Physiological responses of white grape berries to sunlight exposure

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Viticulture and Enology

Sunlight exposure: what is the point?

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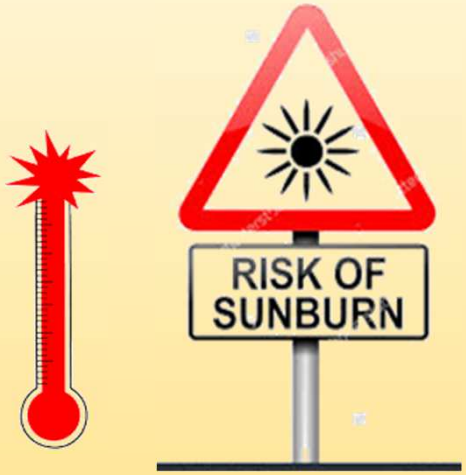
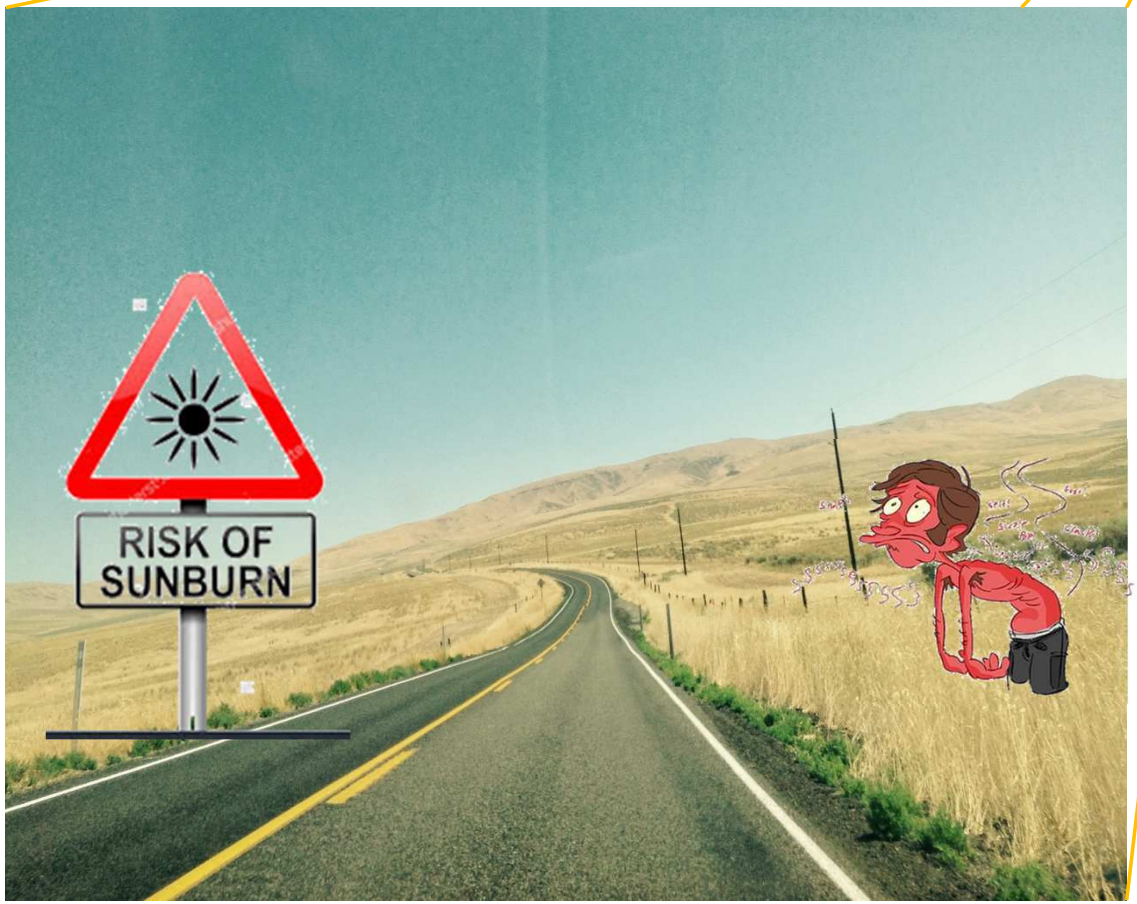
Sunlight exposure: what is the point?



I thought I was safe, but no!

The SPF number lied to me!

Washington State



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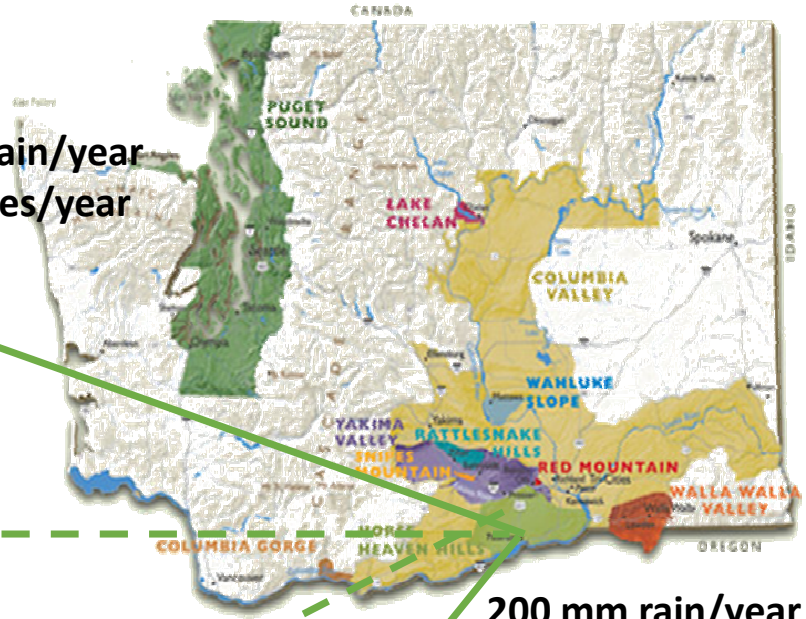
7000 mm rain/year
-> 275 inches/year



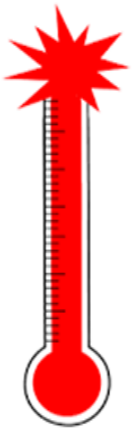
200 mm rain/year
-> 8 inches/year

Let’s see what could happen to the berries…

Excessive sunlight and temperature

Two possible physiological responses:

