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# Comparison of the Evolution of Low Molecular Weight Phenolic Compounds in Typical Sherry Wines: Fino, Amontillado, and Oloroso

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Changes in the content of low molecular weight phenolic compounds (hydroxybenzoic and hydroxycinnamic acids, aldehydes, and their esterified derivatives, tyrosol and 5-(hydroxymethyl)-2-furaldehyde) during the aging of three different classes of Sherry wine, Fino, Oloroso, and Amontillado, have been studied. The samples studied were taken from each of the scales of the particular aging system applied to the three classes of wine. Clear differences were observed in the behavior of the low molecular weight phenolic in the three classes of wine. The wines subjected to oxidative aging presented a higher phenolic content overall, with the exception of the esterified derivatives of phenolic compounds that are mainly found in the samples that have not undergone any process of oxidation. MANOVA results confirmed that there are significant differences between all of the samples of the three types of wines. Using LDA, a classification of 100% of the samples has been made.

**KEYWORDS: Phenolic compounds; Sherry wine; evolution; biological aging; oxidative aging; HPLC; PCA; LDA**

## INTRODUCTION

Several different types of Sherry wine are produced in the Jerez region. The more important being those designated as Fino, Amontillado, and Oloroso. All of these are produced from the Palomino Fino grape variety. During the course of production, they undergo chemical processes of very different kinds: in one type, Fino, reductive processes are predominant, whereas in the other two types, Oloroso and Amontillado, the processes are mainly oxidative.

It should be noted that the Sherry wines typical of the Jerez region, in the Southwest of Spain, are submitted to a traditional system of dynamic aging in wooden barrels. This dynamic aging involves the periodic racking of part of the contents of each barrel into another containing older wine, over the course of several years. The barrels are arranged in a series of scales, known as criaderas, ranked according to the age of the wine contained. The final scale of the system is known as the solera, from which the fully aged wine is drawn off periodically for bottling and sale (*1*).

It has long been known that the wood of which the barrels are made has a considerable influence in the aging of wines and liquors (*2*−*6*). The wooden cask serves both as a container during the period of aging and as an active contributor to the organoleptic properties of the product by the extraction of compounds from the wood. Among these are various phenolic compounds: phenolic aldehydes of the benzoic type, (vanillin and syringaldehyde), phenolic aldehydes of the cinnamic type (coniferylaldehyde and syringaldehyde), and coumarins (scopoletin and esculetin) (*3*, *7*, *8*).

This process of extraction varies according to not only the characteristics of the wood (*9*−*11*) but also the alcoholic degree of the liquid contained, the environmental conditions in which the extraction process takes place, the presence or not of oxygen in the wine, and other variables (*12*).

Therefore, the phenolic composition of the aged wine in wood will depend on the phenolic composition of the original grape from it was made and of the type of aging to which it has been subjected. According to Barroso et al. (*13*), the particular steps followed in the production process can also influence the final phenolic composition of the wine.

Reports can be found in the bibliography of research work studying the changes produced during the process of dynamic aging typical of the procedures used in the wine-producing regions of the south of Spain. Specific studies have been made of changes in the aroma fraction of Sherry wines (*14*), and in the phenolic fraction of flavonol aglycones in Sherry wines (*15*), and of changes in the low molecular weight phenol content of Fino wines (*16*, *17*), Fino and Oloroso wine (*18*), Amontillado wine and Sherry vinegar (*19*), and Sherry vinegars (*20*).

A work exists in which the three wines are compared (*21*), although the wines are only compared already finishes. We do not find any combined study of the three types of wines where the content of the phenolic compounds is compared during the aging. We neither find papers in the bibliography that they study

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the behavior of the hydroxybenzoic and hydroxycinnamic esters along systems such as these.

Today chemometry has become a powerful working tool in studies to evaluate the quality of foodstuffs in general, and in particular of a grape-derived product: must (*22*), wine (*22*, *23*), vinegar (*20*), and spirits (*24*).

Within the general field of characterization of such products, the phenolic compounds play a significant role and have been utilized by many researchers in conducting diverse differentiation studies. Gómez-Plaza et al. (*25*) have studied the relationship between phenolic compounds and color in the aging of young red wines using forward stepwise discriminant analysis and multiple linear stepwise regression; Tinttunen and Lehtonen (*26*) have differentiated organic wines from normal wines on the basis of concentrations of phenolic compounds and spectral data using PCA; Peña-Neira et al. (*27*) have made a survey of phenolic compounds in Spanish wines of different geographical origin applying multivariate analysis (PCA and LDA); Arozarena et al. (*28*) have differentiated wines according to variety and region based on their anthocyanin composition, using PCA and stepwise discriminant analysis (SDA); Castro and Barroso (*29*) have studied the influence of oxygen supply on the susceptibility of must to browning using its phenolic composition and PCA; and more specifically with respect to Sherry wines, Barón et al. (*16*) have utilized PCA to differentiate wines from the various scales of a solera system of Fino wine based on their phenolic composition. In this case, neither have they found statistical studies that indicate to us if differences exist among the three types of wines, as much as wines finished as during their aging.

