An exploration of phenolics in Central Coast wines: Chemical and Sensory Effects of Selected Winemaking Techniques

WiVi Central Coast
March 30th, 2022

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CAL POLY
Wine & Viticulture
COLLEGE OF AGRICULTURE, FOOD & ENVIRONMENTAL SCIENCES

Outline

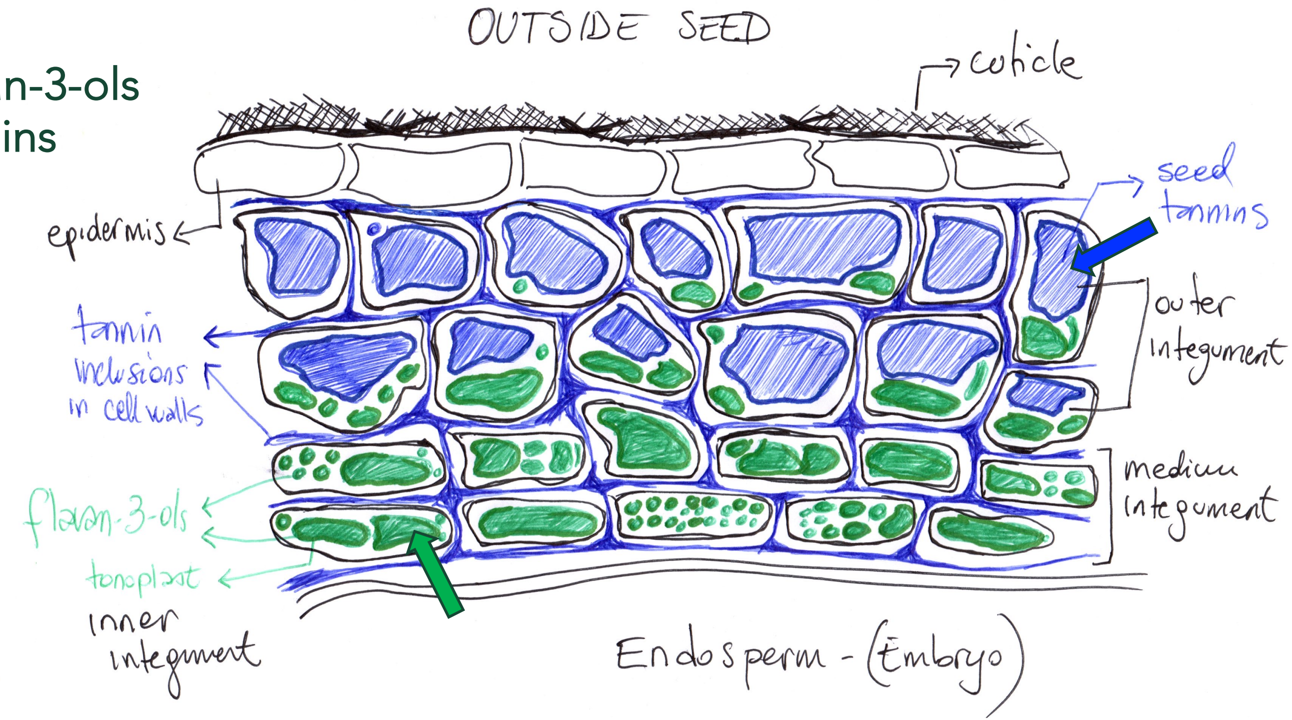
- From cellular structure, location and retention…