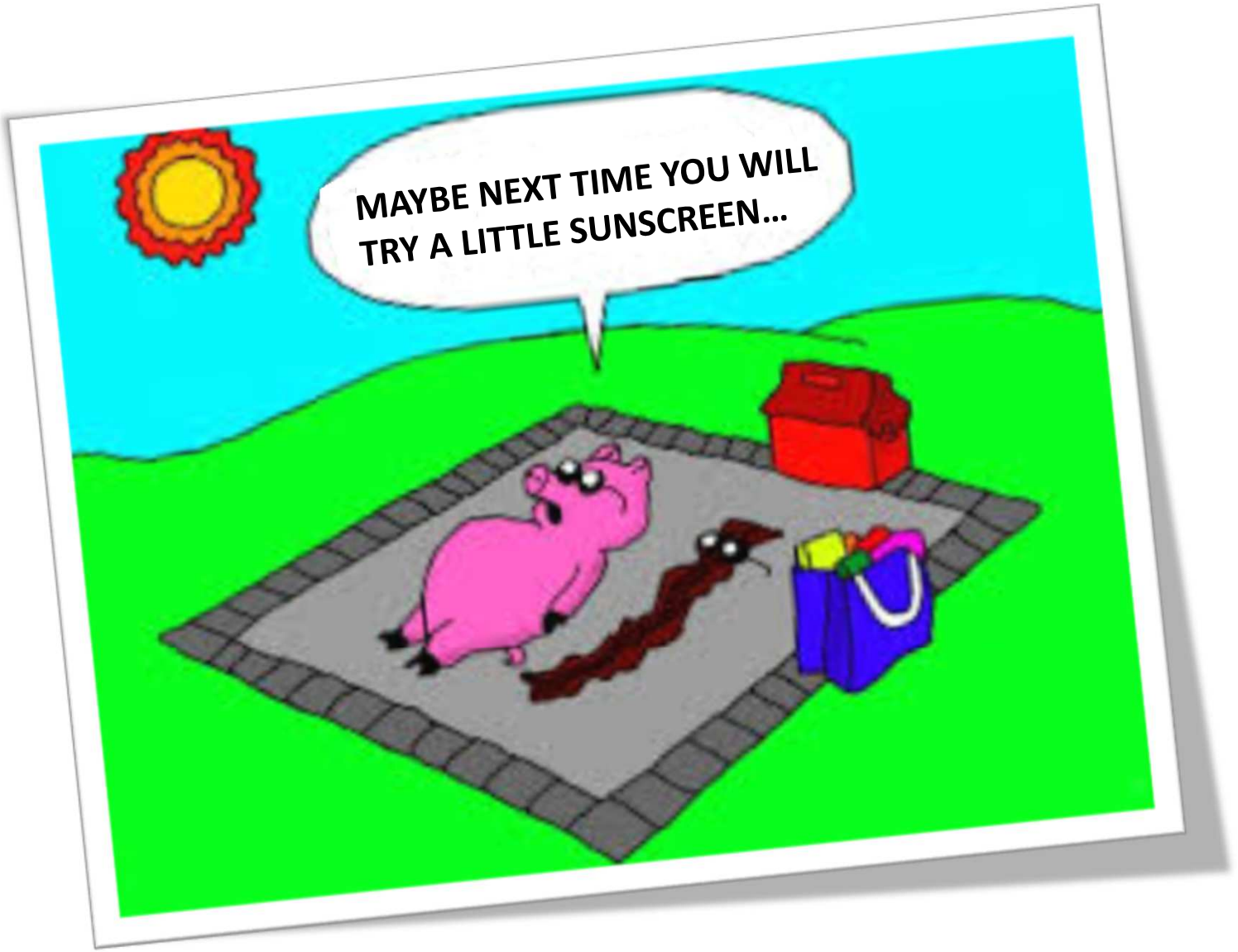
- Tolerance
- Susceptibility



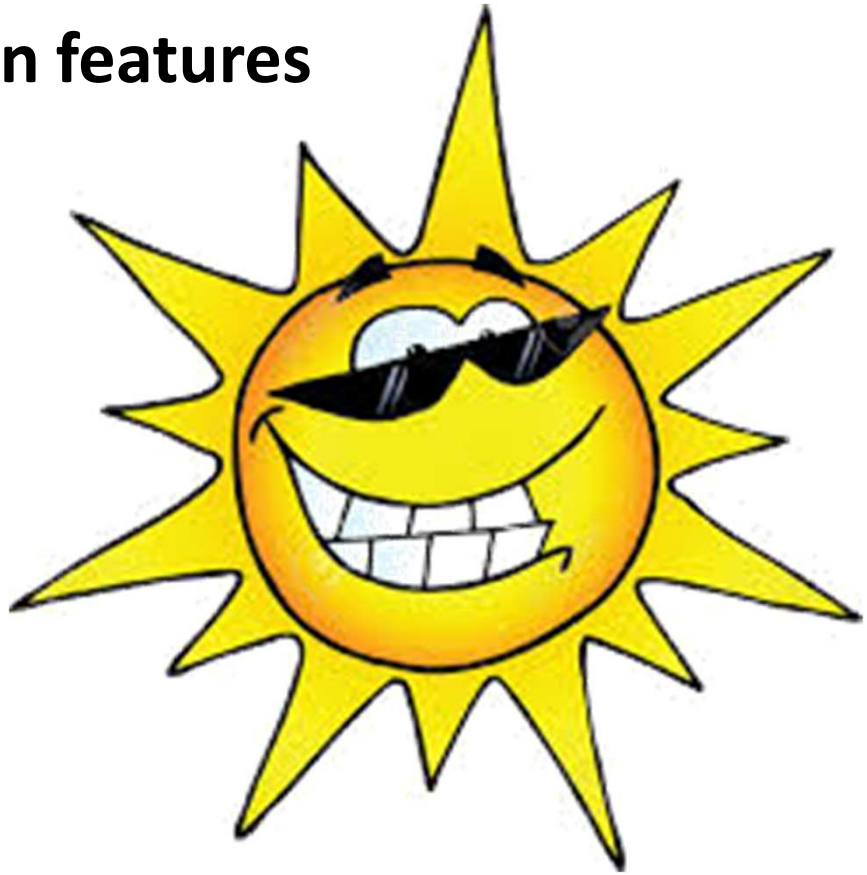
➢ Susceptibility

- Dehydration
- Collapse of the whole berry
- Eventually turns brown in color

= loss of yield


MAYBE NEXT TIME YOU WILL
TRY A LITTLE SUNSCREEN…

Sunburn features



- Polished appearance of the skin
- Shiny surface
- Brown lesions

How could excessive sunlight exposure affect berry quality?

How could excessive sunlight exposure affect berry quality?




…Thus the wine quality?

Grape condition: damaged berries

1. Excessive light exposure might results in undesirable **bitter characters** and **loss of flavor**, and **sunburn**, if severe

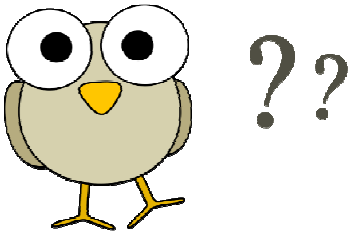
2. Processing grapes for wine could be difficult when berries are excessively dehydrated, **increasing winery costs**

3. **Loss of income** to the grower through **reduced weight**

4. Whereas berry damage is severe, the **price** for the grapes might be **reduced** or the **grapes rejected**

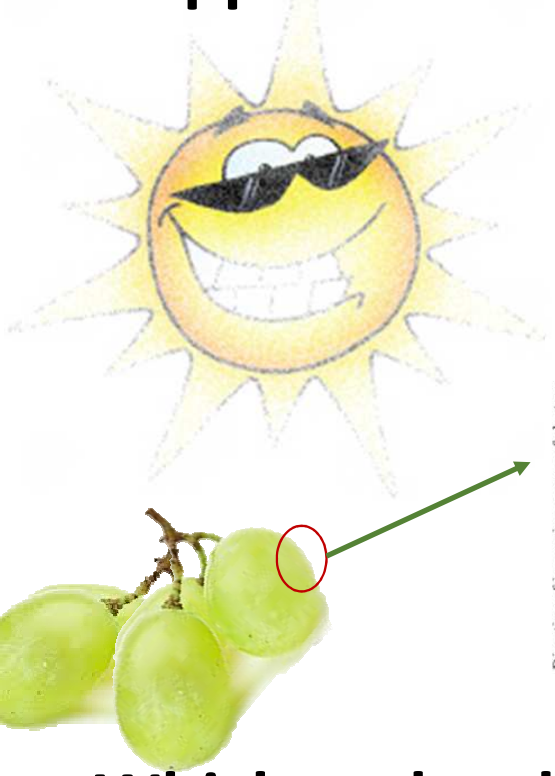
Background hypothesis

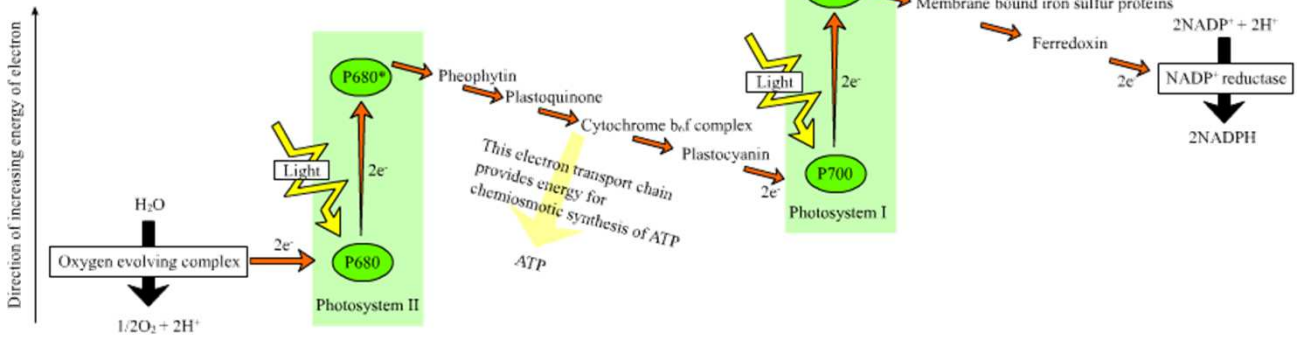
What could affect the physiological responses (tolerance or susceptibility) of white grape berries to sunlight exposure?