The aim of the present study is to compare the evolution of low molecular weight phenolic compounds during the course of the aging process in the three classes of Sherry wine most typical from the Jerez production region: Fino wine, Amontillado wine, and Oloroso wine.

With this study, we want to see which is the behavior that the phenolic compounds present along the system of aging of these three wines; if the wines content a similar or different composition; if this composition stays, or it evolves, during the aging; if the presence of the oxygen during the aging conditions the phenolic content of the wines, or if it influences in the evolution that these compounds present during the aging; or if the process of phenolic compounds extraction from the wood varies according to the presence, or not, of oxygen in the wine.

In addition, we have conducted studies comparing the composition of the wines studied. The use of statistical techniques has allowed us to identify the basic differences among the three classes of wine studied based on its composition in compound phenolic of low molecular weight. It has also allowed us to demonstrate that the differences in the methods of the used production have a significant influence in the phenolic composition of each type.

## MATERIALS AND METHODS

**Reagents and Standards.** The standard compounds used were obtained from Fluka (Buchs, Switzerland), Merck (Darmstadt, Germany), and Eastman Kodak (Rochester, NY). Methanol and all other chemicals used (analytical reagent grade) were obtained from Merck (Darmstadt, Germany). Water was purified in a Milli-Q water purification system (Millipore, Bedford, MA).

**Elaboration Process of Sherry Wines.** The Fino type undergoes a version of the aging process known as dynamic biological aging. Although the wine ages inside the barrel, which is partially, not completely, filled, a layer of yeasts grows and covers its surface: this is known as the veil of flor. One important function of this layer of yeast is to isolate the wine from the air. Hence, Fino is a wine that ages in the absence of oxygen, in other words, in a markedly reductive environment.

In contrast, the Oloroso type undergoes an oxidative aging. It presents a relatively high alcoholic degree (between 18° and 20°), which is too high for the veil of flor to grow on its surface. It is this process of dynamic oxidation over time that gives Oloroso the particular characteristics of color, flavor, and aroma for which it is appreciated by consumers.

The Amontillado type is obtained from a two-stage aging. In the first stage, it undergoes a dynamic biological aging exactly the same as the Fino type. Then, ethanol is added to bring its alcoholic degree up to 18−20°, and it then completes its aging by the oxidative process in the same way as Oloroso wine.

**Sampling.** The samples of the wines used in the study were obtained directly from the winery of "Bodegas Osborne & Cía".

*Fino Sherry Wine*. The system of criaderas used for the aging of the Fino wine studied consisted of four scales. Each scale comprised 36 butts or casks of 600 L capacity but filled with only 500 L of wine to permit the development of the veil of flor on the surface of the liquid. Three samplings were carried out over the course of one year. The analyses were performed on a composite sample made up of separate samples of 50 mL taken from each butt and then combined, to produce a single uniform and representative sample. The total number of samples taken in this aging system was 12: 4 scales × 3 samplings.

*Oloroso Sherry Wine*. In the case of the Oloroso wine studied, the system consisted of nine scales. Two samplings were carried out. In each of the controls, a quantity of 500 mL was taken from every fourth butt, starting from the butts at the head of the rows along the central aisle in the cellar. These were similarly combined to produce a single uniform sample for each tasting. In this aging system, the total number of samples taken was 18: 9 scales × 2 samplings.

*Amontillado Sherry Wine*. The solera system from which the samples of Amontillado were taken consisted of 7 scales. The young scale was formed by finished Fino wine. Three samplings were carried out. In each of the tasting controls, a quantity of 500 mL was taken from one butt out of every four and combined to produce a single uniform sample. The total number of samples taken in this aging system was 21: 7 scales × 3 samplings.

All samplings were carried out over the course of one year, coinciding with the operations of racking off the wine between successive scales routinely performed in the cellar. Each sample was analyzed twice.

**Extraction of Phenolic Compounds from the Wine.** The extraction process was carried out using a rotary continuous extraction device. This method was developed and optimized by Brú et al. (*30*).

*Preparation of Sample*. A total of 100 mL of wine sample were diluted with the same volume of water. The mixture was saturated with sodium chloride. Finally, the solution was extracted with 80 mL of diethyl ether, using a Mascré extractor for 125 min at a rate of 0.8 turns/min. The organic solvent was dried for 1 h with anhydrous sodium sulfate followed by evaporation in a Rotavapor to attain a final volume of 5 mL with a methanol:water (1:1) solution.

*Equipment*. A Waters (Milford, MA) liquid chromatograph with model 510 and M45 pumps, a model 715 automatic injector, and a model 480 UV−vis detector were used. The analyses were carried out using a $C_{18}$ column (Bondapack 300 × 3 mm, 10 $\mu$m particle size) under chromatographic conditions.

*Chromatographic Conditions*. The chromatographic conditions adopted were as follows: flow rate, 1 mL $min^{-1}$; detection, UV absorption at 280 and 340 nm; volume injected, 20 $\mu$L; and mobile phase, methanol-acetic acid−water (10:2:88, v/v) as solvent A, and methanol-acetic acid−water (90:2:8, v/v) as solvent B, with a gradient programmed in two steps (**Figure 1**).

