Grape Cluster Sun Exposure and Wine Phenolics

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One of the major objectives of grape research at Oregon State University has been understanding the effects of vineyard practices on wine quality. Most of our research has been directed toward pinot noir, the state's most widely planted grape variety.

Pinot noir is particularly sensitive to environmental factors. Changes in the climate from one year to the next are responsible for vintage differences in pinot noir. On the vineyard level (mesoclimate) the choice of site can influence grape and wine composition. Within the plant, the microclimate of roots, leaves and clusters influence plant physiologic function, which eventually affects wine.

Cluster sun exposure is an environ-

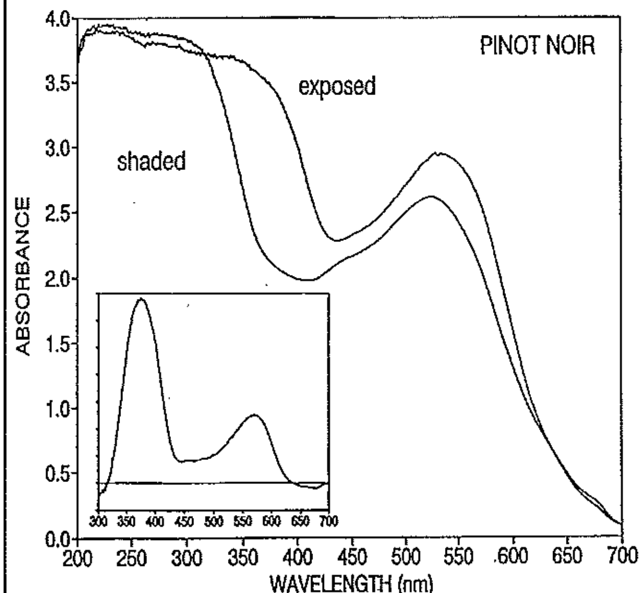


Fig. 1. Light absorbance of grape skins from sun exposed and shaded position on the same clusters. The inset is the difference in absorbance between the two samples. A high absorbence means the skins are absorbing light in those wavelengths and not allowing it to pass into the berry.

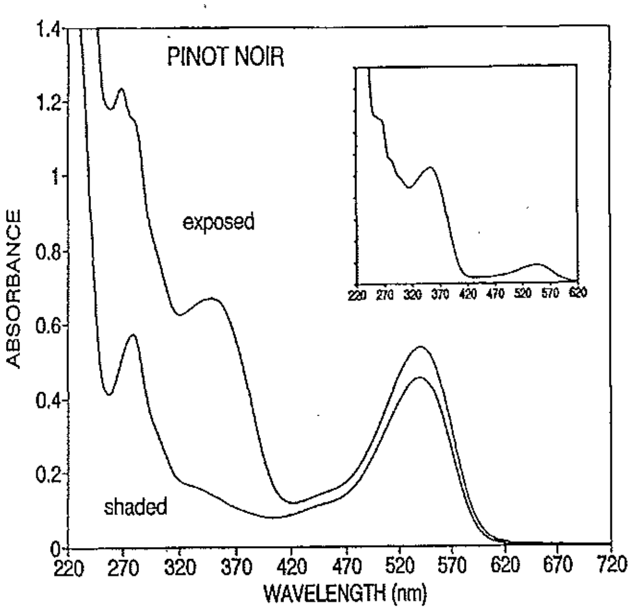


Fig. 2. Light absorbance of ethanol extracts of grape skins from sun exposed and shaded skin disks. The inset is the difference between the two samples.