What happen when the sunlight reaches the berries?

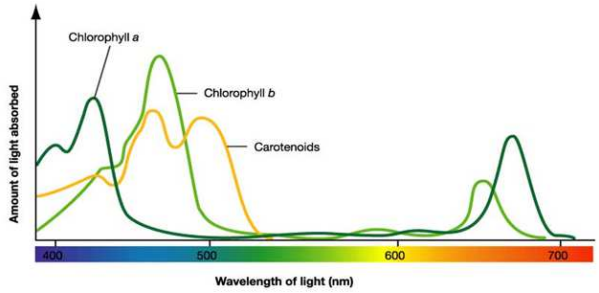
Background hypothesis





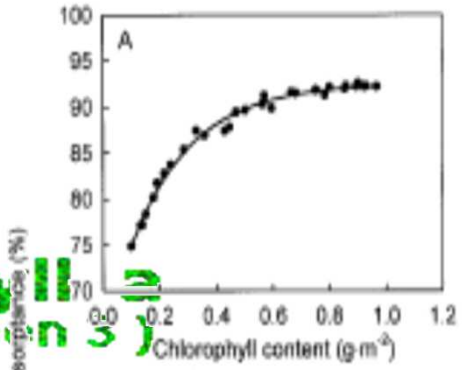
Which molecules could be involved in the sunburn process?

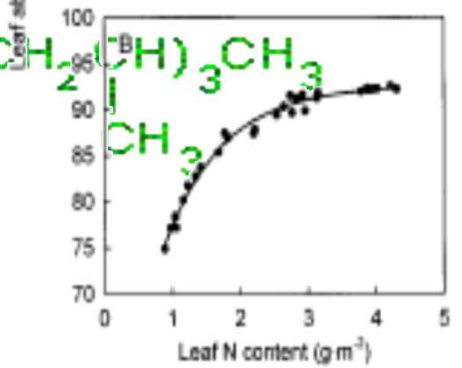
- Chlorophylls
- Carotenoids
- Flavonoids

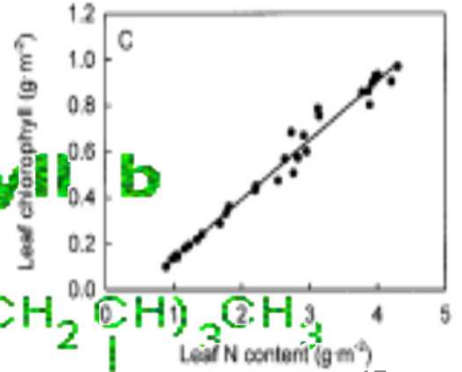


Chlorophyll:

- **Closely related to plant stress and senescence**
  (Hendry 1987, Merzlyak *et al*. 1995)
- **Indirect estimation of plant nutrient status** **(Filella *et al.* 1995, Moran *et al*. 2000)**
- **Indirect estimation of berry radiative condition during ripening** **(Rocchi et al. 2016, Rustioni et al. 2014)**

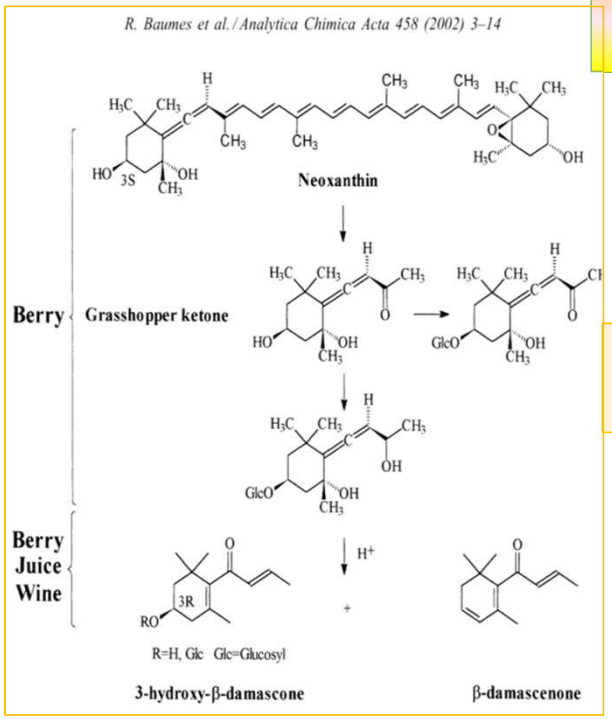


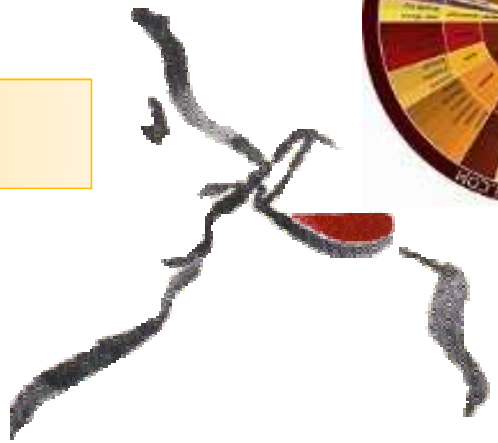




(Cheng et al. 2000)

Carotenoids:





- **Aromatic precursors**

- **Light harvesting & protection mechanism**

By quenching the excited state of the Chl releasing energy in the form of heat

By participating in the process of **not photochemical extinction** of Chl fluorescence (associated predominantly to PSII and PSBS to the protein) (Li et al. 2000).

Flavan3ols and proanthocyanidins

- **The flavan-3-ols and their polymers are accumulated in significant quantities in *V. vinifera* berries** (Kennedy, Matthews and Waterhouse 2000, Kennedy and jones 2001)

- **The vine vigor affected the tannin content and composition of grape skins** (Cortell, et al. 2005)

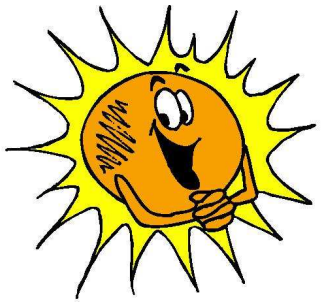
- **In the wine from a sensory standpoint, the flavan-3-ols are compounds that elicit bitterness and proanthocyanidins elicit astringency** (Yaminishi 1990) .

tannin powder

Flavonols

- They accumulated as result of different kinds of stress (Agati, *et al.* 2011, Kidd, *et al.* 2001, Haselgrove, *et al.* 2000, Cockell and Knowland 1999, Price *et al.* 1995)

- Their concentration and biosynthesis are affected by sun exposure (Price *et al.* 1995, Downey *et al.* 2003)



- As yellowish pigment they contribute to the color of the fruit (Van Der Meer, *et al.* 1992)

- They contribute to the bitterness of the wine (Gawel *et al.* 1998)

Background hypothesis

Could a decrease or increase in photosynthetic pigments and flavonoids be:

- Good descriptors for berry physiological response to excessive sunlight and temperature exposure?
- Good estimators of varietal tolerance and/or susceptibility to radiative stress?