**Pattern Recognition Methods.** Multivariant statistical techniques, specifically PCA and LDA, using the STATGRAPHIC 5.0 Professional Edition (Statistical Graphics Corp.) program were utilized to perform the various differentiation studies proposed as objectives for the present study.

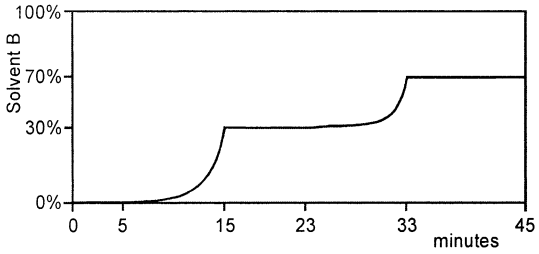


**Figure 1.** Gradient program used in the chromatographic process.

## RESULTS

**Figure 2** shows a typical chromatogram of a sample of Fino wine, Amontillado wine, and Oloroso wine with the more significant peaks identified in each type of wine. The basic datum taken to conduct this study is the height of the chromatographic peak. The height taken was from top of the peak to the basis line (**Figure 2**). For most of the compounds, a wavelength of 280 nm was used. The various peaks were obtained using a diode-array detector at the column outlet, which provided the UV−vis spectrum of the peaks in the various chromatograms.

As can be seen in **Figure 2**, the phenolic compounds found in the samples of Fino wine mainly belong to the group of cinnamic and benzoic acids and esters. We have not found phenolic compouds to the group of cinnamic and benzoic aldheydes.

**Figure 2** also shows a typical chromatogram of a sample of Oloroso wine with the more significant peaks identified. The first thing to be noted is that there is a considerably higher phenolic content compared with Fino wine, both in the total quantity and in the particular compounds present. In this case, there is a wider variety of compounds identified from the various peaks recorded, including not only those found in Fino wine but also benzoic aldehydes and cinnamic aldehydes.

The bottom chromatogram in **Figure 2** shows a typical chromatogram of a sample of Amontillado wine with the more significant peaks identified. It is the only one of the wines studied that has undergone both types of process, first the reductive and then the oxidative aging process. The phase studied here is the second, oxidative phase. Like it was of waiting, the Amontillado wine presents phenolic compounds found in the Fino wine and in the Oloroso wine.

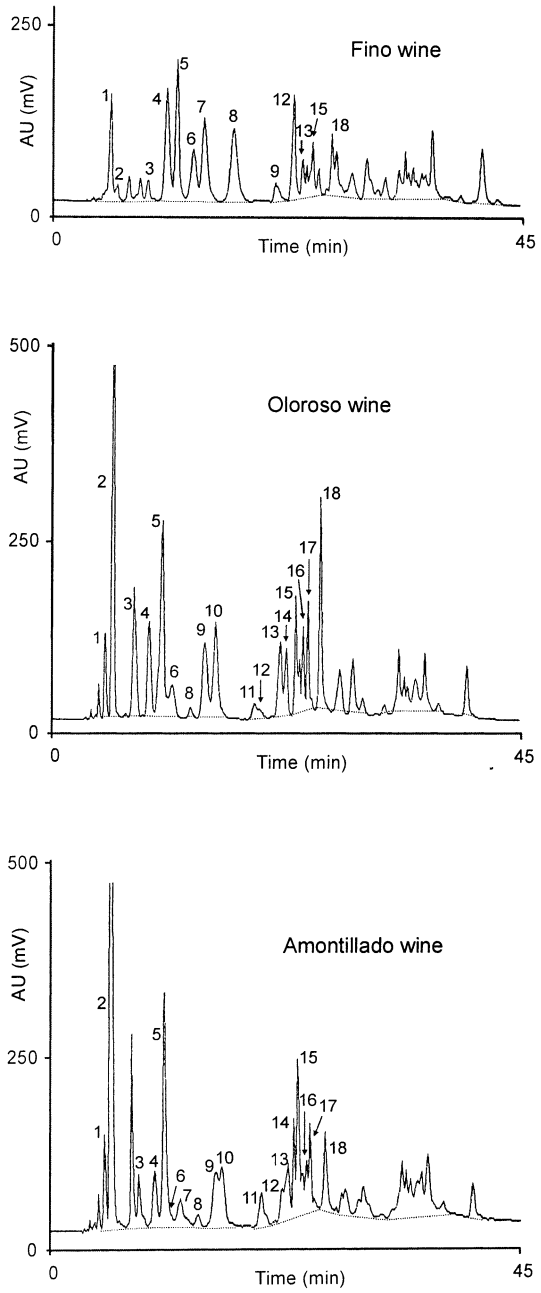


**Figure 2.** Chromatograms of Sherry wines. Peaks: 1 = gallic acid; 2 = HMF; 3 = protocatechuic acid; 4 = caftaric acid; 5 = tyrosol; 6 = *cis-p*-coutaric acid; 7 = hydrocaffeic acid; 8 = *p*-hydroxybenzoic acid; 9 = *trans-p*-coutaric acid; 10 = *p*-hydroxybenzaldehyde; 11 = vanillic acid; 12 = chlorogenic acid; 13 = caffeic acid; 14 = vanillin; 15 = syringic acid; 16 = *cis-p*-coumaric acid; 17 = syringaldehyde; 18 = *trans-p*-coumaric acid; (- - -) basis line taken.