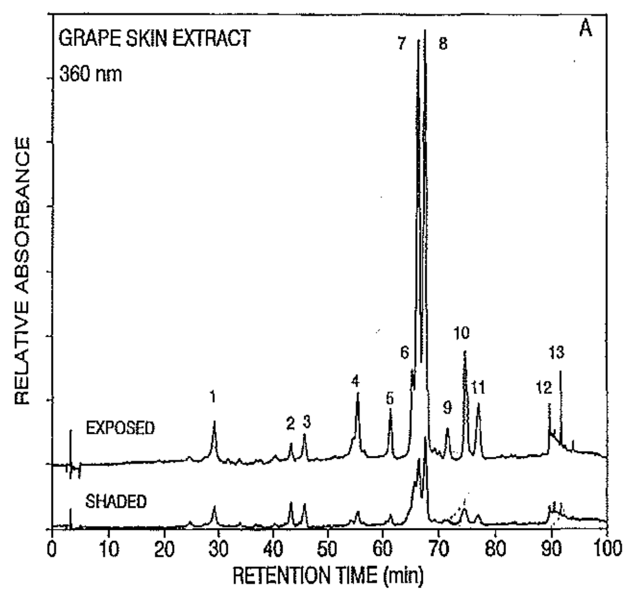


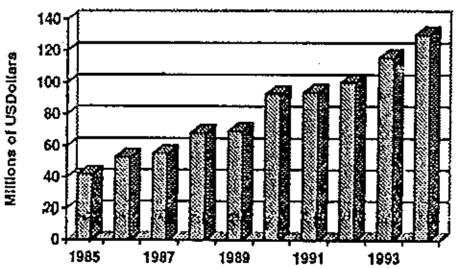
Fig. 3A. Chromatograms of ethanol extracts of grape skin disks from sun exposed and shaded positions on the same cluster. The chromatogram at 360 nm (the wavelength where there appeared to be significant differences in grape skin absorbance) shows the high concentrations of flavonols present in sun exposed extracts. The chromatogram at 520 nm (a wavelength where anthocyanins absorb strongly) shows no difference between the two samples in anthocyanin concentration of the skins.

Grape Industry Sets Export Record

More California table grapes were exported in 1994 than in any year in the industry's history, according to figures released by the U.S. Department of Commerce. Through the end of November, over 100,000 metric tons of grapes worth $125 million were exported to offshore markets and Mexico, exceeding the record of 95,000 metric tons exported in the 1993 season.

According to Scott Horsfall of the California Table Grape Commission, the 1994 record is the continuation of a long-term trend. "This is the tenth consecutive record season for grape exports," said Horsfall, vice president of international marketing. Horsfall credits the opening of Mexico, continued growth in Asian and Latin American markets, aggressive promotion, and a good quality crop as keys to the 1994 results.

Value of US Grape Exports 1985-1994



Source: US Dept. of Commerce.

Top Fifteen Markets for California Grapes

Rank	Country	1993 Volume Metric Tons	1994 Volume Metric Tons	Percent Increase
1	Hong Kong	18,018	21,600	+20
2	Mexico	10,757	20,000	+86
3	Taiwan	13,330	15,200	+14
4	The Philippines	6,188	9,000	+45
5	Singapore	6,726	6,500	-3
6	Japan	3,456	5,000	+45
7	New Zealand	2,426	4,500	+85
8	Malaysia	3,989	4,200	+5
9	United Kingdom	5,012	4,000	-20
10	Indonesia	4,602	3,950	-14
11	Costa Rica	3,173	3,100	-2
12	Panama	1,666	2,000	+20
13	Guatemala	3,035	2,000	-34
14	Brazil	346	2,000	+478
15	Thailand	1,243	1,600	+28

Source: US Dept. of Commerce.

"For the first time in many years, the fresh grape industry was able to sell grapes freely to Mexico," said Horsfall, "where exports reached the 2 million box mark." He added that other markets performing particularly well in 1994 include Hong Kong, Taiwan, the Philippines, New Zealand, Japan, and Thailand.

Horsfall also noted that the industry shipped to several new markets in 1994. "Brazil was probably the most significant of these new markets," Horsfall said, "with imports of over 150,000 boxes. However, the industry also sent a sizable amount of product to Vietnam, Russia, Columbia, and Cambodia. All are countries we expect to become significant export markets in future years."