2013

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Characterization of Grape (*Vitis vinifera* L.) Berry Sunburn Symptoms by Reflectance

Laura Rustioni,* Letizia Rocchi, Eugenio Guffanti, Gabriele Cola, and Osvaldo Failla

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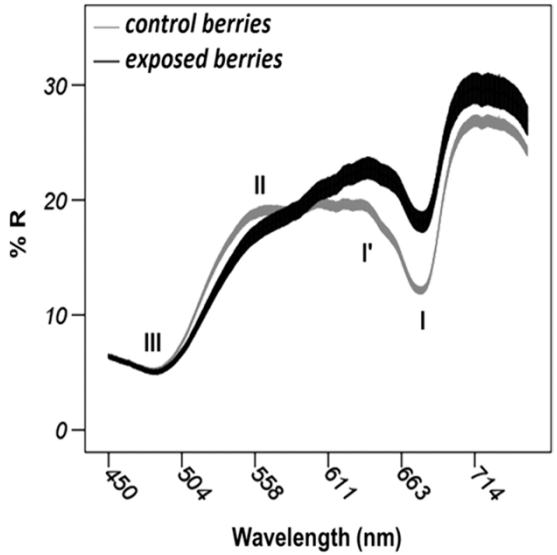

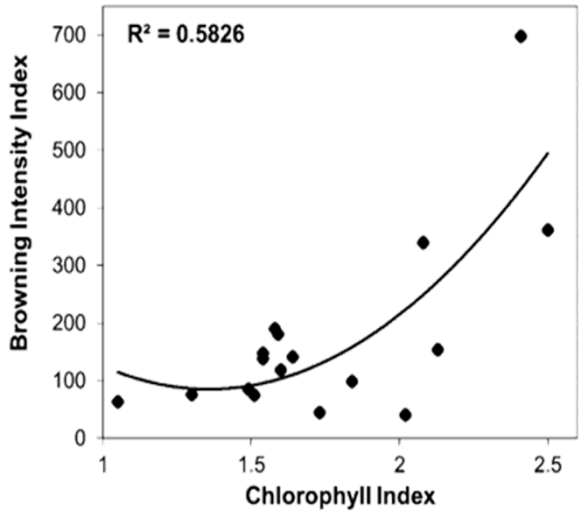

- Highlight the variation in reflectance spectra caused by sunburn symptoms appearance
- Identify the relationship between the browning appearance and the compositional markers of sunburn predisposition
- Proposal of the use of the Chlorophyll Index threshold as a marker for grape susceptibility to sunburn

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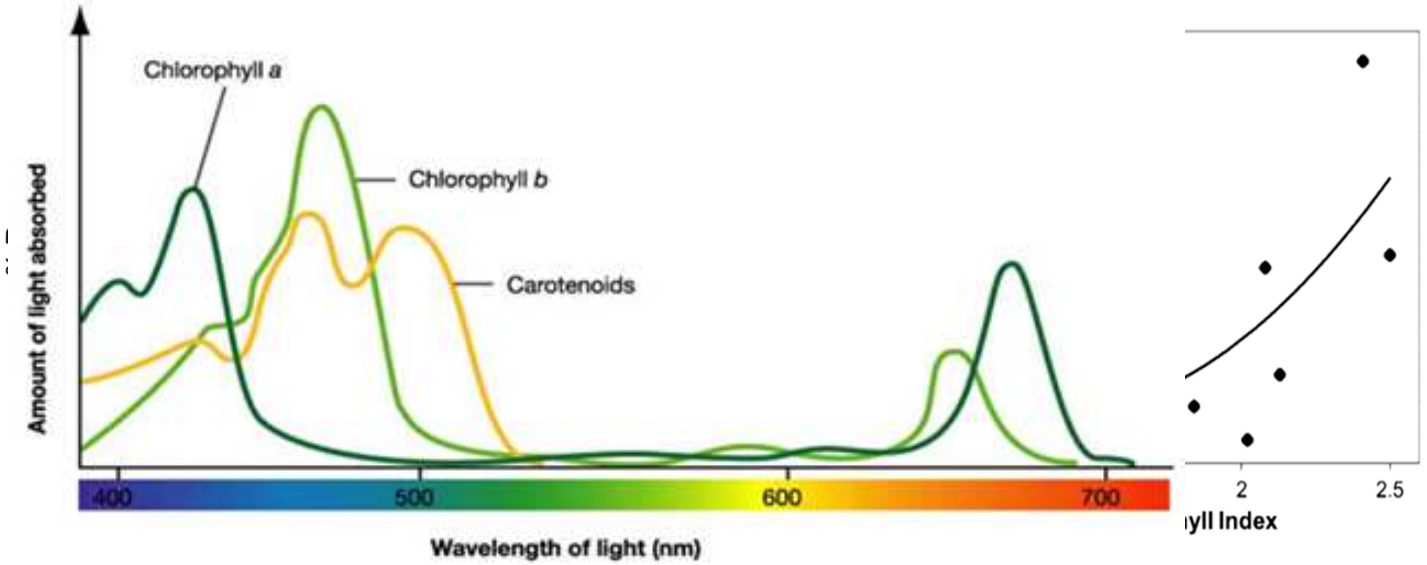

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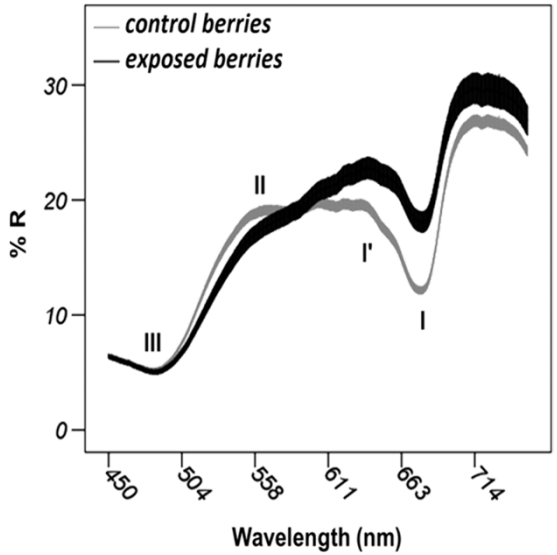