  to

- Sensory impact
- Conclusions

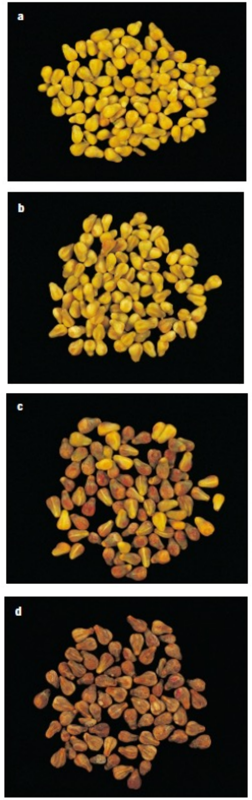
Seed microstructure and chemistry

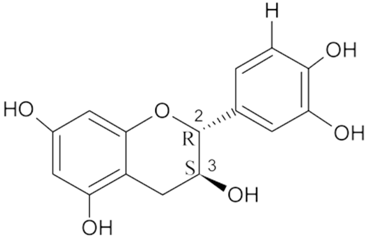
flavan-3-ols
tannins



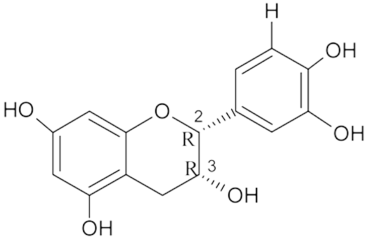
Casassa et al, 2018, Unpublished

Monomeric flavan-3-ols

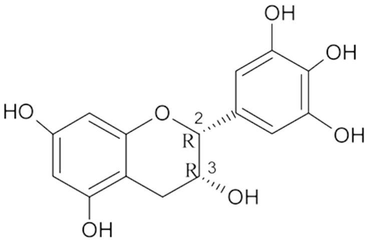




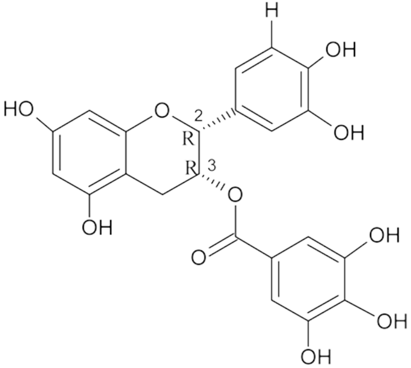
(+)-catechin



(-)-epicatechin



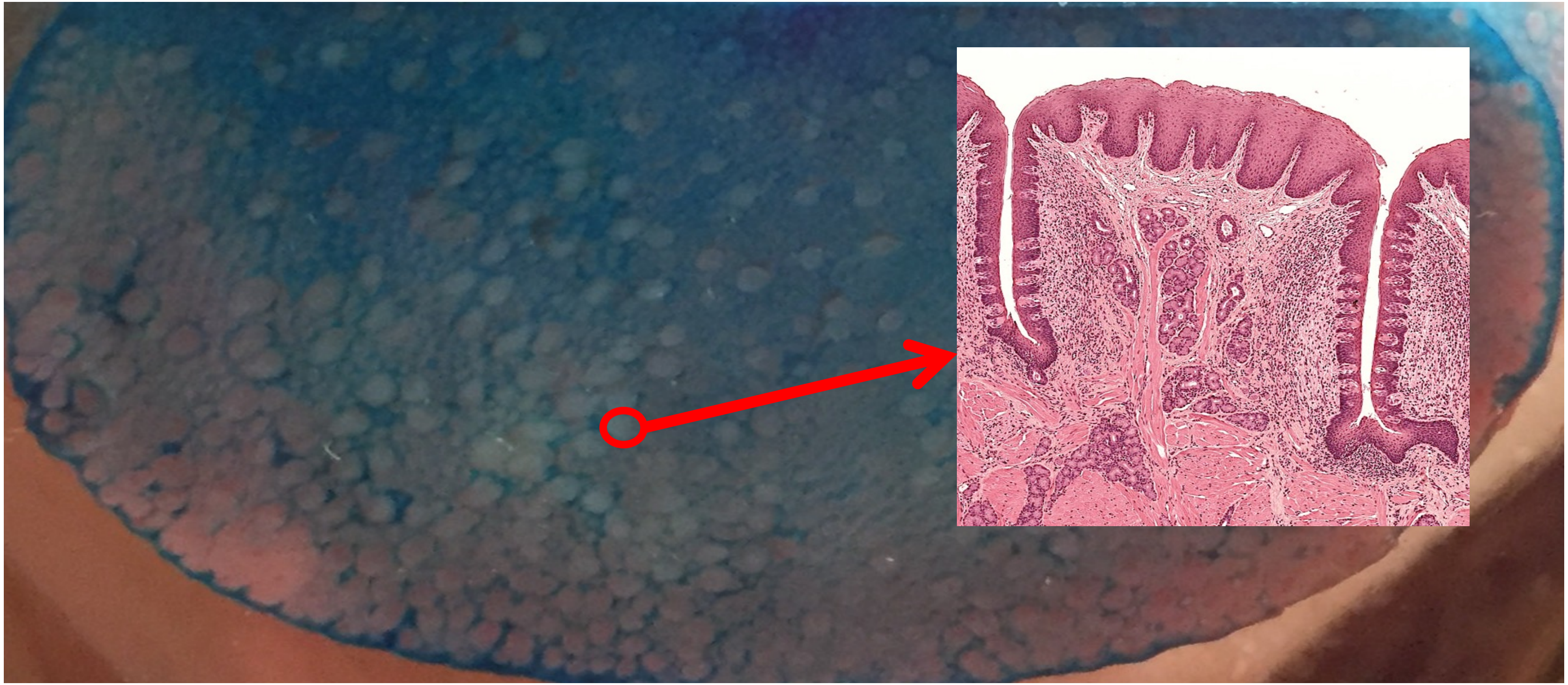
(-)-epigallocatechin



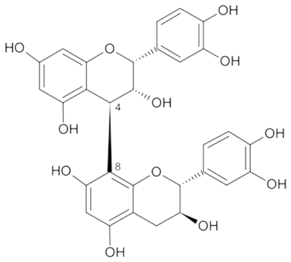
(-)-epicatechin-3-*O*-gallate

0.5 to 0.8 mg/berry

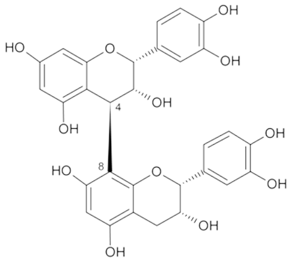
