S4, Supplementary Materials) should be interpreted with appropriate caution, as they are less robust indicators of true biological variability than those derived from larger study counts. More broadly, given that the compiled values originate from studies with heterogeneous methodologies (Section 2.4), the reported CVs should not be interpreted as precise measures of intrinsic biological variance, but rather as descriptive indicators of the overall dispersion observed across the compiled literature.

3.2. Grape Variety Influences Polyphenol Accumulation

A second observation supported by this study reinforces the traditional notion of "inter-cultivar variability" in the concentration of polyphenols in *Vitis vinifera* grapes and wines. For example, the Syrah variety stood out for having the highest average concentration of total phenols and gallic acid in seeds. Similarly, the Malbec variety had the highest average catechin and epicatechin content in seeds, while the Mourvèdre variety stood out for having the highest concentrations of total phenols, catechin, and epicatechin in skins. Taken together, these results for Syrah, Malbec, and Mourvèdre consistently position them as the genotypes reporting the highest phenolic values across multiple compounds in seeds and skins. This convergence across compounds, rather than an isolated pattern in a single parameter, suggests (though does not conclusively establish, given the methodological heterogeneity among the compiled studies) that grape variety may be an influential factor in polyphenolic accumulation in skins and seeds. Confirming this pattern as a genuine varietal characteristic, rather than an artifact of unevenly distributed methodological or environmental conditions across studies, would require standardized comparative trials under controlled growing and analytical conditions [10,14,23].

3.3. Polyphenol Concentrations Vary Widely Within Single Cultivars

A third observation resulting from this study would demonstrate the existence of a very wide "intra-cultivar" variation in polyphenol content in *Vitis vinifera* grapes and wines. For instance, Syrah seeds displayed a particularly broad dispersion in total phenols, with values ranging from 27.7 mg/g to values exceeding 600 mg/g within the same cultivar. This generated a considerably wider interquartile range than those observed in Cabernet Sauvignon or Merlot, which exhibited much more homogenous profiles. This example illustrates a broader pattern observed throughout this study: in several cultivar–compound combinations, the dispersion of values reported within a single cultivar was comparable to, or even exceeded, the differences observed between distinct cultivars, challenging the assumption that inter-cultivar comparison alone can reliably capture the true phenolic identity of a variety. A similar pattern was observed in the total tannin content of Merlot skins, where individual replicates were widely distributed between approximately 0.1 and 95.9 mg/g. In the case of Sangiovese wines, the most notable dispersion was recorded in phenolic acids, with a range of values spanning concentrations between 14.7 and 361.9 mg/L. This high phenolic dispersion in the same variety, which is represented in this study with several examples, would have its origin in the impact of multiple environmental and technological factors on the biosynthesis of these secondary metabolites [5,20,23–25]. Despite the high intra-cultivar variability observed in several phenolic compounds, one aspect that deserves particular attention beyond direct comparisons between cultivars is the recurrence of outliers observed in different tissues and cultivars throughout this study, for example, in Syrah seeds (total tannins, catechin and epicatechin) and also in the skins of Grenache, Syrah and Tannat (total anthocyanins, catechin and epicatechin). These and other exceptions appear to correspond to isolated events in specific samples, which could reflect a greater susceptibility of certain cultivars to specific management, environmental, or even clonal factors, rather than an intrinsically distinct tissue regulation. Furthermore, this pattern (where a cultivar presents individual replicates with extraordinarily high concentrations compared to samples from different studies) raises a relevant methodological/biological question that transcends the analysis of any single tissue. In any case, the distinction between these two possibilities (methodological or biological) cannot be resolved with the current study design; however, their identification is valuable for future research. Subsequent studies could benefit from a larger number of biological replicates per cultivar, as well as a more

detailed record of vineyard environmental conditions, in order to discriminate with greater certainty between experimental variability and true biological variation.

3.4. Multifactorial Contexts Restrict Varietal Comparison and Categorization

The three observational proposals described above together generate a highly relevant challenge that is the basis of this study: the multifactorial effect of environmental, genetic, and cultural contexts on polyphenolic concentrations in grapes and wines restricts the comparative analysis and categorization of distinct *Vitis vinifera* L. varieties. As previously mentioned, the concentration of polyphenols in seeds, skins, and wine is highly dependent on a wide range of factors, which can be classified into methodological and biological variables. From a methodological perspective, the analytical techniques used to determine these chemical compounds are highly diverse. In principle, these techniques include different analytical procedures for extracting these analytes from seeds and skins under varying operational conditions. Furthermore, there is a wide array of methodological proposals for the analysis and quantification itself. For instance, regarding the quantification of total phenols, two methodologies are widely used (absorbance at 280 nm and the Folin–Ciocalteu method [26]), whereas total tannin content is preferentially determined using the techniques proposed by Bate-Smith, Porter et al. and Mercurio et al. [27–29]. In the case of total anthocyanins, several other techniques are also frequently reported [30–33]. Likewise, the methodologies for detailed phenolic profiling are even more diverse. For example, for the determination of anthocyanin profiles, the proposals described by González-San José et al. [34], Carbonneau and Champagnol [35], Revilla et al. [36], Monagas et al. [37], Chira et al. [38], García-Marino et al. [39], Giuffré [40], Gori et al. [41], Gil et al. [42] and Gordillo et al. [43], among others, are available. Similarly, for the quantification of low-molecular-weight phenols, various numerous methodological approaches have been published [11,44–55]. Furthermore, in addition to spectrophotometric approaches, several of the compiled studies used chromatographic and mass spectrometry-based techniques (such as HPLC-DAD, LC-MS/MS, and UHPLC) for the detailed profiling of individual phenolic compounds, which differ substantially from spectrophotometric methods in sensitivity, selectivity, and quantification limits. Beyond the mere coexistence of these methodological approaches, it is relevant to briefly consider their comparative specificity and potential contribution to the observed inter-study variability. Spectrophotometric assays (e.g., Folin–Ciocalteu, absorbance at 280 nm) are rapid and widely accessible, but are inherently less specific: their absorbance-based readouts can be influenced by co-extracted non-phenolic compounds, potentially inflating reported concentrations in a manner that varies with sample matrix and extraction protocol. In contrast, chromatographic and mass spectrometry-based techniques allow the separation and identification of individual phenolic compounds, offering substantially higher specificity and lower susceptibility to matrix interference, but often at the cost of higher analytical complexity and cost, and with results that remain dependent on the reference standards and calibration curves. Consequently, part of the inter-study variability reported in this review is likely attributable not only to genuine biological or environmental differences, but also to the differential specificity and susceptibility to interference inherent to the analytical method employed in each study. A systematic comparison of the analytical performance of each technique is beyond the scope of this review. However, a dedicated comparative analysis of analytical methodologies applied to grape and wine phenolics—evaluating their relative sensitivity, reproducibility, and comparability of results—constitutes a valuable direction for future research. The availability of a very wide variety of methodologies is a relevant factor for research studying any variety. Nevertheless, the use of methodological protocols that employ different solvents, times, temperatures, and other experimental conditions hinders

contrasting comparative analyses. In any case, the high intra- and inter-cultivar dispersion reported in this study, which in several cases was of comparable or greater magnitude within a single cultivar than between different cultivars, reinforces the need for additional analytical verification either by evaluating potential cross-contamination or errors during analysis. Accordingly, in these cases, reanalysis of samples or use of a complementary analytical technique would be advisable before accepting the observed values as part of the natural biological variability of the cultivar. From a biological perspective, it cannot be ruled out that intra- and inter-cultivar phenolic differences reflect genuine phenomena of heterogeneity within and between cultivars. Nonetheless, mounting experimental evidence supports the significant impact on the synthesis of polyphenols displayed by diverse soil–climate and winemaking conditions, which can be grouped into edaphoclimatic conditions, enological–viticultural management practices, and grape variety [5,56,57]. In grapevine, it has been reported that soil nutrition [58–63], vineyard vigor [64], soil characteristics and water deficit [60,61,64–67], hormone levels [68–74], the presence of wounds and diseases [75,76], vineyard altitude [77,78], light intensity [66,79–83], temperature [66,84–87], and humidity [88,89] are crucial factors in the synthesis of polyphenols in berry seeds and skins. In addition, various factors impact the phenolic composition of wines, such as fermentation temperature, pressing intensity, pump-over frequency, maceration time supplementation with commercial tannins [90–92], barrel aging [93], wood format [94], oak species [95], wood toasting level [96–98], barrel age [99,100], aging time [101], and the specific wine variety destined for aging [94], among others. Furthermore, the present study revealed that the behavior of the polyphenolic matrix of one cultivar is not necessarily the same in another, because the transfer of polyphenols from skins and/or seeds to the wine is neither selective nor linear across cultivars. For example, Tannat and Grenache have the highest average values of total tannins in seeds and skins, but Malbec exhibits this same atypical pattern in wines. Similarly, Mourvèdre and Syrah show the highest concentrations of total phenols in seeds and skins, respectively, but Cabernet Sauvignon wine has the highest average values of these chemical compounds. This lack of direct correlation between matrices suggests that all aspects considered during polyphenol extraction during vinification decisively modulate which compounds ultimately predominate in the wine, regardless of their abundance in the raw material. In any case, differentiating between these perspectives (methodological or biological) is beyond the scope of this study, but it represents a relevant direction for future research, ideally incorporating stratified sampling by methodological and biological variables.