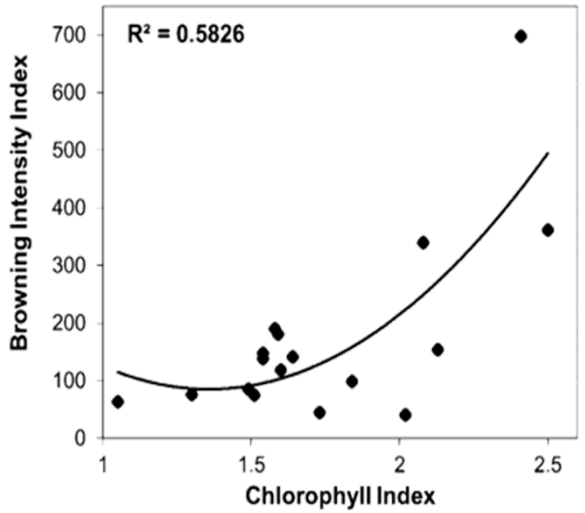

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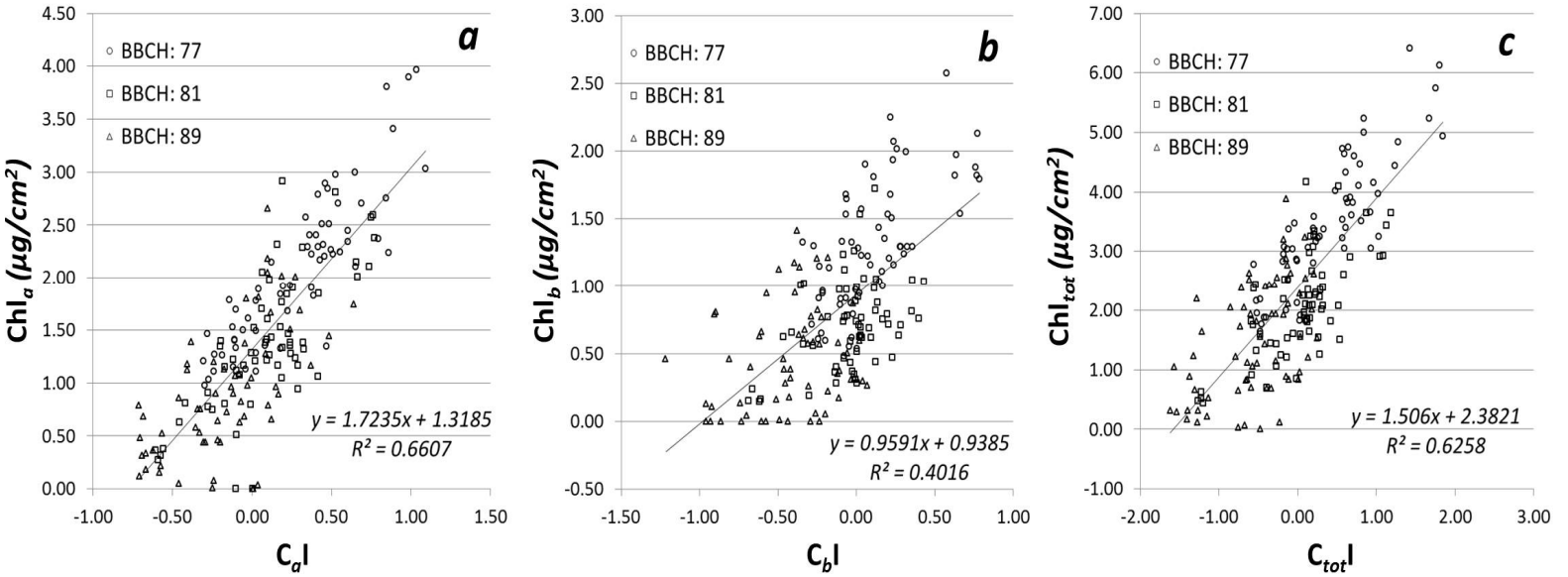
Vitis **55**, 11–16 (2016) DOI: http://dx.doi.org/10.5073/vitis.2016.55.11-16

2013

Chlorophyll and carotenoid quantifications in white grape (*Vitis vinifera* L.) skins by reflectance spectroscopy

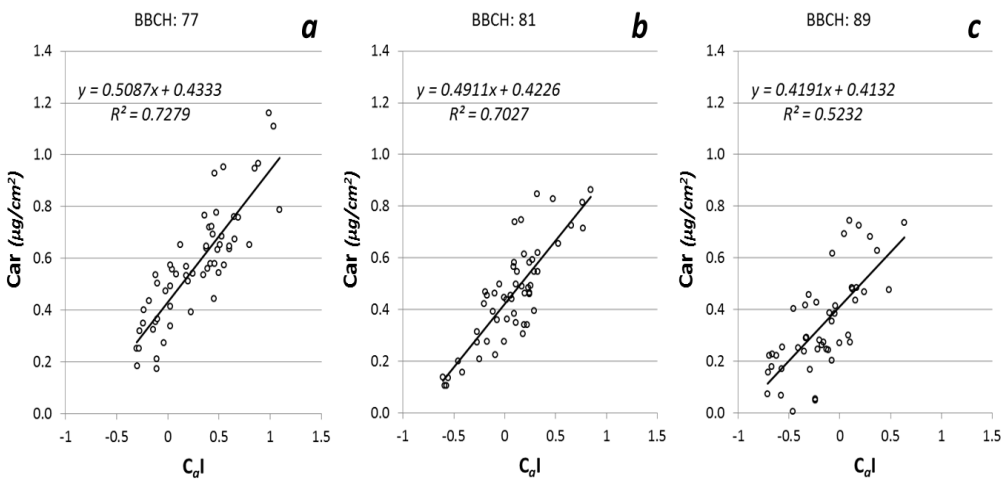
L. Rocchi, L. Rustioni and O. Failla

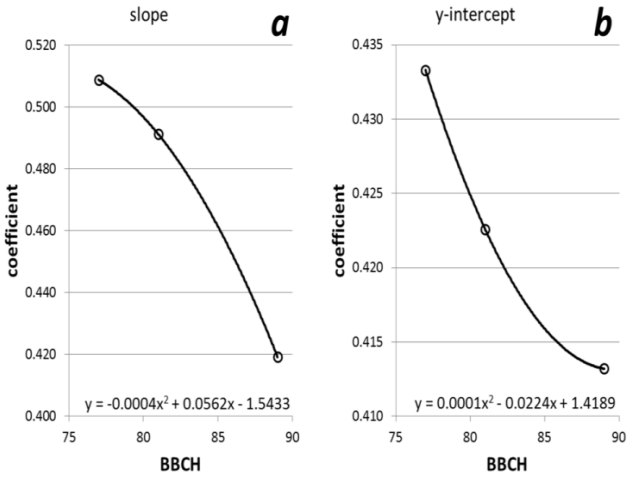
Università degli Studi di Milano, CIRIVE - Centro Interdipartimentale di ricerca per l'innovazione in Viticoltura ed Enologia, Milano, Italy



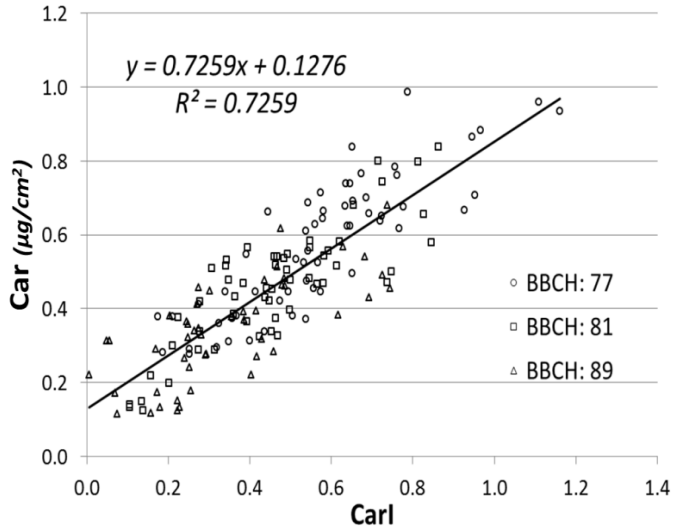
Ca I	$\log[(R_{800}/R_{675})-(R_{800}/R_{660})]$
Cb I	$\log[(R_{800}/R_{650})-(R_{800}/R_{630})]$
Ctot I	$(C_a I+C_b I)$

- **New specific reflectance indices for the evaluation and estimation of photosynthetic pigments are proposed on the basis of grape berry reflectance spectra**