The California Table Grape Commission promotes grape exports in more than 20 countries. ❑

mental variable that often changes in response to vineyard practices. Trellis type, leaf removal, shoot density, vigor reduction techniques, water management and rootstocks can all affect the amount of sun reaching a cluster. Generally, sun-exposed clusters have smaller berries, lower titratable acidity and malic acid, higher anthocyanin concentrations, and higher total phenolics than shaded clusters.

We have been particularly interested in the effects of cluster sun exposure on berry phenolic compounds. Anthocyanins—the phenolic compound responsible for red color in grapes and wine—are an extremely important quality factor in all red wines. Many other phenolics compounds are present in grape berries. Individually and in combination they contribute to a wine's flavor, mouthfeel, astringency and bitterness.

In an experiment on shoot orientation, we observed that sun-exposed clusters had a shift in the ratio of anthocyanins to total phenolics. Anthocyanins did not change much, but total phenolics increased substantially. It appeared that some sort of change in phenolic metabolism was occurring in direct sunlight. Sun-exposed clusters were apparently producing phenolic compounds that were contributing to the total pool of phenolics, but they were not anthocyanins.

Phenolic compounds in plants have many physiological roles. They are involved in plant protection from pathogens and insects; they are precursors of plant structural components; and they act as taste aversion compounds to prevent animal feeding. Anthocyanins are thought to act as feeding attractants to encourage the dispersal of seeds in ripe fruit. Anthocyanins and other phenolic compounds also have an important role in preventing plant damage from ultra-violet (UV) light. It was UV-screening that seemed to have a possible relationship to apparent change in phenolic metabolism we observed in sun-exposed grapes.

Sunlight is composed of energy in a range of wavelengths. Visible light is in the range of 400 to 700 nanometers (nm). The ultra-violet component of sunlight is just below the visible range, from 400 to around 300 nm.

The lower limits of UV light reaching the earth are affected by atmospheric ozone which strongly absorbs solar radiation below 300 nm. Decreasing ozone concentrations in the upper atmosphere will increase the amount of UV light reaching the earth. Wavelengths between 280 and 320 nm, often referred to as UV-B, are the most damaging to plants as well as other living beings. Many plant functions have been shown to be affected by UV-B light, but DNA is particularly sensitive to damage.

Phenolic compounds act as UV screening agents by absorbing light at damaging wavelengths and releasing the energy either as light—at longer, less damaging wavelengths—or as heat. They are concentrated in vacuoles in the cells in the outer few cell layers of the plant epidermis.

We began an investigation of UV-screening in grapes with a study of the light transmission characteristics of sun-exposed and shaded grape skins from the same cluster. We used four varieties—pinot gris, pinot noir, chardonnay, and gewurztraminer. Sun-exposed clusters were selected from the upper surface of vines on a hanging single-wire trellis. Skin disks were cut from sun-exposed or shaded, interior positions of the clusters. Their light absorbance characteristics were measured in a spectrophotometer.

Sun-exposed grape skin of all varieties absorbed substantially more of the UV-wavelengths than skin from shaded berries. The absorbance of pinot noir is shown in Fig. 1. The differences in absorbance between sun-exposed and shaded skin was greatest around 360 nm. We found this same response in the other three varieties as well.

We then extracted the phenolic compounds from those same skin disks with ethanol and examined the light absorbance of the extract. The ethanol extract from sun-exposed skin had higher absorbance at all wavelengths with the greatest differences between shaded and exposed berries at 260 and 360 nm (Fig. 2).

The differences in the UV spectra of skins and extracts clearly showed that UV screening was occurring in grapes in response to sun exposure. The higher absorbance, at 260 and 360 nm, of the extracts from sun exposed berries suggested that flavonols might be involved, as these are wavelengths where flavonols absorb strongly.

Flavonols are phenolic compounds closely related to anthocyanins, but unlike anthocyanins they primarily absorb light in UV wavelengths rather than in the visible range. They have been shown to be effective UV screening compounds in many plant species.