4. Future Projections on the Topic

These findings represent a step beyond simply confirming that environmental and methodological factors influence phenolic variability by providing a cross-matrix, multi-cultivar quantitative framework that demonstrates the practical limits of using phenolic content as a varietal descriptor, and by identifying which specific phenolic classes are more or less susceptible to this variability. We acknowledge as a limitation of this review that a systematic documentation of individual study characteristics (e.g., sample size, growing region, vintage, and analytical technique) was beyond its current scope. Compiling and cross-referencing this metadata across the full set of studies would represent a valuable extension for future, more granular syntheses of grape and wine phenolic variability. Finally, based on the methodological heterogeneity identified throughout this review, we propose the following minimum reporting checklist to improve the comparability of future studies on grape and wine phenolic composition: (a) analytical method and reference standard used for each compound class; (b) expression basis of reported values (for example fresh versus dry weight, per-berry, etc.); (c) sample size (number of biological replicates per

treatment/condition); (d) growing season in which samples were collected; (e) geographic origin and growing conditions; and (f) cultivar clone or accession and, when known, given potential intra-varietal genetic variability. Adoption of these minimum reporting elements would enable future comparative reviews to move beyond descriptive range compilation toward formal variance-partitioning analyses (e.g., mixed-effects models) capable of quantifying the relative contribution of varietal, environmental, and methodological sources to the observed phenolic variability.

5. Conclusions

In brief, the aforementioned background suggests that the high intra- and inter-varietal phenolic variability—with intra-cultivar variability frequently matching or surpassing inter-cultivar differences—creates a critical situation when comparative analyses are performed between wine grape varieties, since even minimal modifications to any viticultural and/or oenological condition can impact phenolic concentration. Thus, this multiplicity of factors involved in the synthesis of these metabolites would allow the generation of different phenolic matrices in grapes and wines, which would further contribute to the comparative problem of the same variety cultivated in different latitudes or under different oenological management. Furthermore, it is highly probable that subtractive, additive, and/or synergistic relationships (scarcely studied) exist among the various factors, potentially leading to highly specific phenolic expression and representing a significant derivative that would further exacerbate the problem addressed in this study. In parallel, the results of this study reveal a certain difficulty in classifying grape varieties according to their phenolic content, since the wide dispersion of these chemical compounds in grapes and wine generates a clear overlap in concentrations among varieties, preventing strict categorization. In summary, each research proposal would be a "snapshot" of a particular moment with specific environmental–agricultural conditions and should in no case be equated with other experimental conditions. Therefore, comparative studies that employ experimental designs with strict standardization of growing area conditions and/or winemaking practices to study one or more factors would contribute to clarifying the accumulation dynamics of these secondary metabolites, so relevant to wine production. Furthermore, phenolic quantification in different tissues of the grape cluster and wine reinforces the value of phenolic profiles as a tool for genotypic characterization and as an objective criterion for guiding winemaking decisions.

Supplementary Materials: The following supporting information can be downloaded at: https://www.mdpi.com/article/10.3390/antiox15101355/s1, Table S1. Concentration range of phenolic compounds in seeds of varieties of *Vitis vinifera* L. [7,9,14,38,71,91,102–124]; Table S2. Concentration range of phenolic compounds in skins of varieties of *Vitis vinifera* L. [3,7,14,24,102,103,105,107,119,120,123–137]; Table S3. Concentration range of phenolic compounds in wines of varieties of *Vitis vinifera* L. [6,104,118–120,125,130,136,138–196]; Table S4. Mean concentration, dispersion (SD) and coefficient of variation (CV) of phenolic compounds in seeds, skins and wine.

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References

1. Fanzone, M.; Peña-Neira, A.; Gil, M.; Jofré, V.; Assof, M.; Zamora, F. Impact of phenolic and polysaccharidic composition on commercial value of Argentinean Malbec and Cabernet Sauvignon wines. *Food Res. Int.* **2012**, *45*, 402–414. [CrossRef]
2. Portu, J.; Gutiérrez-Viguera, A.R.; González-Arenzana, L.; Santamaría, P. Characterization of the color parameters and monomeric phenolic composition of Tempranillo and Graciano wines made by carbonic maceration. *Food Chem.* **2023**, *406*, 134327. [CrossRef]
3. Obreque-Slier, E.; Peña-Neira, A.; López-Solís, R.; Cáceres-Mella, A.; Toledo-Araya, H.; López-Rivera, A. Phenolic composition of skins from four Carmenet grape varieties (*Vitis vinifera* L.) during ripening. *LWT Food Sci. Technol.* **2013**, *54*, 404–413. [CrossRef]
4. Fanzone, M.; Coronado, I.; Sari, S.; Catania, A.; Gil i Cortiella, M.; Assof, M.; Jofré, V.; Ubeda, C.; Peña-Neira, A. Microwave-assisted maceration and stems addition in Bonarda grapes: Effects on wine chemical composition over two vintages. *Food Res. Int.* **2022**, *156*, 111169. [CrossRef]
5. Teixeira, A.; Eiras-Dias, J.; Castellarin, S.D.; Gerós, H. Berry phenolics of grapevine under challenging environments. *Int. J. Mol. Sci.* **2013**, *14*, 18711–18739. [CrossRef]
6. Cáceres-Mella, A.; Ribalta-Pizarro, C.; Villalobos-González, L.; Cuneo, I.F.; Pastenes, C. Controlled water deficit modifies the phenolic composition and sensory properties in Cabernet Sauvignon wines. *Sci. Hortic.* **2018**, *237*, 105–111. [CrossRef]
7. Obreque-Slier, E.; Peña-Neira, A.; López-Solís, R.; Zamora-Marín, F.; Ricardo-da Silva, J.; Laureano, O. Comparative study of the phenolic composition of seeds and skins from Carménère and Cabernet Sauvignon grape varieties (*Vitis vinifera* L.) during ripening. *J. Agric. Food Chem.* **2010**, *58*, 3591–3599. [CrossRef]
8. González-Neves, G.; Charamelo, D.; Balado, J.; Barreiro, L.; Bochicchio, R.; Gatto, G.; Gil, G.; Tessore, A.; Carbonneau, A.; Moutounet, M. Phenolic potential of Tannat, Cabernet-Sauvignon and Merlot grapes and their correspondence with wine composition. *Anal. Chim. Acta.* **2004**, *513*, 191–196. [CrossRef]
9. Obreque-Slier, E.; López-Solís, R.; Castro Ulloa, L.; Romero-Díaz, C.; Peña-Neira, A. Phenolic composition and physicochemical parameters of Carménère, Cabernet Sauvignon, Merlot and Cabernet Franc grape seeds (*Vitis vinifera* L.) during ripening. *LWT-Food Sci. Technol.* **2012**, *48*, 134–141. [CrossRef]
10. Barreto de Oliveira, J.B.; Egipto, R.; Laureano, O.; de Castro, R.; Pereira, G.E.; Ricardo-da-Silva, J.M. Chemical composition and sensory profile of Syrah wines from semiarid tropical Brazil—Rootstock and harvest season effects. *LWT Food Sci. Technol.* **2019**, *114*, 108415. [CrossRef]
11. Santos-Buelga, C.; Francia-Aricha, E.; Escribano-Bailón, M.T. Comparative flavan-3-ol composition of seeds from different grape varieties. *Food Chem.* **1995**, *53*, 197–201. [CrossRef]
12. Fuleki, T.; Ricardo da Silva, J. Catechin and procyanidin composition of seeds from grape cultivars grown in Ontario. *J. Agric. Food Chem.* **1995**, *45*, 1156–1160.
13. Monagas, M.; Gómez-Cordovés, C.; Bartolomé, B.; Laureano, O.; Ricardo da Silva, J.M. Monomeric, oligomeric and polymeric flavan-3-ol composition of wines and grapes from *Vitis vinifera* L. cv. Graciano, Tempranillo, and Cabernet Sauvignon. *J. Agric. Food Chem.* **2003**, *51*, 6475–6481. [CrossRef]
14. Rodríguez-Montealegre, R.; Romero-Peces, R.; Chacón-Vozmediano, J.L.; Martínez-Gascueña, J.; Gárcia-Romero, E. Phenolic compounds in skins and seeds of ten grape *Vitis vinifera* varieties grown in a warm climate. *J. Food Compos. Anal.* **2006**, *19*, 687–693. [CrossRef]
15. Bustamante, M.; Gacía-Estevez, I.; Alcalde-Eon, C.; Fanzone, M.L.; Sari, S.; Escribano-Bailón, M.T.; Peña-Neira, A.; Gil i Cortiella, M. Phenolic composition and extractability of Chilean "Syrah" grapes and wines under contrasting climatic conditions. *J. Agric. Food Res.* **2026**, *28*, 102988. [CrossRef]
16. Gambetta, J.M.; Holzapfel, B.P.; Stoll, M.; Friedel, M. Sunburn in grapes: A review. *Front. Plant Sci.* **2021**, *11*, 604691. [CrossRef]
17. Herzog, K.; Wind, R.; Töpfer, R. Impedance of the grape berry cuticle as a novel phenotypic trait to estimate resistance to *Botrytis Cinerea*. *Sensors* **2015**, *15*, 12498–12512. [CrossRef]
18. Downey, M.O.; Harvey, J.S.; Robinson, S.P. Analysis of tannins in seeds and skins of Shiraz grapes through berry development. *Aust. J. Grape Wine Res.* **2003**, *9*, 15–27. [CrossRef]