$CarI = a * C_aI + b$

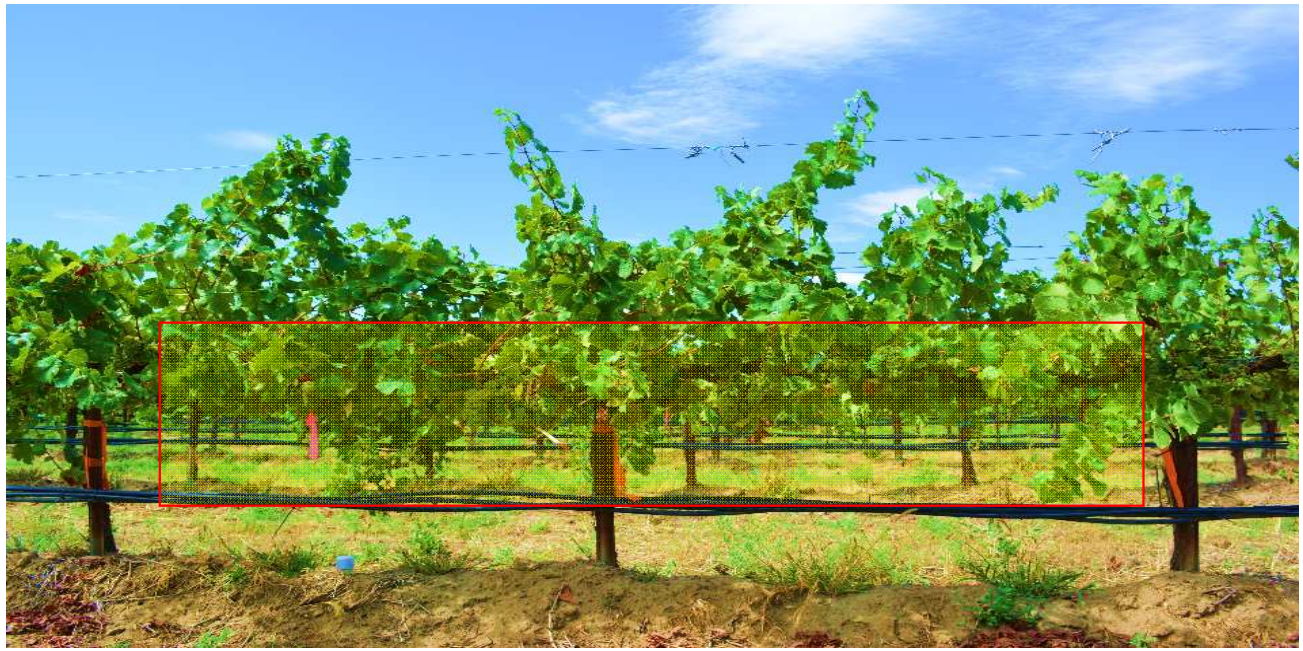


- **A new carotenoid index (CarI) was obtained on the base of the relationship between carotenoids and chlorophyll *a,* at each BBCH phenophase in the range from 77 (pre-veraison: "berries beginning to touch") to 89 (ripening: "berries ripe for harvest")**

Other possible causes determining excessive clusters exposure

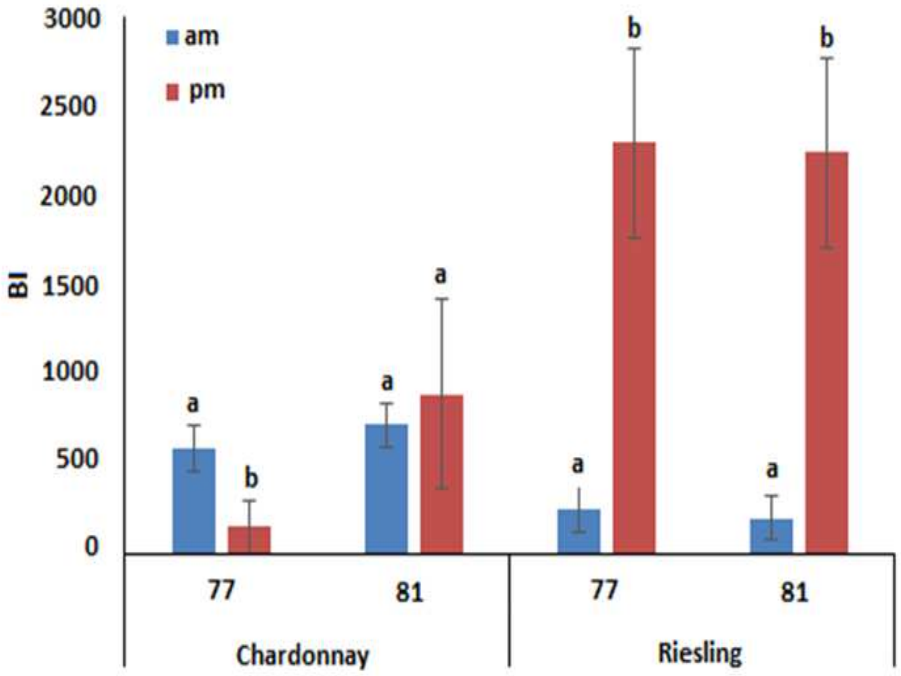
- Unfavorable seasonal conditions (extended hot periods and light stress)
- Water stress, poorly timed application of RDI **-> leaf loss**
- Inappropriate canopy management

-> bunches over exposure



Impact of the cultural practices on sunburn appearance

2013



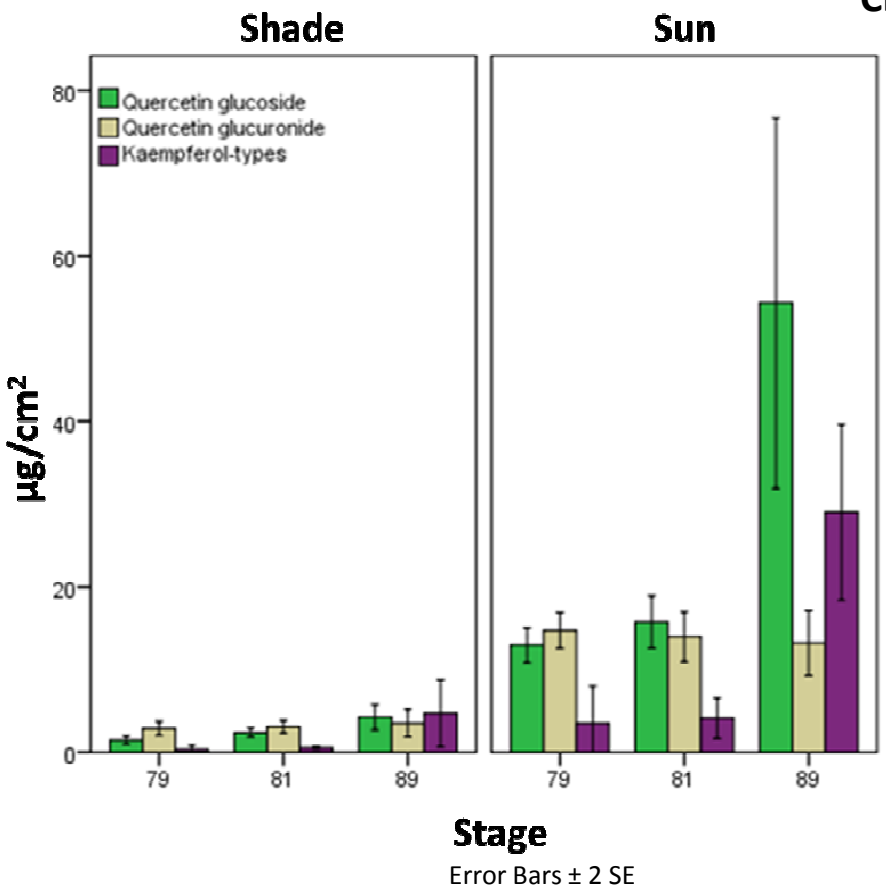
ChI Index: 8.13; 4.34

ChI Index=8.44; 4.35

- Each variety shows a different susceptibility to sunburn.
- The timing of leaf removal during the day is fundamental to reduce the appearance of sunburn symptoms.

- ✓**High light regimes** potentially stimulated a protection mechanism in the skin, **increasing flavonols** over the season.