## DISCUSSION

As already stated, the aim of this research is to study the evolution of the low molecular weight phenolic compounds in the three most important classes of Sherry wine (Fino, Oloroso, and Amontillado) as they are matured in barrels of oak wood in the dynamic aging system.

**Evolution of the Phenolic Compounds.** *Fino Sherry Wine.* As can be seen in **Figure 2**, the phenolic compounds found in the samples of wine mainly belong to the group of cinnamic and benzoic acids and esters.

Although the phenolic aldehydes are typical compounds in any process of aging in wood, it is observed that in the samples of Fino the presence of these compounds is either very low or nonexistent.

The graphs in **Figure 3** present the evolution of the more significant compounds in the course of this wine's passage through the scales of the aging system. It is noted that the only compounds to show an increased content are the benzoic acids. The rest of the compounds either remain at a more or less stable level (as occurs with tyrosol) or show a substantially reduced presence as the aging process takes place, as is the case with the cinnamic and benzoic esters.

According to Estrella et al. (*18*), the increase in the benzoic acids can be explained by the contribution made by the lignin and by the desamination of the nitrogenated compounds produced in the autolysis of the flor yeast. It is assumed, again according to these authors, that the significant increase in the acids of the benzoic type is because they are synthesized at the expense of the cinnamic acids. The very limited presence of aldehydes in the samples of Fino wine appears to be due to their inhibition by the flor yeast.

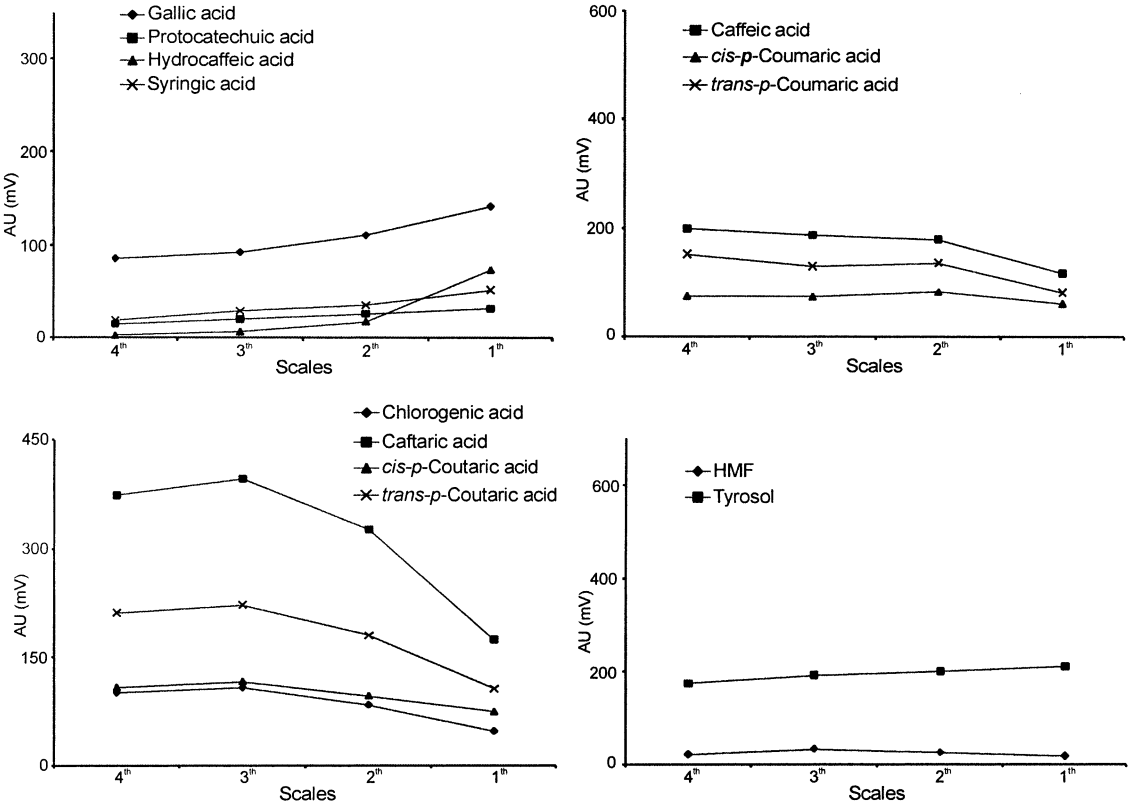


**Figure 3.** Evolution of the more significant phenolic compounds in the aging system of Fino wine. The compounds are divided according to the family to which belongs.

Barón et al. (*16*) also describe the presence of tyrosol at a constant level in samples of Fino wine throughout the process of aging under the veil of flor.

No reference has been found in the bibliography consulted regarding the considerable decrease shown by the esterified derivatives, from the fourth scale of the criadera to the final solera stage. This decrease is not due to hydrolysis of them: we do not observe an increase in the cinnamic acids in inverse proportion to the decrease in the content of esterified derivatives. In fact, we observe the contrary phenomenon: the concentration of cinnamic acids decreases over the course of the aging process. This leads us to think that a different mechanism must cause the degradation of these types of compound.