To determine which compounds were specifically responsible for these differences, we ran the extracts through a high-performance liquid chromatograph (HPLC). An HPLC can separate and identify chemical compounds in complex mixtures. The output of an HPLC are chromatographs, a series of peaks separated by time (Fig. 3A and 3B). Each peak on a chromatograph represents an individual compound and the height and area of the peak are proportional to the concentration of the compound.

Fig. 3A shows two chromatographs of extracts from sun-exposed and shaded pinot noir skins monitored at 360 nm (the wavelength with the

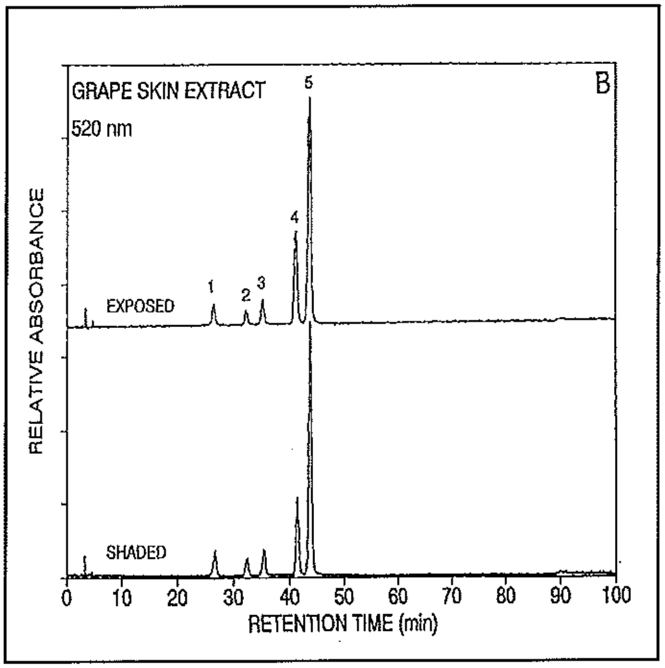


Fig. 3B. Peaks 1 through 5 are the anthocyanin glucosides dephinidin, cyanidin, petunidin, peonidin and malvidin, respectively.

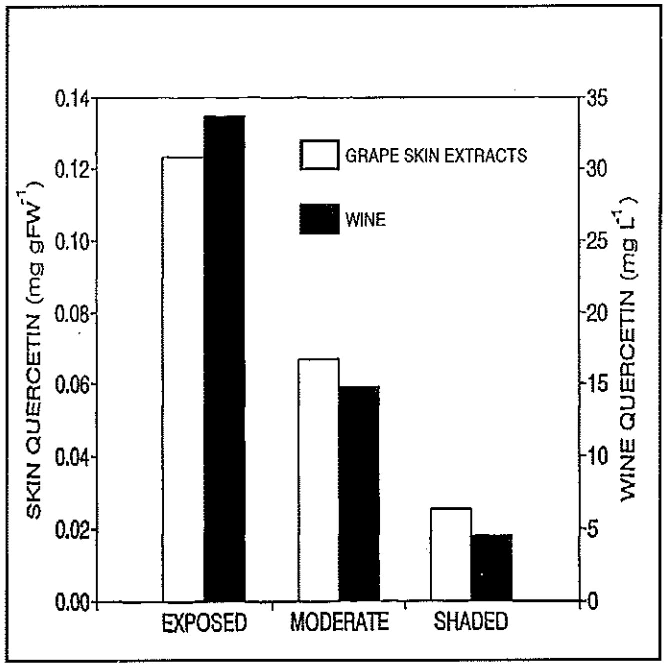


Fig. 4. The quercetin concentration of grape skins and wines from clusters of three sun exposures.

greatest difference in the spectrophotometer runs). Peaks numbered 4 through 11 are flavonol glycosides (flavonols with a sugar attached). Flavonol peaks 7 and 8 are quercetin glucoside and quercetin glucuronide, respectively.

The extract from sun-exposed grape skin had eight times more flavonols than the extract from shaded skin. The same extract, monitored at 520 nm—a wavelength where only anthocyanins have absorbance—showed no difference in anthocyanins (Fig. 3B).