Chardonnay 2014: flavonols trend over the season



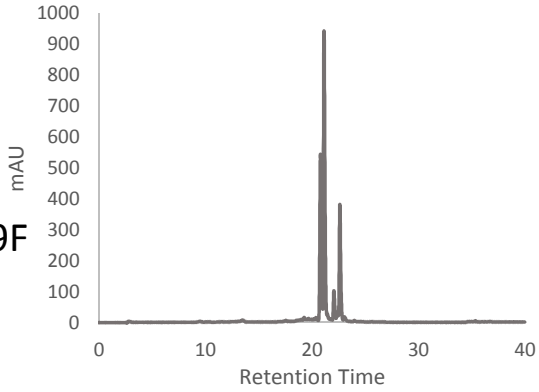
Error Bars ± 2 SE

Variety	Exposure	Irrigation	Hours T> 40 °C	Hours T> 50 °C	L_{mean} (Lux)
Chardonnay	sun	FI	116	13	25157 ± 45292
	shade	FI	4	0	6847 ± 11055
	sun	DI	150	13	29121 ± 50575
	shade	DI	82	3	14460 ± 30760

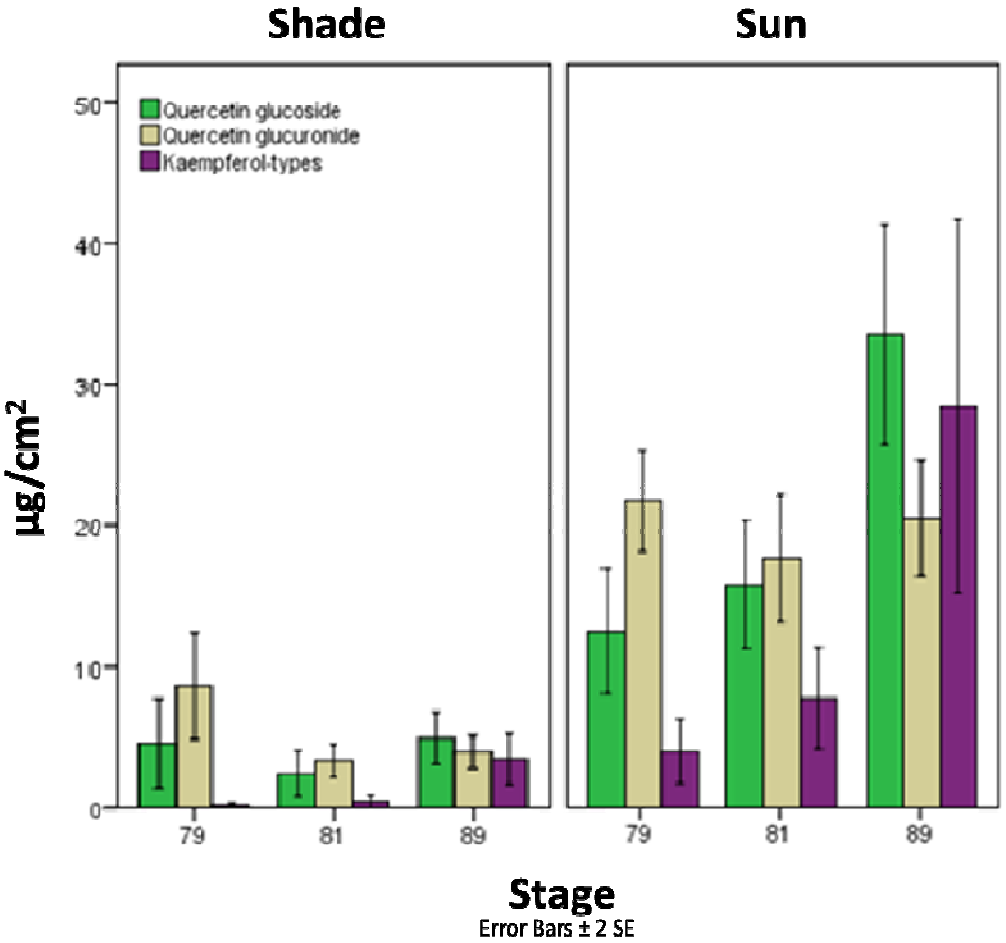
	Stage			Exposure
	79	81	89	Sig.
Quercetin glucoside	b	b	a	***
Quercetin glucuronide	a	a	a	***
Kaempferol-types	b	b	a	***

T_{max}=54°C= 129F

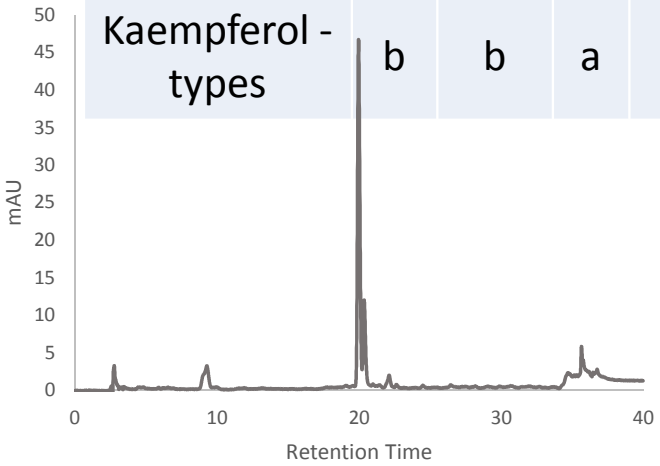
T_{min}=13°C=55F



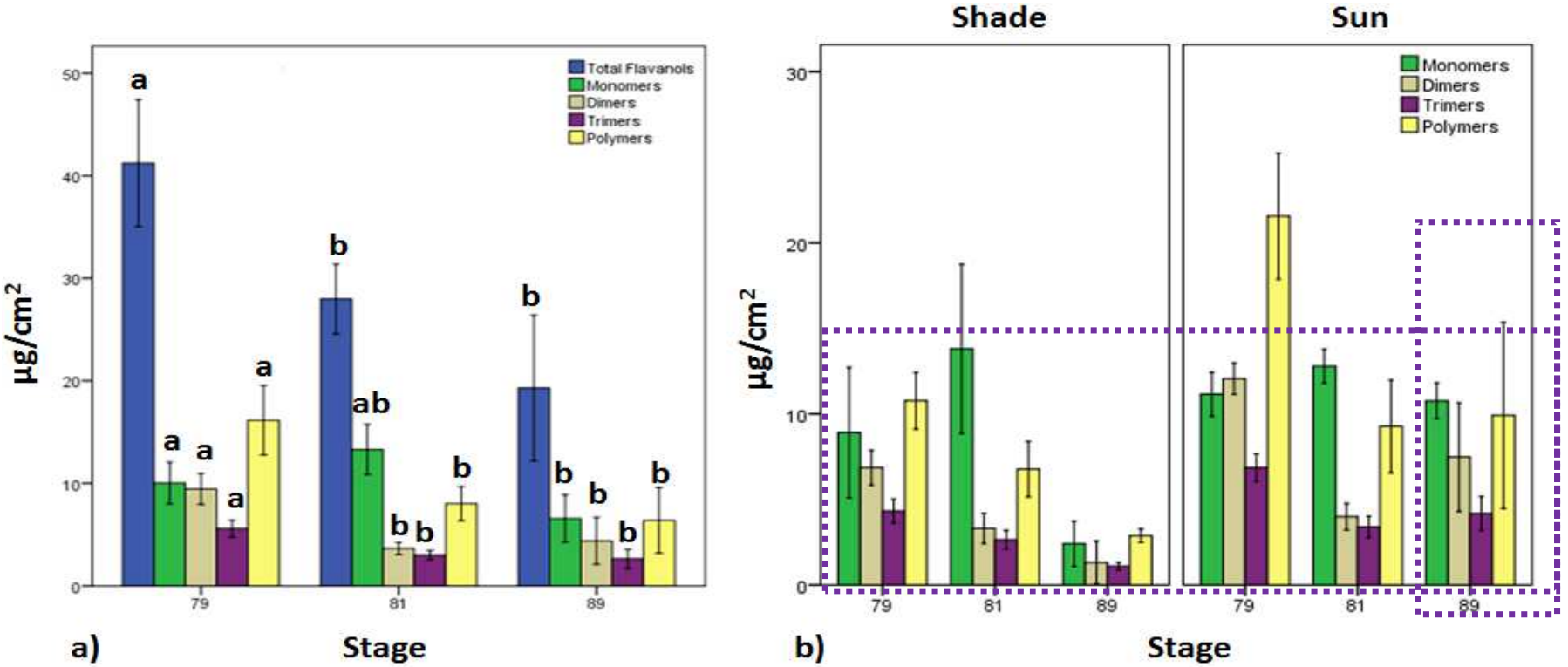
Riesling 2014: flavonols trend over the season