Monomeric flavan-3-ols



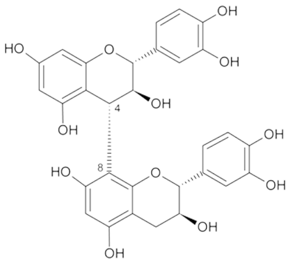
Dimers



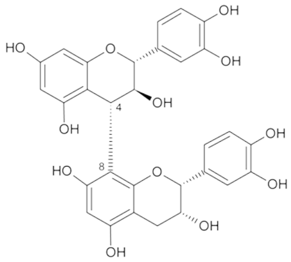
proanthocyanidin B1



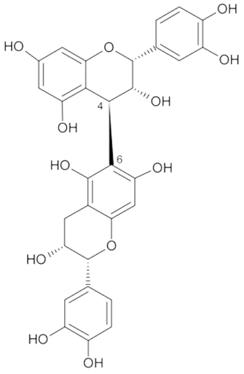
proanthocyanidin B2



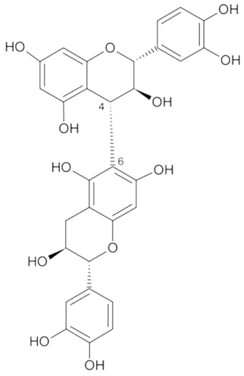
proanthocyanidin B3



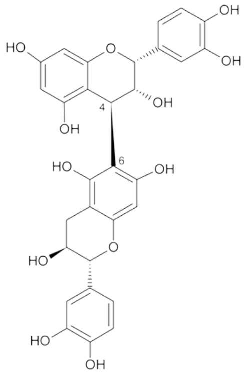
proanthocyanidin B4



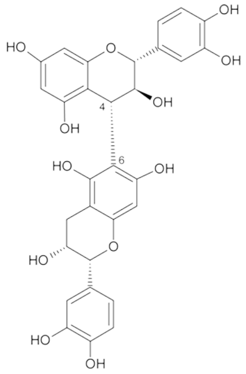
proanthocyanidin B5



proanthocyanidin B6



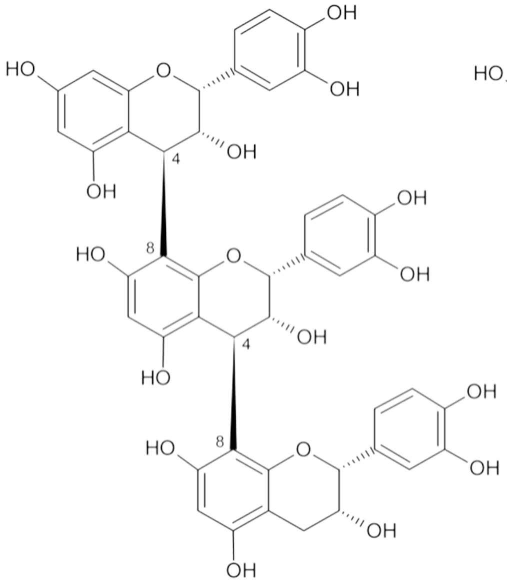
proanthocyanidin B7



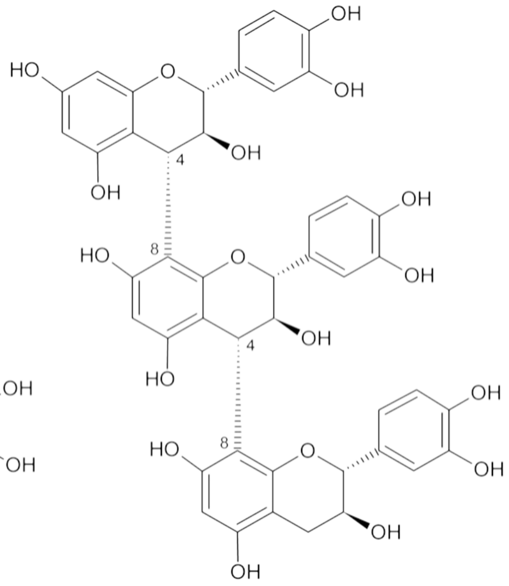
proanthocyanidin B8

Trimers (and above)