19. Bogs, J.; Downey, M.O.; Harvey, J.S.; Ashton, A.R.; Tanner, G.J.; Robinson, S.P. Proanthocyanidin synthesis and expression of genes encoding leucoanthocyanidin reductase and anthocyanidin reductase in developing grape berries and grapevine leaves. *Plant Physiol.* **2005**, *139*, 652–663. [CrossRef]
20. Allegro, G.; Pastore, C.; Valentini, G.; Filippetti, I. The evolution of phenolic compounds in *Vitis Vinifera* L. red berries during ripening: Analysis and role on wine sensory—A review. *Agronomy* **2021**, *11*, 999. [CrossRef]
21. Matus, J.T.; Loyola, R.; Vega, A.; Peña-Neira, A.; Bordeu, E.; Arce-Johnson, P.; Alcalde, J.A. Post-veraison sunlight exposure induces MYB-mediated transcriptional regulation of anthocyanin and flavonol synthesis in berry skins of Vitis vinifera. *J. Exp. Bot.* **2009**, *60*, 853–867. [CrossRef]
22. Wang, J.; Wang, S.; Liu, G.; Edwards, E.J.; Duan, W.; Li, S.; Wang, L. The synthesis and accumulation of resveratrol are associated with veraison and abscisic acid concentration in Beihong (*Vitis vinifera* × *Vitis amurensis)* berry skin. *Front. Plant Sci.* **2016**, *3*, 1605. [CrossRef]
23. Pinasseau, L.; Vallverdú-Queralt, A.; Verbaere, A.; Roques, M.; Meudec, E.; Le Cunff, L.; Péros, J.-P.; Ageorges, A.; Sommerer, N.; Boulet, J.-C.; et al. Cultivar diversity of grape skin polyphenol composition and changes in response to drought investigated by LC-MS based metabolomics. *Front. Plant Sci.* **2017**, *8*, 1826. [CrossRef]
24. Lorrain, B.; Chira, K.; Teissedre, P.-L. Phenolic composition of Merlot and Cabernet-Sauvignon grapes from Bordeaux vineyard for the 2009-vintage: Comparison to 2006, 2007 and 2008 vintages. *Food Chem.* **2011**, *126*, 1991–1999. [CrossRef]
25. Shi, T.; Su, Y.; Lan, Y.; Duan, C.; Yu, K. The molecular basis of flavonoid biosynthesis response to water, light and temperature in grape berries. *Front. Plant Sci.* **2024**, *15*, 1441893. [CrossRef]
26. Singleton, V.L.; Orthofer, R.; Lamuela-Raventós, R.M. Analysis of total phenols and other oxidation substrates and antioxidants by means of Folin-Ciocalteu reagent. *Methods Enzymol.* **1999**, *299*, 152–178. [CrossRef]
27. Bate-Smith, E. Astringent tannins of the leaves of geranium species. *Phytochemistry* **1981**, *20*, 211–216. [CrossRef]
28. Porter, L.; Hritsch, N.; Chan, G. The conversion of procyanidins and prodelphinidins to cyanidin and delphinidin. *Phytochemistry* **1986**, *25*, 223–230. [CrossRef]
29. Mercurio, M.D.; Dambergs, R.G.; Herderich, M.J.; Smith, P.A. High throughput analysis of red wine and grape phenolics adaptation and validation of methyl cellulose precipitable tannin assay and modified somers color assay to a rapid 96 well plate format. *J. Agric. Food Chem.* **2007**, *55*, 4651–4657. [CrossRef]
30. Swain, T.; Hillis, E. The phenolic constituents of *Prunus domestica*. I.-The quantitative analysis of phenolic constituents. *J. Sci. Food Agric.* **1959**, *10*, 63–68. [CrossRef]
31. Ribéreau-Gayon, J.; Stonestreet, E. Le dosage des anthocyanes dans le vin rouge. *Bull. Soc. Chim.* **1965**, *9*, 2649–2652.
32. Paronetto, L. *Polifenoli e Tecnica Enológica*, 1st ed.; Edagricole: Bolognae, Italy, 1997.
33. Somers, T.C.; Evans, M.E. Spectral evaluation of young red wines: Anthocyanin equilibria, total phenolics, free and molecular SO_2, "chemical age". *J. Sci. Food Agric.* **1977**, *28*, 279–287. [CrossRef]
34. González-San José, M.; Diez, C.; Santa María, G.; Garrido, L. Análisis por cromatografía líquida de alta eficacia de los pigmentos antociánicos de uvas de *Vitis vinifera* L. *An. Quím.* **1988**, *84*, 290–293.
35. Carbonneau, A.; Champagnol, F. *Nouveaux Systèmes des Culture Intégrée du Vignoble*; Internal Report of Programme AIR-3-CT93; Institute Agro-Montpellier-Viticulture and Enology: Montpellier, France, 1993.
36. Revilla, E.; García-Beneytez, E.; Cabello, F.; Martin-Ortega, G.; Ryan, J.-M. Value of high-performance liquid chromatographic analysis of anthocyanins in the differentiation of red grape cultivar and red wines made from them. *J. Chromatogr. A* **2001**, *915*, 53–60. [CrossRef]
37. Monagas, M.; Núñez, V.; Bartolomé, B.; Gómez-Cordovés, C. Anthocyanin-derived pigments in Graciano, Tempranillo, and Cabernet Sauvignon wines produced in Spain. *Am. J. Enol. Vitic.* **2003**, *54*, 163–169. [CrossRef]
38. Chira, K.; Schmauch, G.; Saucier, C.; Fabre, S.; Teissedre, P.-L. Grape variety effect on proanthocyanidin composition and sensory perception of skin and seed tannin extracts from Bordeaux wine grapes (Cabernet Sauvignon and Merlot) for two consecutive vintages (2006 and 2007). *J. Agric. Food Chem.* **2009**, *57*, 545–553. [CrossRef]
39. García-Marino, M.; Hernández-Hierro, M.; Rivas-Gonzalo, C.; Escribano-Bailón, T. Colour and pigment composition of red wines obtained from co-maceration of Tempranillo and Graciano varieties. *Anal. Chim. Acta* **2010**, *660*, 134–142. [CrossRef]
40. Giuffrè, A.M. HPLC-DAD detection of changes in phenol content of red berry skins during grape ripening. *Eur. Food Res. Technol.* **2013**, *237*, 555–564. [CrossRef]
41. Gori, C.; Menichetti, S.; Fia, G. Multi-functional oenological machine and use in the oenological production chain. *Eur. Pat.* **2014**, *2*, 22.
42. Gil, M.; Pascual, O.; Gómez-Alonso, S.; García-Romero, E.; Hermosín-Gutiérrez, I.; Zamora, F.; Canals, J.M. Influence of berry size on red wine color and composition. *Aust. J. Grape Wine Res.* **2015**, *21*, 200–212. [CrossRef]
43. Gordillo, B.; Cejudo-Bastante, M.J.; Rodríguez-Pulido, F.J.; González-Miret, M.L.; Heredia, F.J. Application of the differential colorimetry and polyphenolic profile to the evaluation of the chromatic quality of Tempranillo red wines elaborated in warm climate. Influence of the presence of oak wood chips during fermentation. *Food Chem.* **2013**, *141*, 2184–2190. [CrossRef]