*Oloroso Sherry Wine.* As a general rule, the benzoic and cinnamic acids identified are present in constant concentrations throughout the oxidative aging system to which this class of wine is subjected during its production (**Figure 4**).

In contrast, it is the gallic, syringic, and caffeic acids that experience the most changes. Gallic acid presents a sharp decrease in the earlier stages of the aging process and then remains fairly constant. Syringic acid undergoes a progressive increase throughout the entire aging period, from the 9th scale to the final solera; this is similar to the behavior of syringic acid in Fino wine.

The content of esterified derivatives in these samples is much lower than that presented in Fino wine. The evolution of the four esterified derivatives identified is constant, except in the case of caftaric acid, which again presents a sharp decrease in the later stages of the aging process.

The unusually high content of 5-(hydroxymethyl)-2-furaldehyde (HMF) presented by the samples of Oloroso wine is notable, particularly toward the end of the aging process. Normally, the presence of this compound in oxidized wines has been attributed to must caramel addition, which is a legal practice in they making. However, as can be observed in the graph, it is present in significant quantity in the final stages of aging of samples that have not had caramel added. A similar finding is reported by García Parrilla et al. (*20*) in their study of the evolution of phenolic compounds in the production process of Sherry wine vinegar, in which HMF also appears in the final stages of the dynamic oxidative aging process of this type of vinegar. Tyrosol does not present any differences in behavior compared with Fino wine.

*Amontillado Sherry Wine.* The samples from the first or youngest scale of the criadera system (scale no. 7) present a very similar profile to the samples of Fino wine taken from its final scale (**Figure 5**). However, in subsequent scales, its behavior becomes more similar to that of Oloroso wine than to Fino wine. The content of benzoic acids falls strikingly from the 7th scales through to the solera (**Figure 5**), with the exception of syringic acid, which again shows a significant increase during the aging process. The cinnamic acids present a moderate rate of increase with the oxidative process, apart from caffeic acid, which decreases over the course of the system of criaderas. Of the aldehydes identified in the samples of Amontillado wine, vanillin and *p*-hydroxybenzaldehyde show considerable increases during the aging, whereas syringaldehyde remains constant. In respect of the esters, these generally undergo a decrease between scales 7 and 6 and then remain constant until the solera, with the exception of *trans-p*-coutaric, which increases progressively from scale 6 until the solera. A considerable increase of HMF is also observed during aging, whereas tyrosol stays more or less constant.

**Comparative Study between the Three Systems.** There are evident differences in the behavior of the low molecular weight phenolic compounds between the three systems.