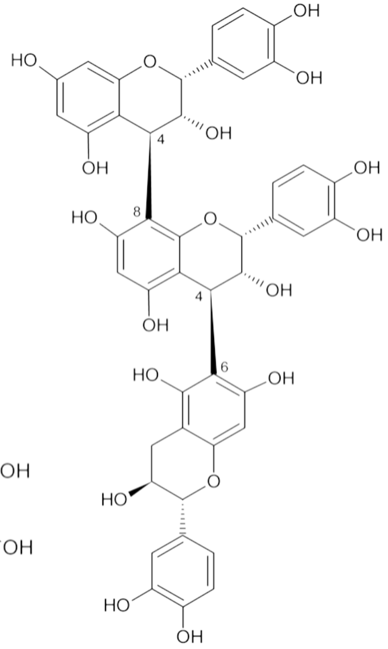
3 to 5 mg/berry



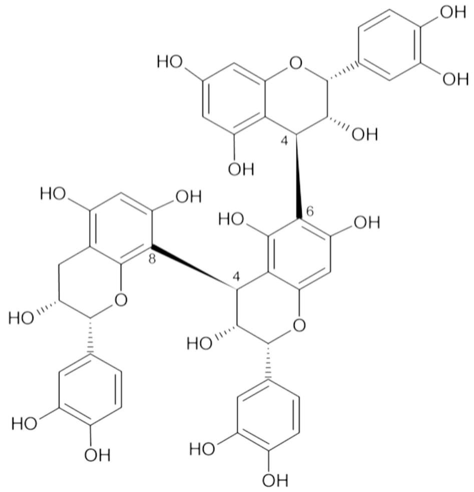
proanthocyanidin C1



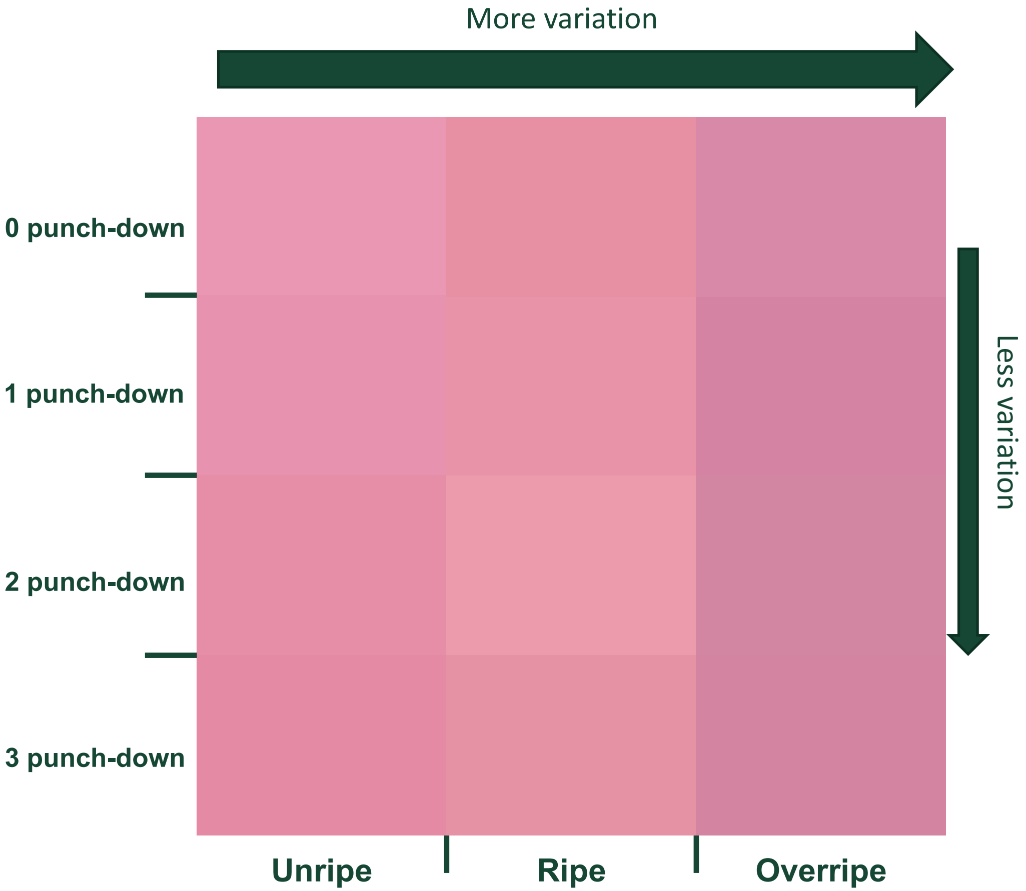
proanthocyanidin C2

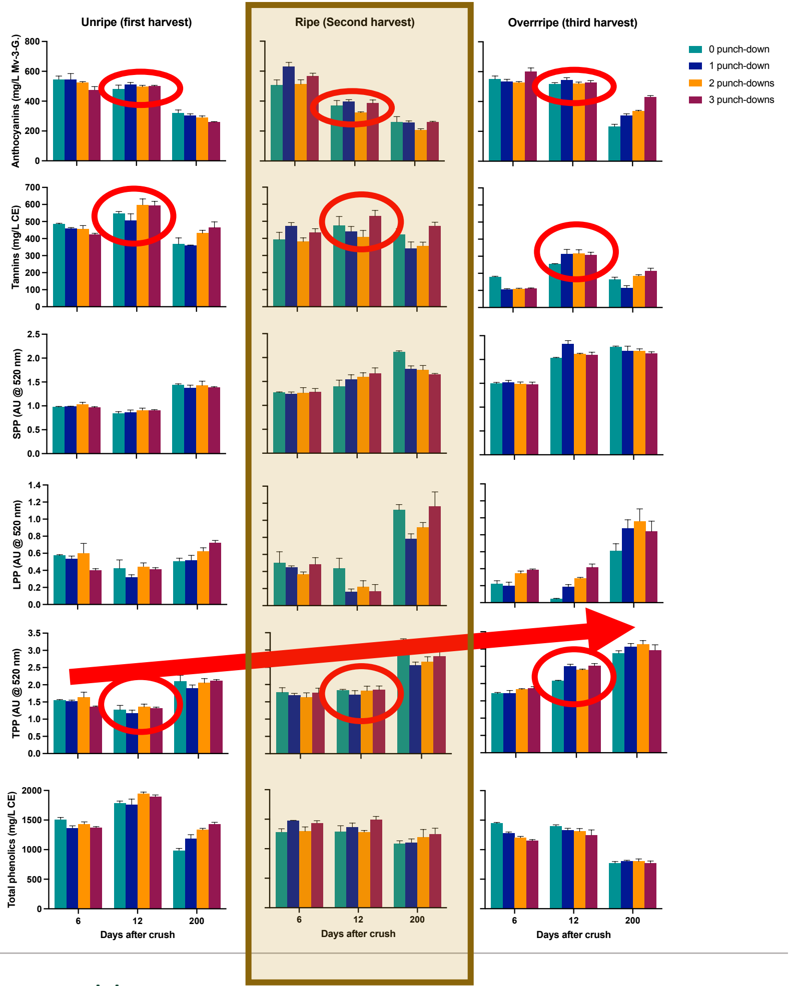


proanthocyanidin T3



proanthocyanidin T4

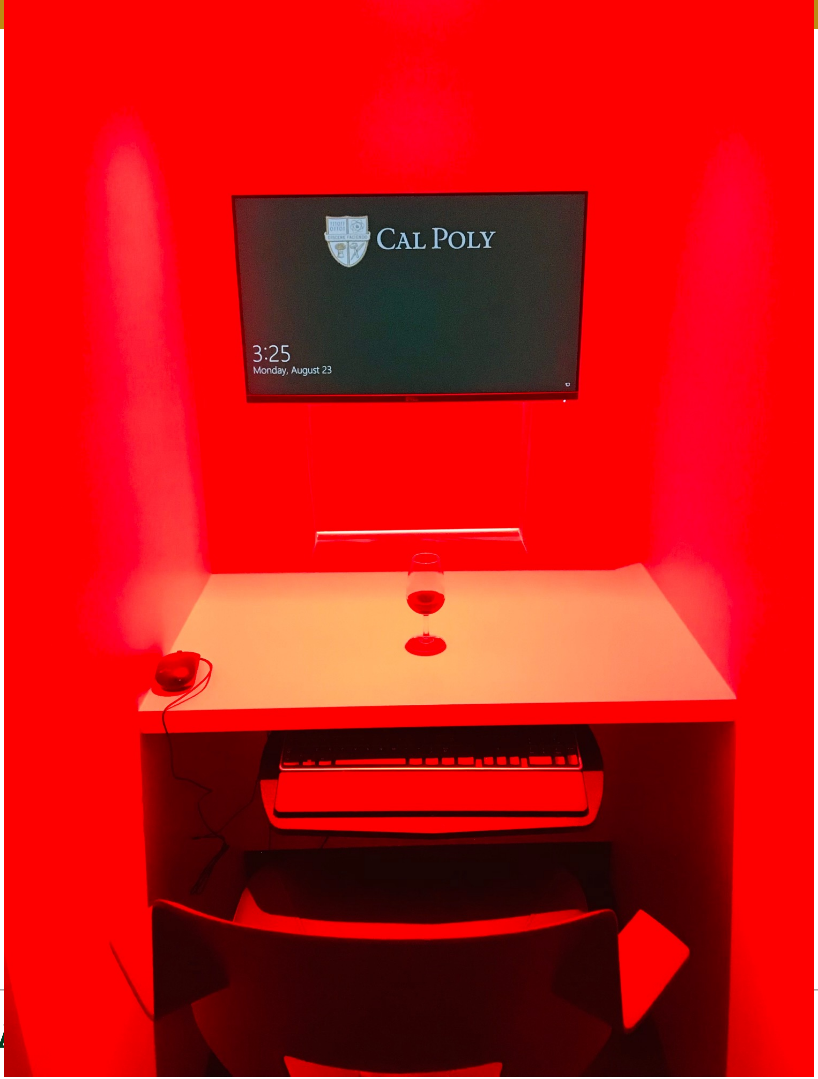




Color of the wines as seen through a 1 mm pathlength cuvette

Cabernet S., 2020, Sunnybrook Ranch, Paso Robles

Casassa Lab, 2021, unpublished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3:25
Monday, August 23