44. Ricardo-da-Silva, J.M.; Darmon, N.; Fernandez, Y.; Mitjavila, S. Oxygen free radical scavenger capacity in aqueous models of different procyanidins from grape seeds. *J. Agric. Food Chem.* **1991**, *39*, 1549–1552. [CrossRef]
45. Escribano-Bailón, T.; Gutiérrez-Fernández, Y.; Rivas-Gonzalo, J.C.; Santos-Buelga, C. Characterization of procyanidins of *Vitis vinifera* variety Tinta del Pais grape seeds. *J. Agric. Food Chem.* **1992**, *40*, 1794–1799. [CrossRef]
46. Vrhovsek, U.; Rigo, A.; Tonon, D.; Mattivi, F. Quantitation of polyphenols in different apple varieties. *J. Agric. Food Chem.* **2004**, *52*, 6532–6538. [CrossRef]
47. Monagas, M.; Bartolomé, B.; Gómez-Cordovés, C. Update knowledge about the presence of phenolic compounds in wine. *Crit. Rev. Food Sci. Nutr.* **2005**, *45*, 85–118. [CrossRef]
48. Guerrero, R.F.; Puertas, B.; Fernández, M.I.; Palma, M.; Cantos-Villar, E. Induction of stilbenes in grapes by UV-C: Comparison of different subspecies of *Vitis*. *Innov. Food Sci. Emerg. Technol.* **2010**, *11*, 231–238. [CrossRef]
49. Natić, M.M.; Dabić, D.C.; Papetti, A.; Fotirić Akšić, M.; Ognjanov, V.; Ljubojević, M.; Tešić, Z. Analysis and characterization of phytochemicals in mulberry (Morus alba L.) fruits grown in Vojvodina, North Serbia. *Food Chem.* **2015**, *171*, 128–136. [CrossRef]
50. Tomaz, I.; Maslov, L. Simultaneous determination of phenolic compounds in different matrices using phenyl-hexyl stationary phase. *Food Anal. Methods* **2016**, *9*, 401–410. [CrossRef]
51. Fontana, A.; Antoniolli, A.; Fernández, M.A.D.; Bottini, R. Phenolics profiling of pomace extracts from different grape varieties cultivated in Argentina. *RSC Adv.* **2017**, *7*, 29446–29457. [CrossRef]
52. Li, S.; Zhu, B.; Reeves, M.J.; Duan, C. Phenolic analysis and theoretic design for Chinese commercial wines' authentication. *J. Food Sci.* **2018**, *83*, 30–38. [CrossRef]
53. Loupit, G.; Prigent, S.; Franc, C.; De Revel, G.; Richard, T.; Cookson, J.; Fonayet, V. Polyphenol profiles of just pruned grapevine canes from wild Vitis accessions and *Vitis vinifera* cultivars. *J. Agric. Food Chem.* **2020**, *68*, 13397–13407. [CrossRef]
54. Da Costa, R.; Rodrigues, M.; De Vasconcelos, F.; Costa, D.; De Lima, C. Trellis systems, rootstock and season influence on the phenolic composition of 'Chenin Blanc' grape. *Sci. Agric.* **2020**, *77*, 20180207. [CrossRef]
55. Zhang, X.K.; Li, S.Y.; Zhao, X.; Pan, Q.H.; Shi, Y.; Duan, C.Q. HPLC-MS/MS based targeted metabolomic method for profiling of malvidin derivatives in dry red wines. *Food Res. Int.* **2020**, *134*, 109226. [CrossRef]
56. Van Leeuwen, C.; Roby, J.P.; de Rességuier, L. Soil-related terroir factors: A review. *Oeno One* **2018**, *52*, 2. [CrossRef]
57. Cataldo, E.; Eichmeier, A.; Mattii, G.B. Effects of global warming on grapevine berries phenolic compounds: A review. *Agronomy* **2023**, *13*, 2192. [CrossRef]
58. Keller, M. *The Science of Grapevine*, 4th ed.; Academic Press: Washington, DC, USA, 2025.
59. Kliewer, W. Influence of temperature, solar radiation and nitrogen on coloration and composition of Emperor grapes. *Am. J. Enol. Vitc.* **1977**, *28*, 96–103. [CrossRef]
60. Russell, E. *Soil Conditions and Plant Growth*, 1st ed.; Longmans: London, UK, 1961.
61. Marschner, H. *Mineral Nutrition of HIGHER Plants*, 2nd ed.; Academic Press: London, UK, 1995.
62. Delgado, R.; Martín, P.; del Álamo, M.; González, M. Changes in the phenolic composition of grape berries during ripening in relation to vineyard nitrogen and potassium fertilization rates. *J. Sci. Food Agric.* **2004**, *84*, 623–630. [CrossRef]
63. Jackson, D.; Lombard, P. Environmental and management practices affecting grape composition and wine quality: A review. *Am. J. Enol. Vitc.* **1993**, *44*, 409–430. [CrossRef]
64. Cortell, J.; Halbleib, M.; Gallagher, A.; Righetti, T.; Kennedy, J. Influence of vine vigor on grape (*Vitis vinifera* L. Cv. Pinot Noir) and wine proanthocyanidins. *J. Agric. Food Chem.* **2005**, *53*, 5798–5808. [CrossRef]
65. Nadal, M.; Arola, L. Effects of limited irrigation on the composition of must and wine of Cabernet sauvignon under semiarid conditions. *Vitis* **1995**, *34*, 151–154.
66. Downey, M.O.; Dokoozlian, N.K.; Krstic, M.P. Cultural practice and environmental impacts on the flavonoid composition of grapes and wine: A review of recent research. *Am. J. Enol. Vitc.* **2006**, *57*, 257–268. [CrossRef]
67. Jones, H. *Plants and Microclimate*, 3rd ed; Cambridge University Press: Cambridge, UK, 1992.
68. Matsushima, J.; Hiratsuka, S.; Taniguchi, N.; Wada, R.; Susaki, N. Anthocyanin accumulation and sugar content in the skin of grape cultivar Olympia treated with ABA. *J. Jpn. Soc. Hortic. Sci.* **1989**, *58*, 551–555. [CrossRef]
69. Dan, D.; Lee, C. The effects of GA3, CPPU and ABA applications on the quality of Kyoho (*Vitis vinifera* L. x Labrusca L.) grape. *Acta Hortic.* **2004**, *653*, 193–197. [CrossRef]
70. Jeong, S.; Goto-Yamamoto, N.; Kobayashi, S.; Esaka, M. Effects of plant hormones and shading on the accumulation of anthocyanins and the expression of anthocyanin biosynthetic genes in grape berry skins. *Plant Sci.* **2004**, *167*, 247–252. [CrossRef]
71. Deikman, J.; Hammer, P.E. Induction of anthocyanin accumulation by cytokinins in Arabidopsis thaliana. *Plant Physiol.* **1995**, *108*, 47–57. [CrossRef]
72. Davies, C.; Boss, P.K.; Robinson, S.P. Treatment of grape berries, a nonclimacteric fruit with a synthetic auxin, retards ripening and alters the expression of developmentally regulated genes. *Plant Physiol.* **1997**, *115*, 1155–1161. [CrossRef]
73. Chervin, C.; El-Kereamy1, A.; Roustana, J.; Latchéa, A.; Lamona, J.; Bouzayen, M. Ethylene seems required for the berry development and ripening in grape, a non-climacteric fruit. *Plant Sci.* **2004**, *167*, 1301–1305. [CrossRef]