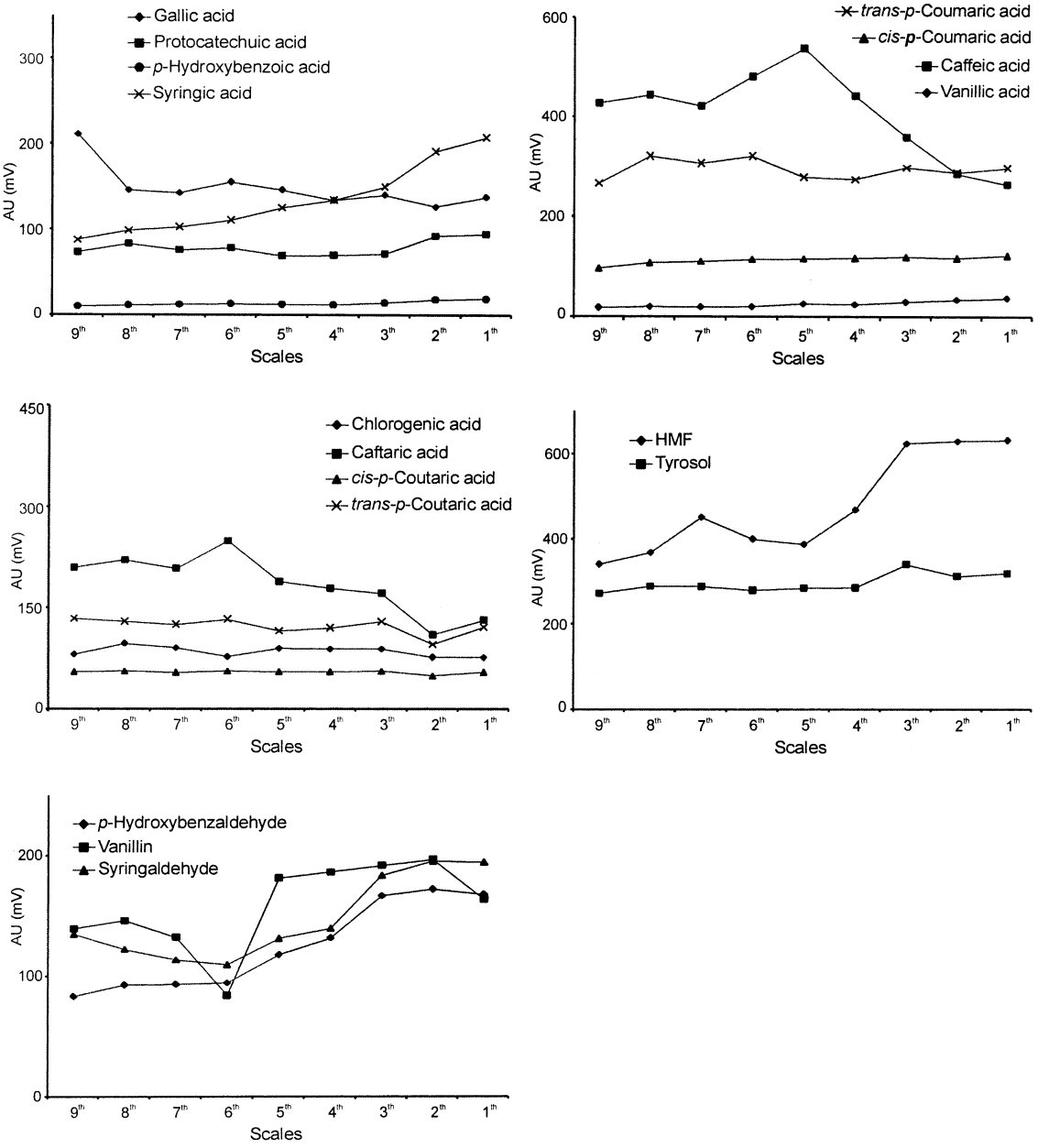


**Figure 4.** Evolution of the more significant phenolic compounds in the aging system of Oloroso wine. The compounds are divided according to the family to which belongs.

Gallic acid presents the opposite behavior in the Fino wine aging system compared with that of Oloroso and Amontillado, increasing from one scale to the next in the Fino and decreasing in the others. In other words, in a reductive environment, its concentration increases, and in an oxidative environment, it decreases. This behavior has been observed in other studies conducted with similar samples. The explanation for this lie is the considerable oxidative capacity presented by gallic acid; in fact, it is considered to be one of the phenolic compounds with the greatest anti-oxidant capacity (*31*).

Hydrocaffeic acid presents a considerable increase in the later phases of the aging of Fino wine but is not detected at all in any of the scales of the Oloroso aging system. However, it is possible to detect this acid in the early stages of the dynamic oxidative aging system of Amontillado wine, and it remains present at very low levels during the remainder of the process. This behavior demonstrates a biological origin and is linked to the metabolism of the flor yeast, and during the oxidative aging process, it presents a high oxidation capacity.

In contrast, *p*-hydroxybenzoic acid presents the opposite behavior to hydrocaffeic acid. It is not detected in the samples of Fino wine but is present, albeit at low level, in the samples of Oloroso and Amontillado wine. In Oloroso, it presents a constant small content throughout the aging process, whereas in Amontillado, its content increases slightly from the youngest to the oldest scale. This observed behavior agrees with the findings of Fabios et al. (*21*) in finished Fino, Oloroso, and Amontillado wines.

A similar behavior is presented by vanillinic acid: it is only detected in the oxidative aging systems (Olorosos and Amontillados), presenting a slight tendency toward an increase.

According to all of the bibliography consulted, the phenolic aldehydes are the compounds most characteristic of a process of aging in barrel, forming part of the process of degradation of the lignin in the wood of the barrel. However, we were unable to detect these compounds in any of the stages of the biological aging of Fino wine. They were, however, detected at significant