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4:00
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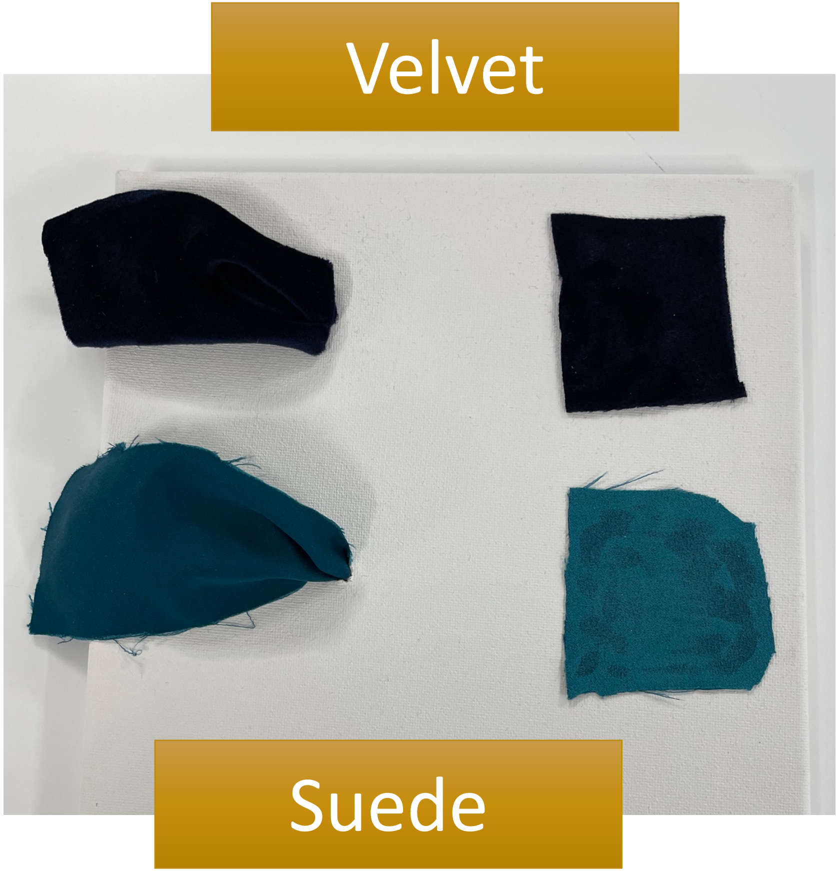
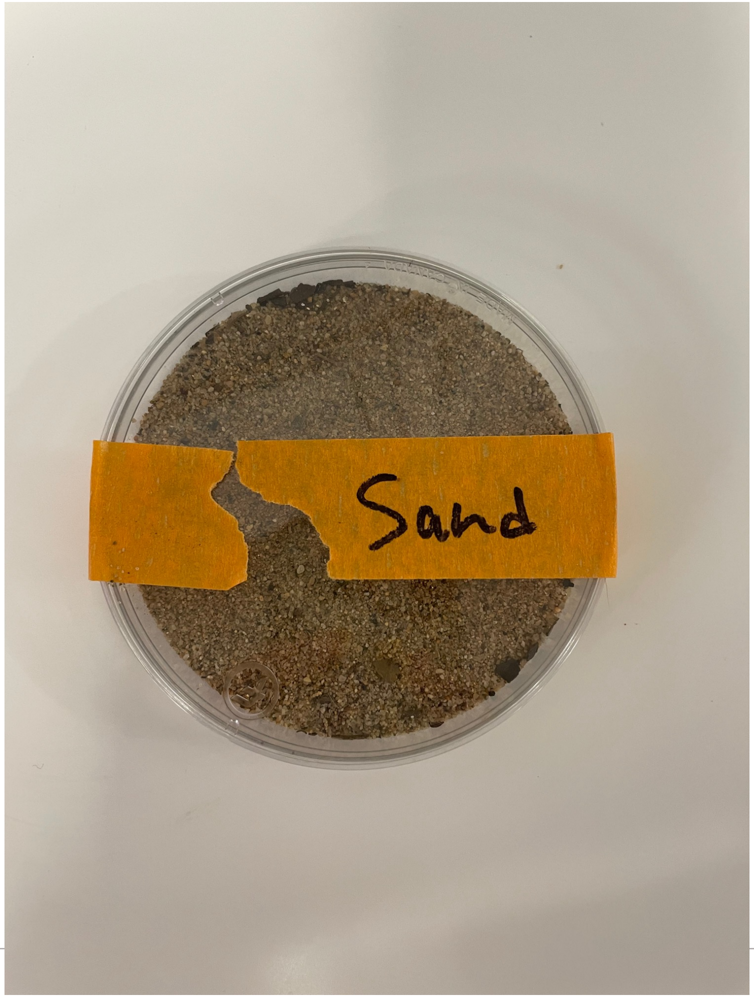
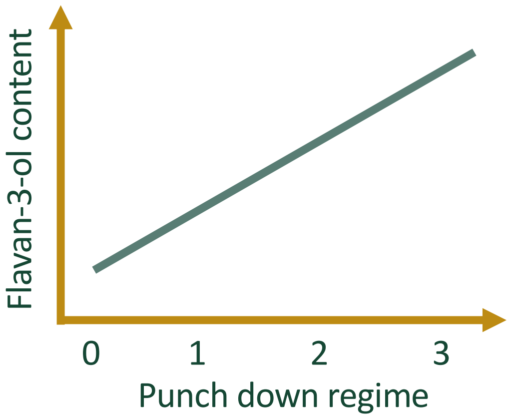
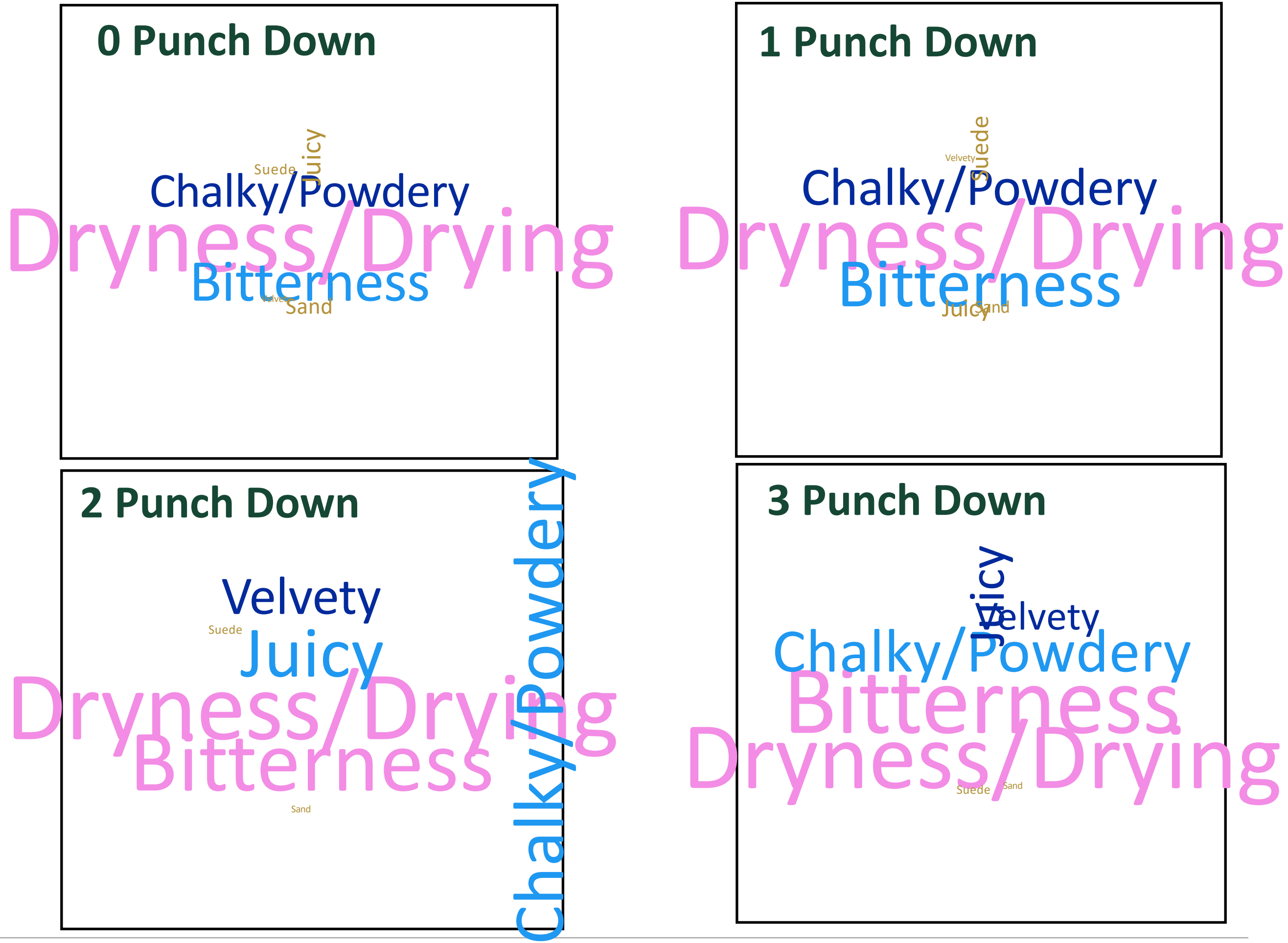