74. Roubelakis-Angelakis, K.A.; Kliewer, W.M. Effects of exogenous factors on phenylalanine ammonia-lyase activity and accumulation of anthocyanins and total phenolics in grape berries. *Am. J. Enol. Vitc.* **1986**, *37*, 275–280. [CrossRef]
75. Langcake, P.; Pryce, R.J. The production of resveratrol and the viniferins by grapevines in response to ultraviolet irradiation. *Phytochemistry* **1977**, *16*, 1193–1196. [CrossRef]
76. Jeandet, P.; Bessis, R.; Maume, B.F.; Meunier, P.; Peyron, D.; Trollat, P. Effect of enological practices on the resveratrol isomer content of wine. *J. Agric. Food Chem.* **1995**, *43*, 316–319. [CrossRef]
77. Mateus, N.; Marques, S.; Gonçalves, A.C.; Machado, J.M.; De Freitas, V. Proanthocyanidin composition of red Vitis vinifera varieties from the Duoro Valley during ripening: Influence of cultivation altitude. *Am. J. Enol. Vitc.* **2001**, *52*, 115–121. [CrossRef]
78. Mateus, N.; Machado, J.M.; De Freitas, V. Development changes of anthocyanins in *Vitis vinifera* grapes grown in the Douro Valley and concentration in respective wines. *J. Sci. Food Agric.* **2002**, *82*, 1689–1695. [CrossRef]
79. Kliewer, W.M.; Torres, R.E. Effect of controlled day and night temperatures on grape coloration. *Am. J. Enol. Vitc.* **1972**, *23*, 71–77. [CrossRef]
80. Dokoozlian, N.; Kliewer, W. Influence of light on grape berry growth and composition varies during fruit development. *J. Amer. Soc. Hort. Sci.* **1996**, *121*, 869–874. [CrossRef]
81. Bergqvist, J.; Dokoozlian, N.; Ebisuda, N. Sunlight exposure and temperature effects on berry growth and composition of Cabernet sauvignon and Grenache in the Central San Joaquin Valley of California. *Am. J. Enol. Vitc.* **2001**, *52*, 1–7. [CrossRef]
82. Spayd, S.; Tarara, J.; Mee, D.; Ferguson, J. Separation of sunlight and temperature effects on the composition of *Vitis vinifera* cv. Merlot berries. *Am. J. Enol. Vitc.* **2002**, *53*, 171–181. [CrossRef]
83. Downey, M.O.; Harvey, J.S.; Robinson, S.P. The effect of bunch shading on berry development and flavonoid accumulation in Shiraz grapes. *Aust. J. Grape Wine Res.* **2004**, *10*, 55–73.
84. Buttrose, M.S.; Hale, C.R.; Kliewer, W.M. Effect of temperature on the composition of Cabernet Sauvignon berries. *Am. J. Enol. Vitc.* **1971**, *22*, 71–75. [CrossRef]
85. Mori, K.; Sugaya, S.; Gemma, H. Decreased anthocyanin biosynthesis in grape berries grown under elevated night temperature condition. *Sci. Hortic.* **2005**, *105*, 319–330. [CrossRef]
86. Ferrini, F.; Mattii, G.B.; Nicese, F.P. Effect of temperature on key physiological responses of grapevine leaf. *Am. J. Enol. Vitc.* **1995**, *46*, 375–379. [CrossRef]
87. Coombe, B.G. Influence of temperature on composition and quality of grapes. *Acta Hortic.* **1987**, *206*, 23–35. [CrossRef]
88. Haselgrove, L.; Botting, D.; Van Heeswijck, R.; Hoj, P.; Dry, P.; Ford, C.; Land, P.G.I. Canopy microclimate and berry composition: The effect of bunch exposure on the phenolic composition of *Vitis vinifera* L cv. Shiraz grape berries. *Aust. J. Grape Wine Res.* **2000**, *6*, 141–149. [CrossRef]
89. Vogt, T.; Pollak, P.; Tarlyn, N.; Taylor, L. Pollination or wound-induced kaempferol accumulation in petunia stigmas enhances seed production. *Plant Cell* **1994**, *6*, 11–23. [CrossRef]
90. Manns, D.C.; Lenerz, C.T.M.C.; Mansfield, A.K. Impact of processing parameters on the phenolic profile of wines produced from hybrid red grapes Marechal Foch, Corot noir, and Marquette. *J. Food Sci.* **2013**, *78*, C696–C702. [CrossRef]
91. Aleixandre, J.L.; du Toit, W. The role of UV-Visible spectroscopy for phenolic compounds quantification in winemaking. In *Frontiers and New Trends in the Science of Fermented Food and Beverages*; IntechOpen: London, UK, 2018.
92. Wojdyło, A.; Samoticha, J.; Chmielewska, J. Effect of different pre-treatment maceration techniques on the content of phenolic compounds and color of Dornfelder wines elaborated in cold climate. *Food Chem.* **2021**, *339*, 127888. [CrossRef]
93. Lei, Z.; Jervis, J.; Helm, R.F. Use of methanolysis for the determination of total ellagic and gallic acid contents of wood and food products. *J. Agric. Food Chem.* **2001**, *49*, 1165–1168. [CrossRef]
94. Laqui-Estaña, J.; López-Solís, R.; Peña-Neira, A.; Medel-Marabolí, M.; Obreque-Slier, E. Wines in contact with oak wood: The impact of the variety (Carménere and Cabernet Sauvignon), format (barrels, chips and staves), and aging time on the phenolic composition. *J. Sci. Food Agric.* **2018**, *99*, 436–448. [CrossRef]
95. Del Álamo-Sanza, M.; Nevares, I. Oak wine barrel as an active vessel: A critical review of past and current knowledge. *Crit. Rev. Food Sci. Nutr.* **2018**, *58*, 2711–2726. [CrossRef]
96. Cadahía, E.; Fernández de Simón, B.; Proveda, P.; Del Álamo-Sanza, M. *Utilización de Quercus Pirenaica Willd. De Castilla y León en el Envejecimiento de Vinos. Comparación Con Roble Francés y Americano*; Monografía Serie Forestal; Instituto Nacional de Investigación y Tecnología Agraria y Alimentaria (INIA): Madrid, Spain, 2008; Volume 18.
97. Cadahía, E.; Fernández de Simón, B.; Proveda, P.; Del Álamo-Sanza, M.; Colio, J. Chemical and chromatic characteristics of Tempranillo, Cabernet Sauvignon and Merlot wines from DO Navarra aged in Spanish and French oak barrels. *Food Chem.* **2009**, *115*, 639–649. [CrossRef]
98. Rubio-Bretón, P.; Garde-Cerdán, T.; Martínez, J. Use of oak fragments during the aging of red wines. Effect on the phenolic, aromatic, and sensory composition of wines as a function of the contact time with wood. *Beverages* **2018**, *4*, 102. [CrossRef]
99. Prida, A.; Puech, J.L. Ellagitannins in different oak species. *Vinodel./Vinograd.* **2002**, *5*, 24–25.

100. Michel, J.; Albertin, W.; Jourdes, M.; Le Floch, A.; Giordanengo, T.; Mourey, N.; Teissedre, P.L. Variations in oxygen and ellagitannins, and organoleptic properties of red wine aged in French oak barrels classified by a near infrared system. *Food Chem.* **2016**, *204*, 381–390. [CrossRef]
101. Rasines-Perea, Z.; Jacquet, R.; Jourdes, M.; Quideau, S.; Teissedre, P.L. Ellagitannins and flavanol-ellagitannins red wines tendency in different areas, barrel origin and ageing time in barrel and bottle. *Biomolecules* **2019**, *9*, 316. [CrossRef]
102. Pantelić, M.; Dabić Zagorac, D.; Davidović, S.; Todić, S.; Bešlić, Z.; Gašić, U.; Tešić, Ž.; Natić, M. Identification and quantification of phenolic compounds in berry skins, pulp, and seeds in 13 grapevine varieties grown in Serbia. *Food Chem.* **2016**, *211*, 243–252. [CrossRef]
103. Tahmaz-Karaman, H.; Küskü, D.Y.; Söylemezoglu, G. Phenolic compounds and antioxidant capacities in grape berry skin, seed and stems of six wine grape varieties grown in Turkey. *Acta Sci. Pol. Hortorum Cultus* **2021**, *20*, 5–25. [CrossRef]
104. Obreque-Slier, E.; Bravo-Reyes, V.; Maldonado-Maldonado, E.; López-Solís, R. Comparative profiling of small-sized phenolics throughout maturation in grape seeds of six *Vitis vinifera* L. red varieties grown under normalized ambient and viticultural conditions. *J. Food Compos. Anal.* **2023**, *116*, 105077. [CrossRef]
105. Ky, I.; Lorrain, B.; Kolbas, N.; Crozier, A.; Teissedre, P.-L. Wine by-products: Phenolic characterization and antioxidant activity evaluation of grapes and grape pomaces from six different French grape varieties. *Molecules* **2014**, *19*, 482–506. [CrossRef]
106. Luzio, A.; Bernardo, S.; Correia, C.; Moutinho-Pereira, J.; Dinis, L.-T. Phytochemical screening and antioxidant activity on berry, skins, pulp and seeds from seven red Mediterranean grapevines varieties (*Vitis vinifera* L.) treated with kaolin foliar sunscreen. *Sci. Hortic.* **2021**, *281*, 109962. [CrossRef]
107. Fanzone, M.; Zamora, F.; Jofre, V.; Assof, M.; Peña-Neira, A. Phenolic composition of Malbec grape skins and seeds from Valle de Uco (Mendoza, Argentina) during ripening. Effect of cluster thinning. *J. Agric. Food Chem.* **2011**, *59*, 6120–6136. [CrossRef]
108. Benbouguerra, N.; Richard, T.; Saucier, C.; Garcia, F. Voltametric behavior, flavanol and anthocyanin contents, and antioxidant capacity of grape skins and seeds during ripening (*Vitis vinifera* var. Merlot, Tannat, and Syrah). *Antioxidants* **2020**, *9*, 800. [CrossRef]
109. Ivanova, V.; Stefova, M.; Vojnoski, B.; Dörnyei, Á.; Márk, L.; Dmovska, V.; Stafilov, T.; Kilár, F. Identification of polyphenolic compounds in red and white grape varieties grown in R. Macedonia and changes of their content during ripening. *Food Res. Int.* **2011**, *44*, 2851–2860. [CrossRef]
110. Zhou, Y.; Su, P.; Yin, H.; Yang, Z.; Yuan, C. Effects of different harvest times on the maturity of polyphenols in two red wine grape cultivars (*Vitis vinifera* L.) in Qingtongxia (China). *S. Afr. J. Enol. Vitic.* **2019**, *40*, 2. [CrossRef]
111. Capozzi, A.; Dodouit, A.; Garcia, L.; Carnac, G.; Hugon, G.; Saucier, C.; Bisbal, C.; Lambert, K. Syrah grape polyphenol extracts protect human skeletal muscle cells from oxidative and metabolic stress induced by excess of palmitic acid: Effect of skin/seed ripening stage. *Antioxidants* **2024**, *13*, 373. [CrossRef]
112. Georgieva, P.; Ivanov, Y.; Chengolova, Z.; Nakov, G.; Godjevargova, T. Stability of individual phenolic compounds and antioxidant activity during storage of a syrah grape seed extract. *Processes* **2026**, *14*, 1721. [CrossRef]
113. Favre, G.; Gómez-Alonso, S.; Pérez-Navarro, J.; García-Romero, E.; Mena-Morales, A.; Piccardo, D.; Gonzalez-Neves, G. Seed and skin-derived flavanols in red wine: A study of Syrah, Marselan and Tannat cultivars. *Eur. Food Res. Technol.* **2023**, *250*, 845–857. [CrossRef]
114. Tița, O.; Lengyel, E.; Stegăruș, D.I.; Săvescu, P.; Ciubara, A.B.; Constantinescu, M.A.; Tița, M.A.; Rață, D.; Ciubara, A. Identification and quantification of valuable compounds in red grape seeds. *Appl. Sci.* **2021**, *11*, 5124. [CrossRef]
115. Dabetic, N.; Todorovic, V.; Malenovic, A.; Sobajic, S.; Markovic, B. Profiling of phenolic compound from red grape seed extracts using conventional and deep eutectic solvents. *Antioxidants* **2022**, *11*, 1595. [CrossRef]
116. Dudoit, A.; Benbouguerra, N.; Richard, T.; Hornedo-Ortega, R.; Valls-Fonayet, J.; Coussot, G.; Saucier, C. α-Glucosidase inhibitory activity of Tannat grape phenolic extracts in relation to their ripening stages. *Biomolecules* **2020**, *10*, 1088. [CrossRef]
117. Torchio, F.; Giacosa, S.; Río Segade, S.; Gerbi, V.; Rolle, L. Berry heterogeneity as a possible factor affecting the potential of seed mechanical properties to classify wine grape varieties and estimate flavanol release in wine-like solution. *S. Afr. J. Enol. Vitic.* **2014**, *35*, 20–42. [CrossRef]
118. Edo-Roca, M.; Nadal, M.; Sánchez-Ortiz, A.; Lampreave, M. Anthocyanin composition in Carignan and Grenache grapes and wines as affected by plant vigor and bunch uniformity. *OENO One* **2014**, *48*, 201–217. [CrossRef]
119. De Oliveira, J.B.; Egipto, R.; Laureano, O.; de Castro, R.; Pereira, G.E.; Ricardo-da-Silva, J.M. Climate effects on physicochemical composition of Syrah grapes at low and high-altitude sites from tropical grown regions of Brazil. *Food Res. Int.* **2019**, *121*, 870–879. [CrossRef]
120. Guchu, E.; Ebeler, S.; Lee, J.; Mitchell, A. Monitoring selected monomeric polyphenol composition in pre- and post-fermentation products of *Vitis vinifera* L. cv. Airén and cv. Grenache noir. *LWT Food Sci. Technol.* **2015**, *60*, 552–562. [CrossRef]
121. Guendez, R.; Kallithraka, S.; Makris, D.; Kafalsa, P. Determination of low molecular weight polyphenolic constituents in grape (*Vitis vinifera* sp.) seed extracts: Correlation with antiradical activity. *Food Chem.* **2005**, *1*, 1–9. [CrossRef]