The HPLC data confirmed the results of the spectrophotometer: UV-screening was occurring in grapes and UV-absorbing compounds were being synthesized in response to sun exposure and were accumulating in skins. The response was not a result of a general increase in all phenolics, but, rather, was limited to specific phenolic compounds, with flavonols, particularly quercetin, predominate.

Quercetin has long been known to be present in grapes and wine, but its role as a UV screening agent in grapes had never been shown before. Quercetin has been receiving increased attention recently because of its possible health benefits in wine, both as a possible anticarcinogen and for its possible role in reducing heart disease.

Because of this interest and because we thought quercetin might affect wine quality, we continued our investigation with a study on the effects of cluster exposure on wine phenolic composition.

Experimental wines were made from pinot noir clusters harvested from defined positions in a grape canopy.

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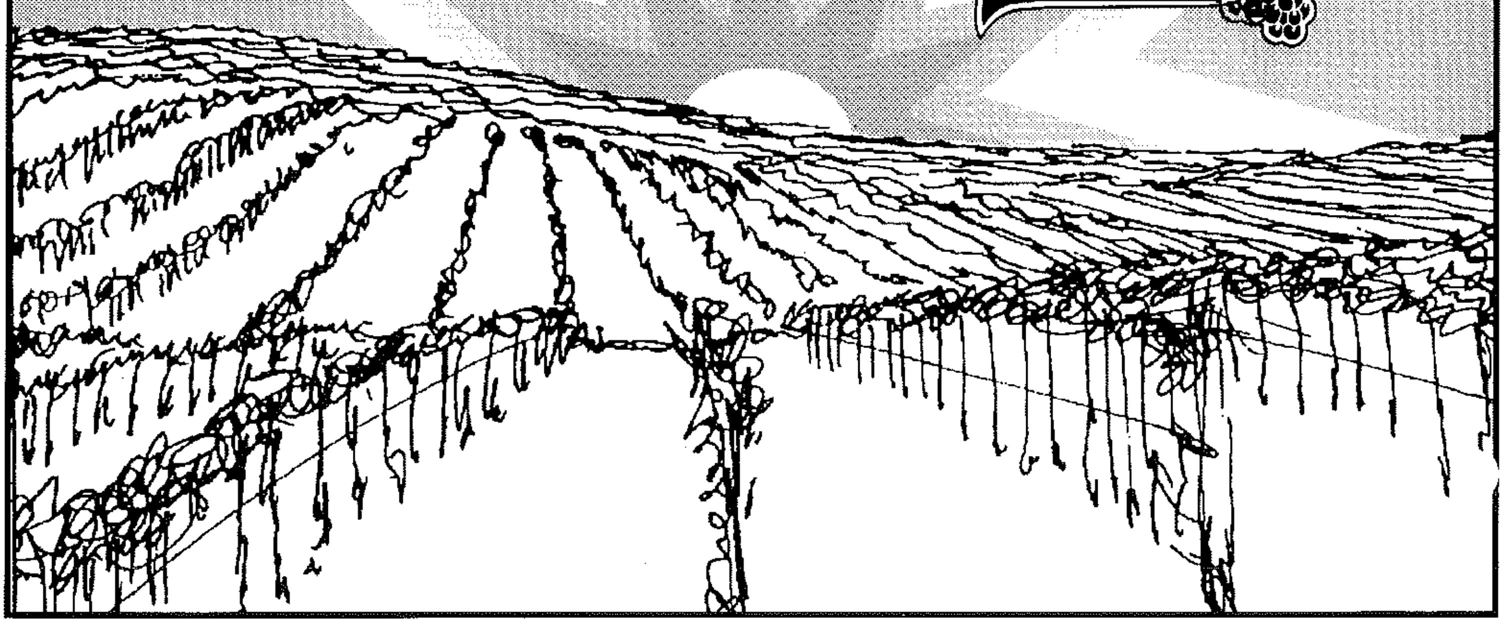

The vines were trained to a single high wire system and cane pruned. Three levels of cluster sun exposure were defined at the harvest: exposed (clusters on the top of the canopy with little or no leaf cover); moderately exposed (clusters receiving at least some sun exposure each day); and shaded (clusters that receive no direct sun exposure).