Velvet
Suede

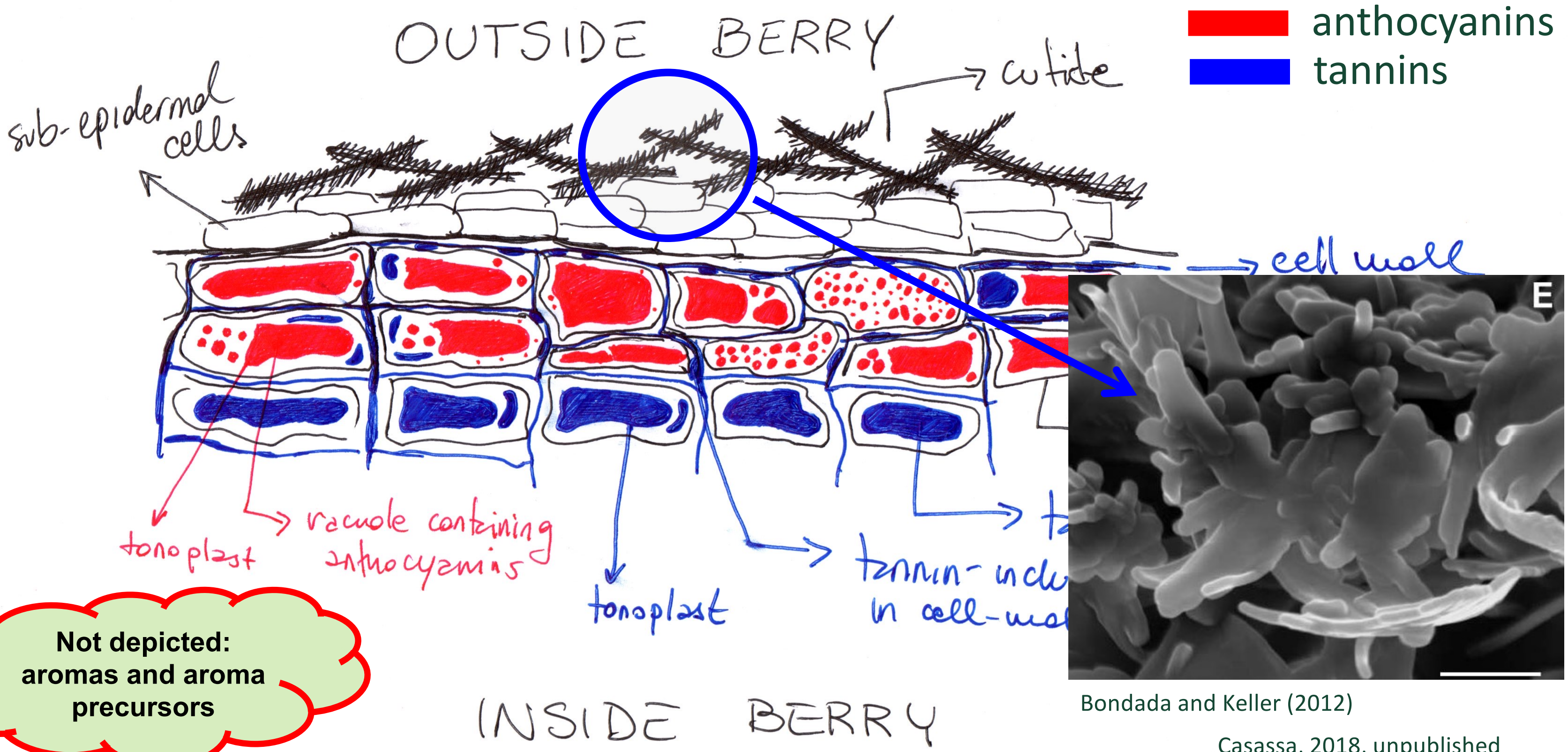

Sand

Punch down regime: flavan-3-ol extraction





Skin microstructure & chemistry

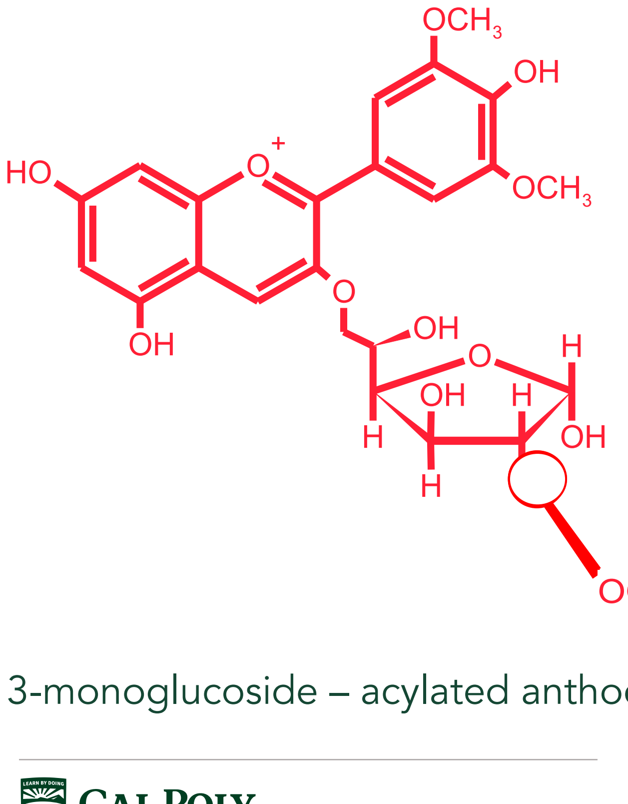


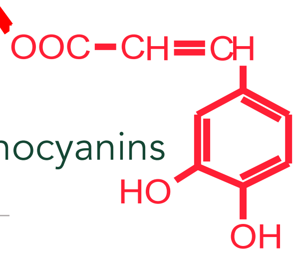
Bondada and Keller (2012)