122. Banjanin, T.; Özcan, M.M.; Al Juhaimi, F.; Ranković-Vasić, Z.; Uslu, N.; Mohamed, I.A.; Ghafoor, K.; Babiker, E.E.; Osman, M.A.; Gassem, M.A.; et al. Effect of varieties on bioactive compounds, fatty acids, and mineral contents in different grape seed and oils from Bosnia and Herzegovina. *J. Food Process Preserv.* **2019**, *43*, 13981. [CrossRef]
123. Macías-Gallardo, F.; Ramírez-Santoyo, L.F.; Miranda-Avilés, R.; Zanor, G.A.; Ozuna, C. Sustainable viticulture in Guanajuato (Central Mexico): Influence of agricultural management and soil composition on grape sugar and organic acid profiles. *Food Humanit.* **2025**, *5*, 100764. [CrossRef]
124. Boido, E.; García-Marino, M.; Dellacassa, E.; Carrau, F.; Rivas-Gonzalo, J.; Escribano-Bailón, M. Characterization and evolution of grape polyphenol profiles of Vitis vinifera L. cv. Tannat during ripening and vinification. *Aust. J. Grape Wine Res.* **2011**, *17*, 383–393. [CrossRef]
125. Pardo-García, A.I.; Mártinez-Gil, A.M.; Cadahía, E.; Pardo, F.; Alonso, G.L.; Salinas, M.R. Oak extract application to grapevines as a plant biostimulant to increase wine polyphenols. *Food Res. Int.* **2014**, *55*, 150–160. [CrossRef]
126. Obreque-Slier, E.; Herrera-Bustamante, B.; López-Solís, R. Ripening-associated flattening out of inter-varietal differences in some groups of phenolic compounds in the skins of six emblematic grape wine varieties. *J. Food Compos. Anal.* **2021**, *99*, 103858. [CrossRef]
127. Somkuwar, R.G.; Hakale, D.P.; Sharma, A.K. Studies on Biochemical of Different Parts of Berries and Wine Quality of Wine Varieties (*Vitis vinifera* L.). *Int. J. Curr. Microbiol. App. Sci.* **2019**, *8*, 155–164. [CrossRef]
128. Benbouguerra, N.; Valls-Fonayet, J.; Krisa, S.; Garcia, F.; Saucier, C.; Richard, T.; Hornedo-Ortega, R. Polyphenolic characterization of Merlot, Tannat and Syrah skin extracts at different degrees of maturity and anti-inflammatory potential in RAW 264.7 Cells. *Foods* **2021**, *10*, 541. [CrossRef]
129. Pantelić, M.; Dabić Zagorac, D.; Natić, M.; Gašić, U.; Jović, S.; Vujović, D.; Popović Djordjević, J. Impact of clonal variability on phenolics and radical scavenging activity of grapes and wines: A study on the recently developed Merlot and Cabernet Franc clones (*Vitis vinifera* L.). *PLoS ONE* **2016**, *11*, e0163823. [CrossRef]
130. Moreno-Olivares, J.D.; Paladines-Quezada, D.F.; Giménez-Bañón, M.J.; Cebrían-Pérez, A.; Férnandez-Férnandez, J.I.; Gómez-Martínez, J.C.; Bleda-Sánchez, J.A.; Gil-Muñoz, R. Cell Wall characterization of new Monastrell hybrid descendants and their phenolic wine composition. *Eur. Food Res. Technol.* **2022**, *248*, 1253–1265. [CrossRef]
131. Da Mota, R.; Angelucci, D.; Favero, C.; Purgatto, E.; Murillo de Albuquerque, R. Effect of trellising system on grape and wine composition of Syrah vines grown in the cerrado region of Minas Gerais. *Food Sci. Technol.* **2011**, *31*, 967–972. [CrossRef]
132. Wei, X.; Wang, W.; Min, Z.; Li, Z.; Ouyang, Y.; Ruan, X.; Fang, Y.; Li, D. Transcriptomics combined with metabolisms reveals the effect of light-exclusive films on the quality and polyphenols of 'Cabernet Sauvignon' grapes. *Food Res. Int.* **2023**, *170*, 112754. [CrossRef]
133. Ortega-Regules, A.; Romero-Cascales, I.; García, J.M.R.; Bautista-Ortín, A.B.; López-Roca, J.M.; Fernández-Fernández, J.I.; Gómez-Plaza, E. Anthocyanins and tannins in four grape varieties (*Vitis vinifera* L.) Evolution of their content and extractability. *J. Int. Sci. Vigne Vin.* **2008**, *42*, 147–156. [CrossRef]
134. Anić, M.; Osrečak, M.; Andabaka, Ž.; Tomaz, I.; Večenaj, Ž.; Jelić, D.; Kozina, B.; Kontić, J.K.; Karoglan, M. The effect of leaf removal on canopy microclimate, vine performance and grape phenolic composition of Merlot (*Vitis vinifera* L.) grapes in the continental part of Croatia. *Sci. Hortic.* **2021**, *285*, 110161. [CrossRef]
135. Shi, P.; Song, C.; Chen, H.; Duan, B.; Zhang, Z.; Meng, J. Foliar applications of iron promote flavonoids accumulation in grape berry of Vitis vinifera cv. Merlot grown in the iron deficiency soil. *Food Chem.* **2018**, *253*, 164–170. [CrossRef]
136. Filippetti, I.; Allegro, G.; Valentini, G.; Pastore, C.; Colucci, E.; Intrieri, C. Influence of vigour on vine performance and berry composition of cv. Sangiovese (Vitis vinifera L.). *OENO One* **2013**, *47*, 21–33. [CrossRef]
137. Chen, H.; Yang, J.; Deng, X.; Lei, Y.; Xie, S.; Guo, S.; Ren, R.; Li, J.; Zhang, Z.; Xu, T. Foliar-sprayed manganese sulfate improves flavonoid content in grape berry skin of Cabernet Sauvignon (*Vitis vinifera* L.) growing on alkaline soil and wine chromatic characteristic. *Food Chem.* **2020**, *314*, 126182. [CrossRef]
138. Van Leeuw, R.; Kevers, C.; Pincemail, J.; Defraigne, J.; Dommes, J. Antioxidant capacity and phenolic composition of red wines from various grape varieties: Specificity of Pinot Noir. *J. Food Compos. Anal.* **2014**, *36*, 40–50. [CrossRef]
139. Ju, Y.; Yang, L.; Yue, X.; Li, Y.; He, R.; Deng, S.; Yang, X.; Fang, Y. Anthocyanin profiles and color properties of red wines made from Vitis davidii and *Vitis vinifera* grapes. *Food Sci. Hum. Wellness* **2021**, *10*, 335–344. [CrossRef]
140. Vazallo-Valleumbrocio, G.; Medel-Marabolí, M.; Peña-Neira, A.; López-Solís, R.; Obreque-Slier, E. Commercial enological tannins: Characterization and their relative impact on the phenolic and sensory composition of Carménère wine during bottle aging. *Food Sci. Technol.* **2017**, *83*, 172–183. [CrossRef]
141. Zuñiga, M.; Pérez-Roa, R.; Olea-Azar, C.; Laurie, V.F.; Agosin, E. Contribution of metals, sulfur-dioxide and phenolic compounds to the antioxidant capacity of Carménère wine. *J. Food Comp. Anal.* **2014**, *35*, 37–43. [CrossRef]
142. López-Solís, R.; Cortés-Araya, K.; Medel-Marabolí, M.; Obreque-Slier, E. Different physicochemical interactions between varietal wines and human saliva: Correspondence with astringency. *Food Res. Int.* **2024**, *178*, 113964. [CrossRef]
143. Medel-Marabolí, M.; López-Solís, R.; Valenzuela-Prieto, D.; Vargas-Silva, S.; Obreque-Slier, E. Limited relationship between temporality of sensory-perception and phenolic composition of red wines. *LWT* **2021**, *142*, 111028. [CrossRef]