	Stage			Exposure
	79	81	89	Sig.
Quercetin glucoside	b	b	a	***
Quercetin glucuronide	a	a	a	***
Kaempferol - types	b	b	a	***



✓ **Flavanols** also had **highest concentration in the sun**;

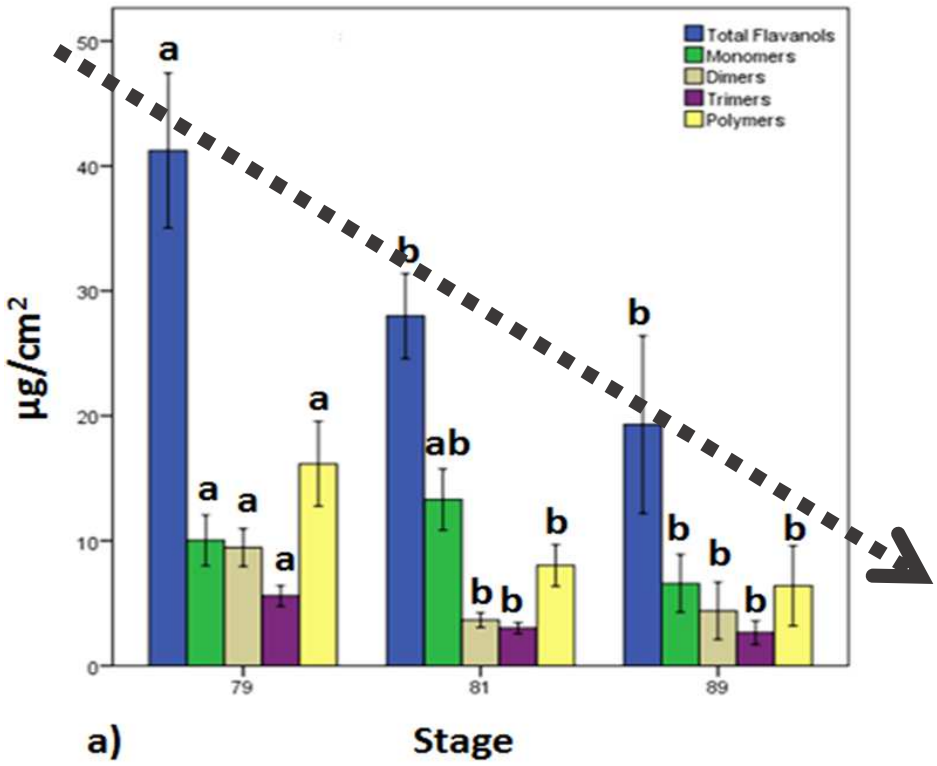


➢ it could be speculated a **possible involvement** of these molecules in the **photo-protection mechanisms** of the berry.

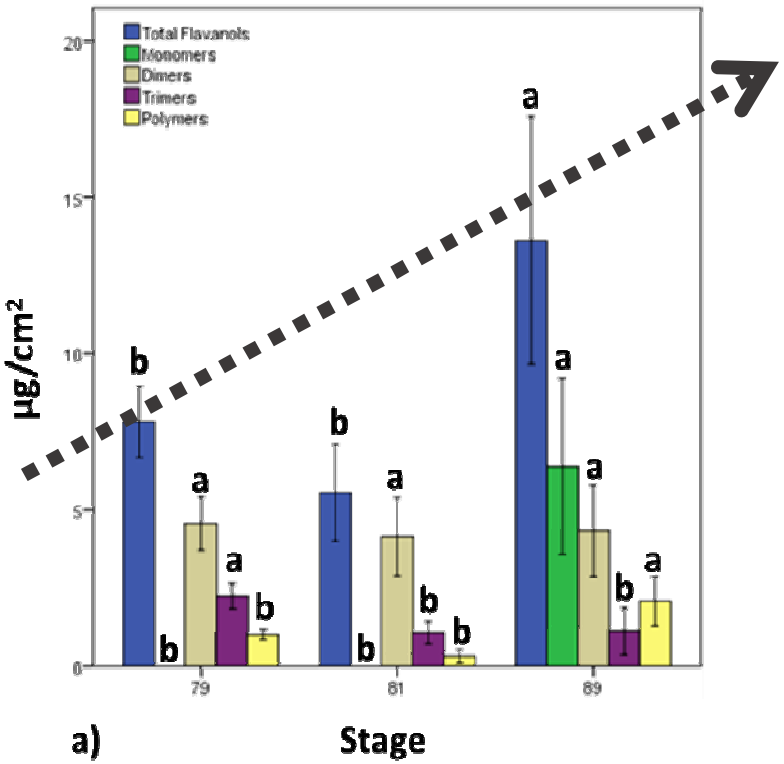
Chardonnay 2014

✓ **Hot temperature** did not affect flavonols biosynthesis, but **could** have had a role in significantly **reduced flavanol formation** in **Chardonnay**, especially **at harvest**.

Chardonnay 2014



Riesling 2014



- ✓Chardonnay had much higher flavanol concentration than Riesling.

- ✓ **No effects** on flavonol accumulation were **directly due to the irrigation** regimes in either cultivar.

Conclusion 2014

- **Leaf area reduction** as consequence of water deficit, thus **irrigation regime management**, seems to **indirectly affect** the **flavanols and flavonols** by providing **high exposure of fruit**, also generating sunburn appearance.

- Thus to avoid late and unpleasant disappointment it is important to choose:

✓ The more suitable **rows orientation**

- ✓ To avoid **trellis system** that have **excessive fruit exposure**
- ✓ To avoid **severe leaf removal**

Conclusion and Perspective

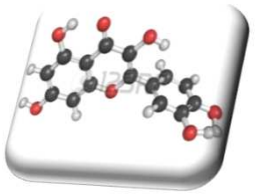
It could be interesting:

- to **separate** the effects of **light** from those of **temperature** on the biosynthesis of these compounds.

- to **separate vinification** of grapes according to fruit exposure, under different irrigation regimes, **to support** both **growers** and **winemakers**, in terms of:

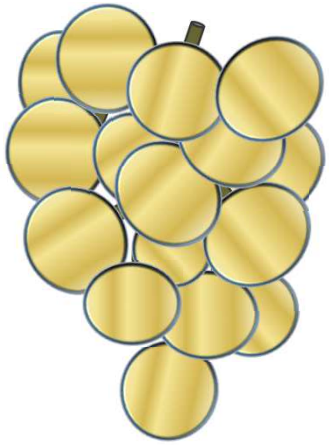
  - **canopy** and **water stress management**,
  - the final **wine** and its **style**.

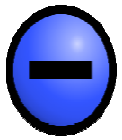
MORE SUN



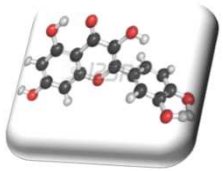
MORE FLAVONOLS AND FLAVANOLS

MORE BITTERNESS AND ASTRINGENCY





LESS SUN



LESS FLAVONOLS AND FLAVANOLS

LESS BITTERNESS

These projects are planned in the framework of the

- **USDA Specialty Crops Block Grant**

- **Washington State Grape and Wine Research Program**

- **COST Action FA1003** – *Grapenet: East-West Collaboration for Grapevine Diversity Exploration and Mobilization of Adaptive Traits for Breeding*

- **Innovine European Project** – *Combining innovation in vineyard management and genetic for a sustainable European viticulture*

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Thank you!

Letizia Rocchi