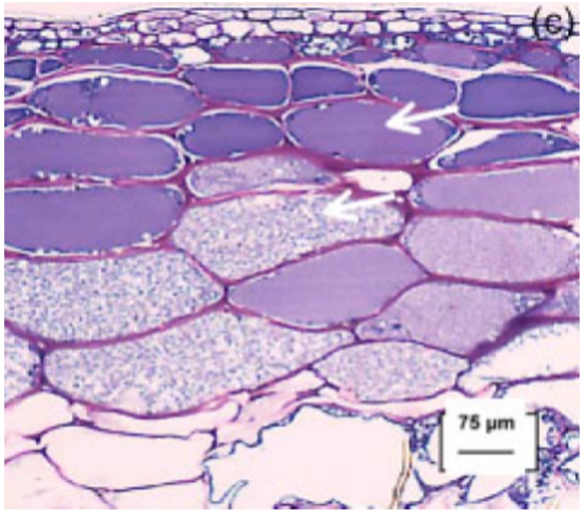
Not depicted: aromas and aroma precursors

Casassa, 2018, unpublished

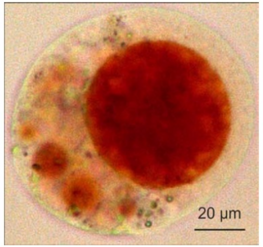
Anthocyanins







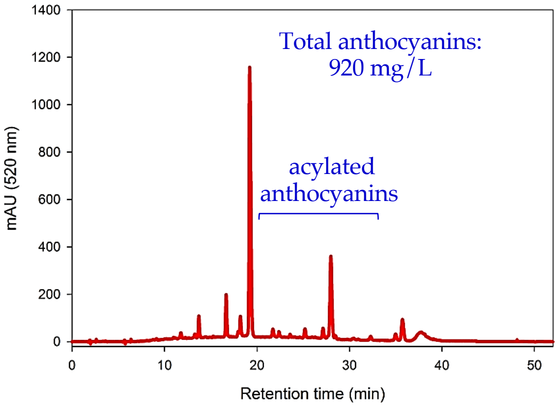
Cadot *et al.* 2011



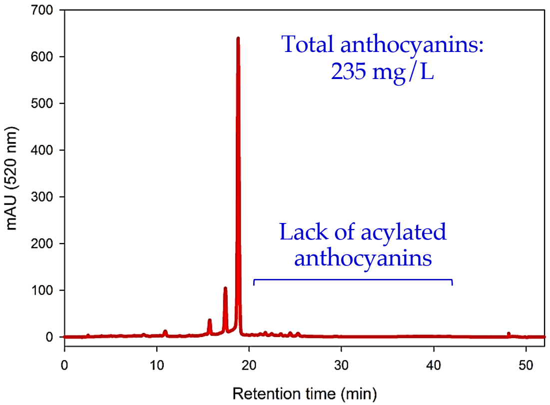
3-monoglucoside – acylated anthocyanins

Anthocyanins

2014 Syrah @ pressing



2014 Pinot Noir @ pressing



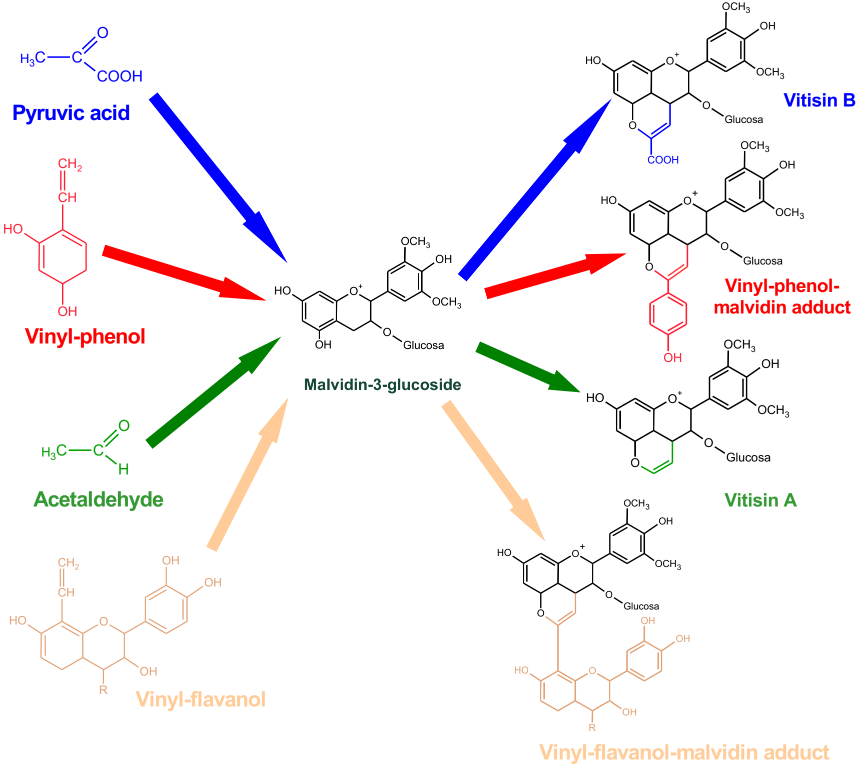
Casassa et al. (2014), unpublished

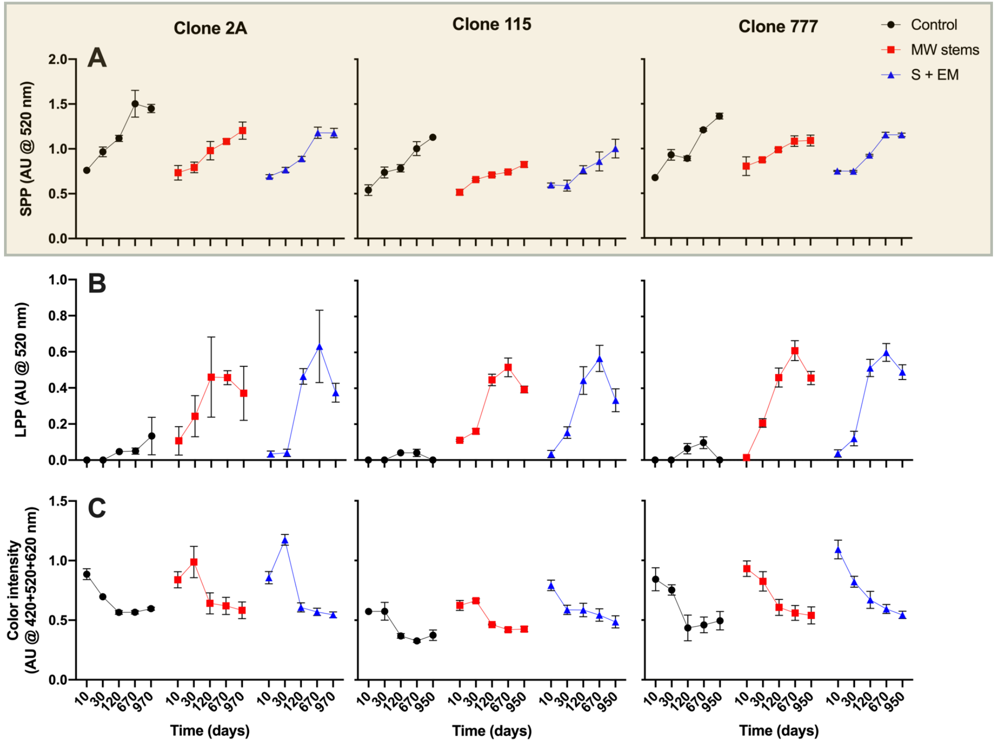
Anthocyanins

- Tasteless
- May affect Redox Potential (high content → tendency to reduction, low content → tendency to oxidation)
- Upon extraction into must/wine form pyranoathocyanins
  - Low molecular weight pigments
- And polymeric pigments
  - Covalent reactions between anthocyanins and tannins
  - Winemaking artifacts
  - Specific mouthfeel properties
  - Stable color (but lower than that of intact anthocyanins)

Polymeric pigments