144. López-Giral, N.; González-Arenzana, L.; González-Ferrero, C.; López, R.; Santamaría, P.; López-Alfaro, I.; Garde-Cerdán, T. Pulsed electric field treatment to improve the phenolic compound extraction from Graciano, Tempranillo and Grenache grape varieties during two vintages. *Innov. Food Sci. Emerg. Technol.* **2015**, *28*, 31–39. [CrossRef]
145. Gombau, J.; Pons-Mercadé, P.; Conde, M.; Asbiro, L.; Pascual, O.; Gómez-Alonso, S.; García-Romero, E.; Canals, J.M.; Hermosín-Gutiérrez, I.; Zamora, F. Influence of grape seeds on wine composition and astringency of Tempranillo, Garnacha, Merlot and Cabernet Sauvignon wines. *Food Sci. Nutr.* **2020**, *8*, 3442–3455. [CrossRef]
146. Maza, M.A.; Martínez, J.M.; Hernández-Orte, P.; Cebrián, G.; Sánchez-Gimeno, A.C.; Álvarez, I.; Raso, J. Influence of pulsed electric fields on aroma and polyphenolic compounds of Garnacha wine. *Food Bioprod. Process.* **2019**, *116*, 249–257. [CrossRef]
147. Pascual, O.; Ortiz, J.; Roel, M.; Kontoudakis, N.; Gil, M.; Gómez-Alonso, S.; García-Romero, E.; Canals, J.M.; Hermosín-Gutíerrez, I.; Zamora, F. Influence of grape maturity and prefermentative cluster treatment of the Grenache cultivar on wine composition and quality. *OENO One* **2016**, *50*, 169–181. [CrossRef]
148. Diago, M.; Vilanova, M.; Blanco, J.; Tardaguila, J. Effects of mechanical thinning on fruit and wine composition and sensory attributes of Grenache and Tempranillo varieties (*Vitis vinifera* L.). *Aust. J. Grape Wine Res.* **2010**, *16*, 314–326. [CrossRef]
149. López-Giral, N.; López, R.; Santamaría, P.; González-Arenzana, L.; Garde-Cerdán, T. Phenolic and colour characteristics of must and wine obtained from red grapes treated by pulsed electric fields. Efficacy of PEF to reduce maceration time in elaboration of red wines. *Eur. Food Res. Technol.* **2022**, *249*, 273–282. [CrossRef]
150. Luengo, E.; Franco, E.; Ballesteros, F.; Álvarez, I.; Raso, J. Winery trial on application of pulsed electric fields for improving vinification of Garnacha grapes. *Food Bioprocess Technol.* **2014**, *7*, 1457–1464. [CrossRef]
151. López, N.; Puértolas, E.; Condón, S.; Álvarez, I.; Raso, J. Application of pulsed electric fields for improving the maceration process during vinification of red wine: Influence of grape variety. *Eur. Food Res. Technol.* **2008**, *227*, 1099–1107. [CrossRef]
152. Maza, M.A.; Pereira, C.; Martínez, J.M.; Camargo, A.; Álvarez, I.; Raso, J. PEF treatments of high specific energy permit the reduction of maceration time during vinification of Caladoc and Grenache grapes. *Innov. Food Sci. Emerg. Technol.* **2020**, *63*, 102375. [CrossRef]
153. Fanzone, M.; Peña-Neira, A.; Jofré, V.; Assof, M.; Zamora, F. Phenolic characterization of Malbec wines from Mendoza province (Argentina). *J. Agric. Food Chem.* **2010**, *58*, 2388–2397. [CrossRef]
154. Fanzone, M.; Peña-Neira, A.; Jofré, V.; Assof, M.; Zamora, F. Efecto de la técnica de sangrado sobre la composición fenólica de vinos cv. Malbec. *Rev. Fac. Cienc. Agrar.* **2013**, *45*, 199–209.
155. Osrečak, M.; Karoglan, M.; Kozina, B. Influence of leaf removal and reflective mulch on phenolic composition and antioxidant activity of Merlot, Teran and Plavac mali wines (*Vitis vinifera* L.). *Sci. Hortic.* **2016**, *209*, 261–269. [CrossRef]
156. Ntuli, R.; Saltman, Y.; Ponangi, R.; Jeffery, D.; Bindon, K.; Wilkinson, K. Impact of skin contact time. oak and tannin addition on the chemical composition, color stability and sensory profile of Merlot wines made from flash dètente treatment. *Food Chem.* **2023**, *405*, 134849. [CrossRef]
157. Gómez-Plaza, E.; Olmos, O.; Bautista-Ortín, A.B. Tannin profile of different Monastrell wines and its relation to projected market prices. *Food Chem.* **2016**, *204*, 506–512.
158. Becatti, E.; Genova, G.; Ranieri, A.; Tonutti, P. Postharvest treatments with ethylene on *Vitis vinifera* (cv Sangiovese) grapes affect berry metabolism and wine composition. *Food Chem.* **2014**, *159*, 257–266. [CrossRef]
159. Gordillo, B.; Chamizo-González, F.; González-Miret, M.L.; Heredia, F.J. Impact of alternative protein fining agents on the phenolic composition and color of Syrah red wines from warm climate. *Food Chem.* **2021**, *342*, 128297. [CrossRef]
160. Alves, C.A.N.; Biasoto, A.C.T.; Torres, L.H.P.d.S.; Corrêa, L.C.; Leão, P.C.d.S.; Barros, A.P.A.; de Vasconcelos, L.B. Chemical typicity of tropical Tannat red wines from sub-middle São Francisco Valley, Brazil. *J. Food Sci. Technol.* **2022**, *59*, 3578–3590. [CrossRef]
161. Bian, L.; Yu, X.; Zhang, Z.; Tong, Y.; Zhang, L.; Xu, Q.; Fu, J.; Wang, Q.; Zhao, W.; Wang, J.; et al. Mechanical summer pruning of "Syrah" grapes in arid and semi-arid regions: The impact of canopy thickness on grape and wine phenolic compounds. *Food Chem.* **2026**, *509*, 148640. [CrossRef]
162. Favre, G.; Peña-Neira, A.; Baldi, C.; Hernández, N.; Traverso, S.; Gil, G.; González-Neves, G. Low molecular-weight phenols in Tannat wines made by alternative winemaking procedures. *Food Chem.* **2014**, *158*, 504–512. [CrossRef]
163. Vidal, L.; Antúnez, L.; Giménez, A.; Medina, K.; Boido, E.; Ares, G. Sensory characterization of the astringency of commercial Uruguayan Tannat wines. *Food Res. Int.* **2017**, *102*, 425–434. [CrossRef]
164. González-Neves, G.; Favre, G.; Piccardo, D.; Ferrer, M.; Echeverría, G. Efecto de técnicas alternativas de maceración sobre el color y composición de vinos tintos de seis variedades de uva. *Agrociencia* **2015**, *19*, 1. [CrossRef]
165. Piccardo, D.; Favre, G.; Pascual, O.; Miquel-Canals, J.; Zamora, F.; González-Neves, G. Influence of the use of unripe grapes to reduce ethanol content and pH on the color, polyphenol and polysaccharide composition of conventional and hot macerated Pinot Noir and Tannat wines. *Eur. Food Res. Technol.* **2019**, *245*, 1321–1335. [CrossRef]
166. Ren, R.; Shi, J.; Zeng, M.; Tang, Z.; Xie, S.; Zhang, Z. Inter-and intra-varietal genetic variations co-shape the polyphenol profiles of *Vitis vinifera* L. grapes and wines. *Food Chem. X* **2023**, *20*, 101030. [CrossRef]
167. Casassa, L.F.; Fanzone, M.L.; Sari, S.E. Comparative phenolic, chromatic and sensory composition of five monovarietal wines processed with microwave technology. *Heliyon* **2022**, *8*, e12332. [CrossRef]