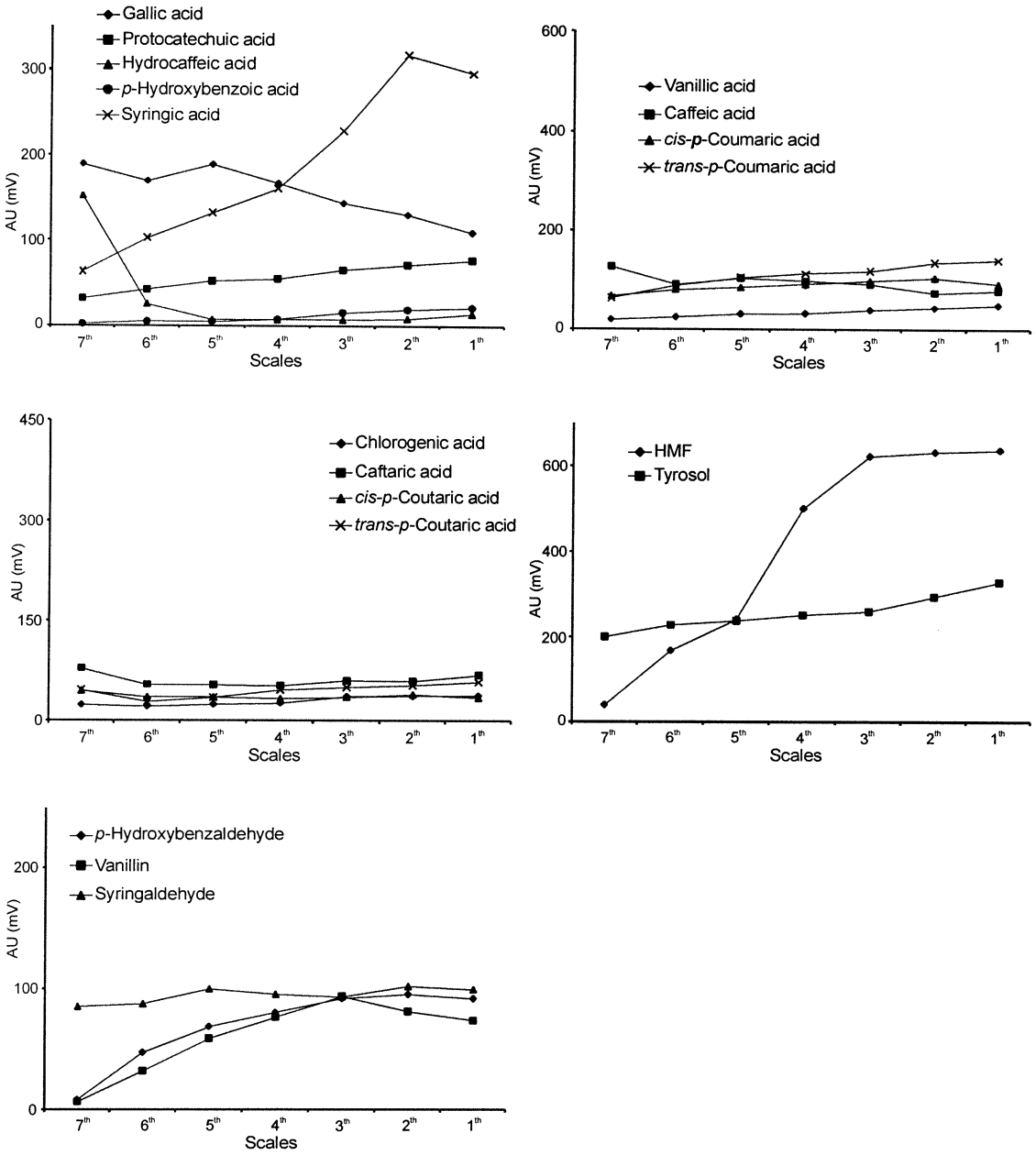


**Figure 5.** Evolution of the more significant phenolic compounds in the aging system of Amontillado wine. The compounds are divided according to the family to which belongs.

levels in all of the samples taken during the aging of Oloroso and Amontillado wines.

The aldehydes identified in these samples are vanillin, syringaldehyde, and *p*-hydroxybenzaldehyde, but coniferylaldehyde was not detected. The two former compounds originate in the degradation of lignin by the alcohol, and they are found in a great number of aged alcoholic drinks, including cognac (*32*), whiskies (*33*), and brandy (*34*), as well as in Sherry wine vinegar (*20*). The latter, *p*-hydroxybenzaldehyde, is present exclusively in Sherry wine and Sherry wine vinegar aged for long periods.

**Statistical Studies.** The differences found in phenolic composition of the three classes of aged wine were studied statistically. The complete set of data on the contents of phenolic compounds was submitted to chemometric analysis. Samples were divided into three groups according to the aging system of origin. The groups include samples taken from all of the scales of their aging system. The first group includes all of the samples taken from the biological aging system (Fino wine), the second group includes all of the samples taken from the Oloroso aging system, and the third group includes all of the samples taken from the Amontillado aging system.

First, a multiple analysis of variance (MANOVA) was applied, yielding a Wilks' lambda of 0.000346; therefore, it was assumed that significant differences did exist between the three groups (p-level 0.0000).

To visualize the trends, a Principal Component Analysis was conducted. The first three components obtained accounted for 92.5% of the overall variance of the original data.

The first two components obtained from the PCA are plotted in **Figure 6**. As can be seen, all of the samples of the first group (Fino wine) are located on the left-hand side of the plot, all of the samples of the second group (Oloroso wine) are located on the right upper-hand side, whereas all of the samples of the third group (Amontillado wine) are located on the lower side of the plot.

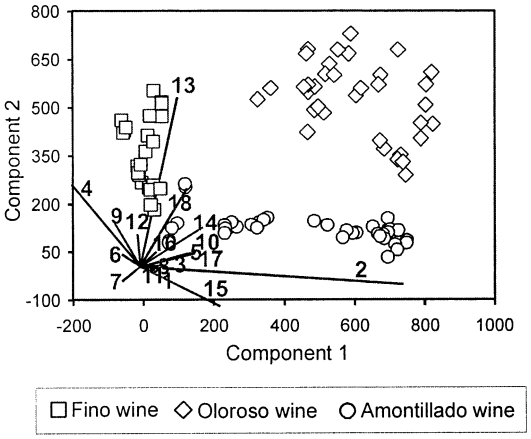


**Figure 6.** Biplot of vector loadings and distribution of samples for principal component analysis (PCA) according to the type of Sherry wine (for identification see **Figure 2**).