Quercetin content of grape berries and wine is shown in Fig. 4. In both grapes and wine, there was at least a six-fold difference in quercetin concentration with the highest quercetin concentrations found in the exposed treatment and the lowest in the shaded. There was no difference in the anthocyanin concentrations of grape berries or wine between the exposed and moderately exposed treatments, but the shaded treatment had significantly lower anthocyanin concentrations in both grape and wine, probably due to the larger berries in the shaded fruit and reduced anthocyanin synthesis.

Quercetin is only one of many compounds that were affected by light in this trial. Cluster sun exposure resulted in differences in cluster morphology, titratable acidity, malic acid, and other phenolic compounds. Catechins and caftaric acid were highest in wine from shaded clusters and caffeic acid and polymeric anthocyanins were highest in wine from sun-exposed clusters.

Some of the differences in these wines, such as quercetin, can be related directly to differences in fruit. Other phenolics in wine, such as caffeic acid and polymeric anthocyanins, are not present in fruit and are only formed in wine during fermentation and aging. It is possible that some of these fermentation and aging products are affected by the quercetin concentration in the wine.

Polymeric anthocyanins are particularly important for effects on wine color stability. Their concentration was highest in the wines with high quercetin levels. It may be that quercetin was combining with anthocyanins to form stable polymers. Although the anthocyanin concentrations in fruit from sun-exposed and moderately exposed positions were not different a year and one-half after crushing, wines from sun-exposed clusters were much darker than the wines from moderate and shaded cluster exposures.

We are currently investigating some of the quality implications of quercetin in wine and we are continuing our work on the effects of vineyard management techniques on quercetin and other phenolics in grapes. We are surveying commercial vineyards to determine the range of quercetin present in Pinot noir in Oregon, and are monitoring commercial wine lots from the same blocks.

The phenolic responses to cluster sun exposure are complicated, especially in wine. But our research effects on cluster sun exposure and wine phenolics has provided some insight. The response of quercetin was clear and unambiguous: increasing cluster sun exposure increases quercetin concentration in grapes and wine. The quality ramifications are more complex, however, and are still being actively investigated. ❑

Table Grapes to Move to 48 X 40 Pallet

Shippers of California table grapes will reduce the net weight of plain packed grapes and move to the 48 x 40 pallet beginning with the 1996 shipping season. The change was announced today by John Giumarra Jr., chairman of the California Table Grape Commission, who said that the weight change will enable the table grape industry to deliver an even better product to retailers and ultimately to consumers.

The weight change, which was voted in by the industry's elected representatives at the commission's winter meeting, results from findings of a three-year research project conducted by the University of California.

The objective of the research was to determine how to get fresh grapes from the vine to the consumer in optimum condition. The research, which focused on packing and shipping methods, sought to reduce bruising, shattering, and splitting of the product. The commission and the California Grape and Tree Fruit League collaborated in the study.

The vote is a recommendation to all shippers and growers that a weight change begin on April 1, 1996. The weight change is a reduction for plain pack grapes from 23 pounds to 21 pounds in the San Joaquin Valley and from 22 pounds to 20 pounds in the Coachella Valley. According to Bruce Obbink, president of the commission, the weight reduction is based on the research which clearly show that the grapes arrive at their destination in optimum condition when packed at the new weight levels.

According to Giumarra, the change in the grape packing weights was needed to maximize the quality of the delivered product. Giumarra also pointed out that the weight reduction will have the added benefit of allowing the industry to accommodate receiver needs through industry-wide use of the 48 x 40 pallet.

This spring the industry will petition the California Department of Food and Agriculture to change the California agricultural code to reflect the recommended weight changes. ❑