168. Li, R.; Yang, D.; Li, Z.; Tang, X.; Zhong, K.; Ding, Y.; Han, X.; Guan, X.; Sun, Y. The effect of stem contact fermentation on the quality of Cabernet Sauvignon and Merlot wines from Yantai, China. *Food Biosci.* **2025**, *64*, 105872. [CrossRef]
169. Álvarez, I.; Aleixandre, J.; García, M.; Lizama, V. Impact of prefermentative maceration on the phenolic and aromatic compounds in Monastrell red wines. *Anal. Chim. Acta* **2006**, *563*, 109–115. [CrossRef]
170. Martínez-Moreno, A.; Pérez, E.; López, R.; Paladines, D.; Moreno, D.; Intrigliolo, D.; Gil, R. Effects of deficit irrigation with saline water on wine color and polyphenolic composition of Vitis vinifera L. cv. Monastrell. *Sci. Hortic.* **2021**, *283*, 110085. [CrossRef]
171. Romero, P.; Gil, R.; del Amor, F.; Valdés, E.; Fernández, J.; Martínez, A. Regulated deficit irrigation based upon optimum water status improves phenolic composition in Monastrell grapes and wines. *Agric. Water Manag.* **2013**, *121*, 85–101. [CrossRef]
172. Romero, P.; Gil, R.; Fernández, J.; del Amor, F.; Martínez, A.; García, J. Improvement of yield and grape and wine composition in field-grown Monastrell grapevines by partial root zone irrigation, in comparison with regulated deficit irrigation. *Agric. Water Manag.* **2015**, *149*, 55–73. [CrossRef]
173. Rinaldi, A.; Louazil, P.; Iturmendi, N.; Moire, V.; Moio, L. Effect of marc pressing and geographical area on Sangiovese wine quality. *LWT* **2020**, *118*, 108728. [CrossRef]
174. Vidal, L.; Antúnez, L.; Rodriguez-Haralambides, A.; Giménez, A.; Medina, K.; Boido, E.; Ares, G. Relationship between astringency and phenolic composition of commercial Uruguayan Tannat wines: Application of boosted regression trees. *Food Res. Int.* **2018**, *112*, 25–37. [CrossRef]
175. De Andrade, R.H.S.; Do Nascimento, L.S.; Pereira, G.E.; Hallwass, F.; Silveira Paim, A.P. Anthocyanic composition of Brazilian red wines and use of HPLC-UV–Vis associated to chemometrics to distinguish wines from different regions. *Microchem. J.* **2013**, *110*, 256–262. [CrossRef]
176. González-Neves, G.; Franco, J.; Barreiro, L.; Gil, G.; Moutounet, M.; Carbonneau, A. Varietal differentiation of Tannat, Cabernet-Sauvignon and Merlot grapes and wines according to their anthocyanic composition. *Eur. Food Res. Technol.* **2007**, *225*, 111–117. [CrossRef]
177. Song, L.; Sun, X.; Shi, B.; Yang, W.; Ma, W. Chemosensory analysis of condensed tannins and their astringency perception in Marselan, Cabernet Sauvignon and Merlot red wines during winemaking. *LWT* **2024**, *212*, 116983. [CrossRef]
178. Casassa, L.F.; Bolcato, E.A.; Sari, S.E.; Barda, N. Effects of maceration length after prefermentative cold soak: Detailed chromatic, phenolic and sensory composition of Cabernet Sauvignon, Malbec, and Merlot wines. *J. Food Compos. Anal.* **2021**, *104*, 104168. [CrossRef]
179. Belmiro, T.M.C.; Fernandes, C.; Silveira, P. Red wines from South America: Content of phenolic compounds and chemometric distinction by origin. *Microchem. J.* **2017**, *133*, 114–120. [CrossRef]
180. Tong, W.; Sun, B.; Ling, M.; Zhang, X.; Yang, W.; Shi, Y.; Pan, Q.; Duan, C.; Lan, Y. Influence of modified carbonic maceration technique on the chemical and sensory characteristics of Cabernet Sauvignon wines. *Food Chem.* **2023**, *403*, 134341. [CrossRef]
181. Lingua, M.S.; Fabani, M.P.; Wunderlin, D.A.; Baroni, M.V. From grape to wine: Changes in phenolic composition and its influence on antioxidant activity. *Food Chem.* **2016**, *208*, 228–238. [CrossRef]
182. Valentin, L.; Barroso, L.P.; Barbosa, R.M.; de Paulo, G.A.; Castro, I.A. Chemical typicality of South American red wines classified according to their volatile and phenolic compounds using multivariate analysis. *Food Chem.* **2020**, *302*, 125340. [CrossRef]
183. López-Solís, R.; Osorio-Umaña, P.; Medel-Marabolí, M.; Obreque-Slier, E. Comparative analysis of the evolution of phenolic profiles during wood aging of a Carménère wine using novel products or procedures aimed at re-using oak barrels. *Food Biosci.* **2024**, *57*, 103623. [CrossRef]
184. Da Costa, N.; Valentin, L.; Alves-Castro, I.; Melgaco, R. Predictive modeling for wine authenticity using a machine learning approach. *Artif. Intell. Agric.* **2021**, *5*, 157–162. [CrossRef]
185. Marquez, A.; Serratosa, M.P.; López-Toledano, A.; Merida, J. Colour and phenolic compounds in sweet red wines from Merlot and Tempranillo grapes chamber-dried under controlled conditions. *Food Chem.* **2012**, *130*, 111–120. [CrossRef]
186. Bautista-Ortín, A.B.; Romero-Cascales, I.; Fernández-Fernández, J.I.; López-Roca, J.M.; Gómez-Plaza, E. Influence of the yeast strain on Monastrell wine colour. *Innov. Food Sci. Emerg. Technol.* **2007**, *8*, 322–328. [CrossRef]
187. Tessarin, P.; Chinnici, F.; Donnini, S.; Liquori, E.; Ripon, C.; Rombolà, A.D. Influence of canopy-applied chitosan on the composition of organic cv Sangiovese and Cabernet Sauvignon berries and wines. *Food Chem.* **2016**, *210*, 512–519. [CrossRef]
188. Parpinello, G.P.; Rombolà, A.D.; Simoni, M.; Versari, A. Chemical and sensory characterization of Sangiovese red wines: Comparison between biodynamic and organic management. *Food Chem.* **2015**, *167*, 145–152. [CrossRef]
189. Urvieta, R.; Buscema, F.; Bottini, R.; Coste, B.; Fontana, A. Phenolic and sensory profiles discriminate geographical indications for Malbec wines from different regions of Mendoza, Argentina. *Food Chem.* **2018**, *265*, 120–127. [CrossRef]
190. Gómez-Míguez, M.; González-Miret, M.L.; Heredia, F.J. Evolution of colour and anthocyanin composition of Syrah wines elaborated with pre-fermentative cold maceration. *J. Food Eng.* **2007**, *79*, 271–278. [CrossRef]
191. Gordillo, B.; Rivero, F.J.; Jara-Palacios, M.J.; González-Miret, M.L.; Heredia, F.J. Impact of a double post-fermentative maceration with ripe and overripe seeds on the phenolic composition and color stability of Syrah red wines from warm climate. *Food Chem.* **2021**, *346*, 128919. [CrossRef]

192. Vergara, C.; Von Baer, D.; Mardones, C.; Gutiérrez, L.; Hermosín-Gutiérrez, I.; Castillo-Muñoz, N. Flavonol Profiles for Varietal Differentiation Between Carménere and Merlot Wines Produced in Chile and Chemometric Analysis. *J. Chil. Chem. Soc.* **2011**, *56*, 827–832. [CrossRef]
193. Leborgne, C.; Ducasse, M.; Meudec, E.; Carrillo, S.; Verbaere, A.; Sommerer, N.; Bougreau, M.; Masson, G.; Vernhet, A.; Mouret, J.; et al. Multi-method study of the impact of fermentation on the polyphenol composition and colour of Grenache, Cinsault, and Syrah rosé wines. *Food Chem.* **2023**, *403*, 134396. [CrossRef]
194. Shi, P.; Yao, H.; Chai, J.; Hua, Y.; Zhang, A.; Cui, Y. Effect of flash release treatment on phenols profiles, color stability, and volatile aroma compositions of Cabernet Sauvignon wine in Changli County (China). *J. Food Comp. Anal.* **2026**, *155*, 109260. [CrossRef]
195. Mendoza, L.; Matsuhiro, B.; Aguirre, M.J.; Isaacs, M.; Sotés, G.; Cotoras, M.; Melo, R. Characterization of phenolic acids profile from Chilean red wine by high-performance liquid chromatography. *J. Chil. Chem. Soc.* **2011**, *56*, 688–691. [CrossRef]
196. Xie, Q.; Tang, Y.; Wu, X.; Luo, Q.; Zhang, W.; Liu, H.; Fang, Y.; Yue, X.; Ju, Y. Combined ultrasound and low temperature pretreatment improve the content of anthocyanins, phenols and volatile substance of Merlot red wines. *Ultrason. Sonochem.* **2023**, *100*, 106636. [CrossRef]

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