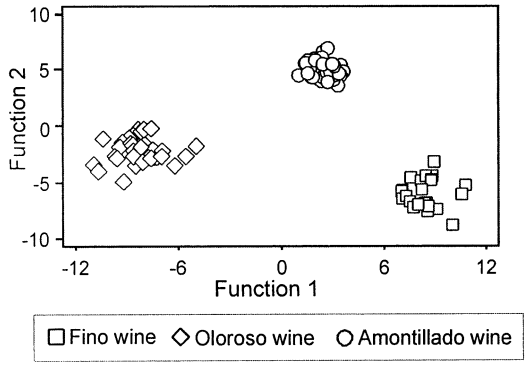


**Figure 7.** Plot of discriminant function scores for samples of Sherry wine.

HMF accounted for the most statistical weight in component 1, which accounted for over 57.3% of the overall variance. Caffeic, caftaric, and *trans-p*-coumaric acids accounted for the most statistical weights in component 2, which accounted for over 28.4% of the overall variance. Finally, caftaric acid, caffeic acid, *trans-p*-coutaric acid, and HMF contributed most to component 3, which accounted only for 6.7% of the overall variance.

Observing the distribution of the samples in the plane defined by the first two components, it can be considered that the first component explains the degree of oxidation of the samples and the second component explains the effect of the process of biological aging. In fact, the samples of Amontillado wine aged for less time are closely adjacent to the samples of Fino wine aged for a longer period of time in the biological system; similarly, those samples of Amontillado aged for more time are located closer in the space to the samples of Oloroso wine aged for the longest times.

In light of this ordination of the samples in the plane of principal components, a second analysis was performed. The method used was LDA because this is a good method to identify the most useful variables to differentiate between groups. Applying a stepwise selection algorithm, a classification of 100% of the samples has been made (**Figure 7**). A total of 12 variables were selected consistent with the Wilks' lambda criterion: HMF, caftaric acid, hydrocaffeic acid, *trans-p*-coutaric acid, *p*-hydroxybenzaldehyde, vanillinic acid, chlorogenic acid, caffeic acid, syringic acid, *cis-p*-coumaric acid, syringaldehyde, and *trans-p*-coumaric acid.

**Table 1** shows the unstandardized coefficients of the functions used to discriminate between the groups. From the relative magnitude of the unstandardized coefficients in the equation, we can determine that the most significant independent variables to discriminate between the groups are syringaldehyde, *trans-p*-coumaric acid, caffeic acid, *trans-p*-coutaric acid, and syringic acid in the first function and *p*-hydroxybenzaldehyde, trans-*p*-coutaric acid, vanillinic acid, and syringaldehyde in the second function. Three of the variables were not been detected in Fino wine (HMF, *p*-hydroxybenzaldehyde, and syringaldehyde); one was not detected in Oloroso wine (hydrocaffeic acid). All of the other variables present a different behavior depending on the aging system applied.

**Table 1.** Unstandardized Coefficients of the Two Functions Used to Discriminate among the Different Levels of Type Wine

| | function 1 | function 2 |
|---|---|---|
| HMF | –0.002 312 94 | 0.005 465 02 |
| caftaric acid | –0.010 005 30 | 0.016 916 70 |
| hydrocaffeic acid | –0.008 841 83 | –0.015 698 4 |
| *trans-p*-coutaric acid | 0.033 093 40 | –0.064 637 6 |
| *p*-hydroxybenzaldehyde | 0.010 453 70 | –0.070 162 8 |
| vanillic acid | –0.046 582 50 | 0.179 570 0 |
| chlorogenic acid | 0.022 692 00 | –0.000 256 7 |
| caffeic acid | –0.012 367 80 | –0.000 025 0 |
| syringic acid | 0.010 318 70 | –0.010 242 3 |
| *cis-p*-coumaric acid | 0.002 785 34 | 0.019 957 5 |
| syringaldehyde | –0.049 820 7 | 0.050 040 6 |
| *trans-p*-coumaric acid | –0.037 948 3 | –0.020 727 3 |
| constant | 10.368 200 0 | 2.261 830 0 |

It is therefore concluded that the three main classes of Sherry wine present sufficient and clear differences in their composition in low molecular weight phenolic compounds to enable their differentiation even in the earliest stages of their respective aging processes.

In general, the compounds of the hydroxybenzoic and hydroxycinnamic acid fractions increased in the wines subjected to prolonged aging, because of the extraction of components from the wood and the slow evaporation of water and/or ethanol. However, we have observed that this behavior does not take place in the wines subjected to biological aging, particularly Fino Sherry wine. The biological aging affects the low molecular weight phenolic composition of the wines. In fact, differences between the samples of the Amontillado wine and of the Oloroso wine can be detected from the start until the finish of the aging process. Multiple analysis of variance (MANOVA) results confirmed that there are significant differences between all of the samples of the three types of wines, and using LDA, a classification of 100% of the samples has been made.

In definitive, the differences in the aging have a marked influence in the phenolic composition of these wines: the Fino wine does not contain a typical phenolic composition of wine aged in wood, and their phenolic composition is different to the composition of the other two studied wines. The Amontillado wine and Oloroso wine contain some phenolic compounds, as *p*-hydroxybenzaldehyde; they are not typical of wines aged in wood; they are exclusive of Sherry wine and Sherry wine vinegar. These wines also present differences of composition among them, although some organoleptic characteristics of these wines are similar.

## ABBREVIATION USED

HMF, 5-(hydroxymethyl)-2-furaldehyde; MANOVA, multiple analysis of variance; PCA, principal component analysis; LDA, linear discriminant analysis.

## ACKNOWLEDGMENT

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