Pinot noir, clones 2A, 115 and 777
(Spanish Spring vyd, Edna valley)

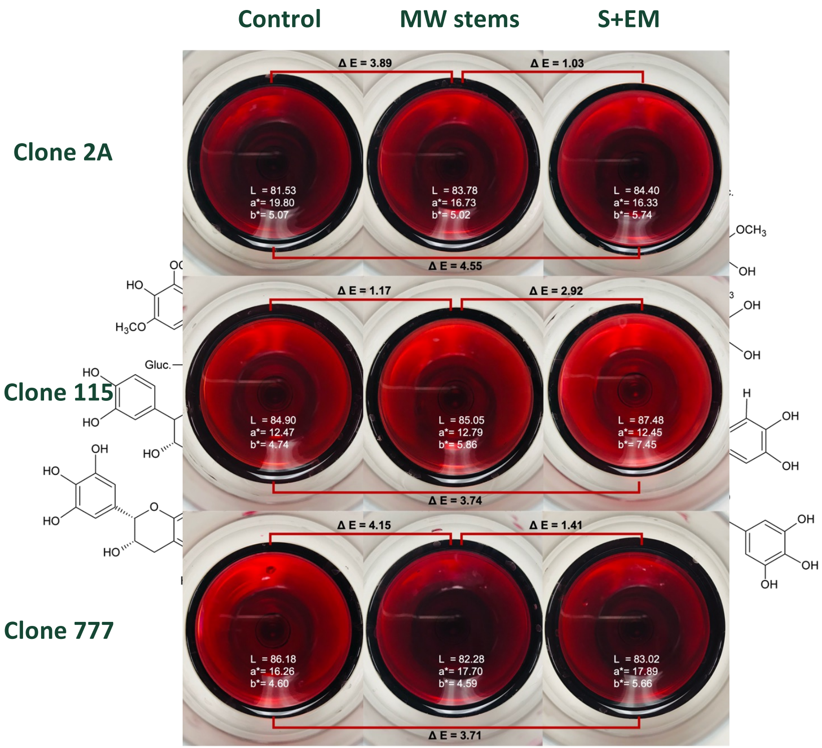


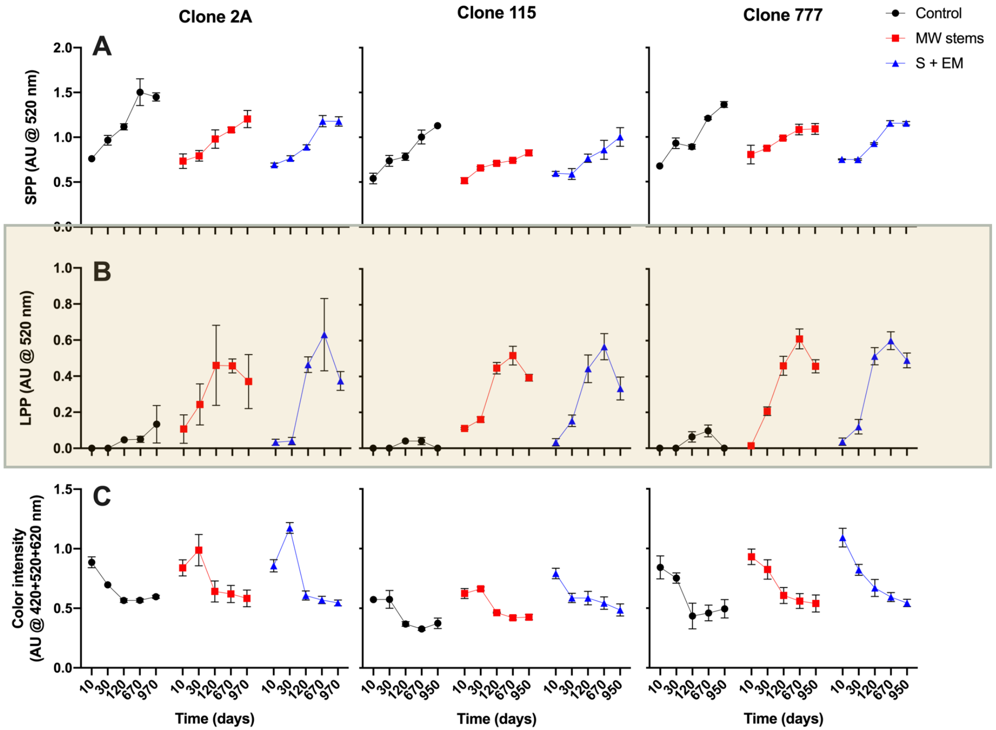


Casassa et al. 2021, AGJWR

Polymeric pigments

Pinot noir, clones 2A, 115 and 777 (Spanish Spring vyd, Edna valley)





Casassa et al. 2021, AGJWR

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Polymeric pigments

$750 bottle Napa V. Red blend (2013 vintage)

100 pts RP; 49% Cabernet Sauvignon, 38% Cabernet Franc, 8% Petit Verdot and 5% Merlot.

Anthocyanins (mg/L)	SPP (AU)	LPP (AU)	Total Polymeric pigments (AU)	Tannins (mg/L)
170	4.43	4.02	8.45	1046

$2,490 bottle Napa V. Cabernet S. (2012 vintage)

79% cabernet sauvignon, 17% merlot, and 4% cabernet franc.

Anthocyanins (mg/L)	SPP (AU)	LPP (AU)	Total Polymeric pigments (AU)	Tannins (mg/L)
169	2.91	2.80	5.71	813

(*) Time of analysis and prices: March 2018

Polymeric pigments

+120 commercial CA red wines

Retail price

LPP > TPP and TP > Tannins > SPP

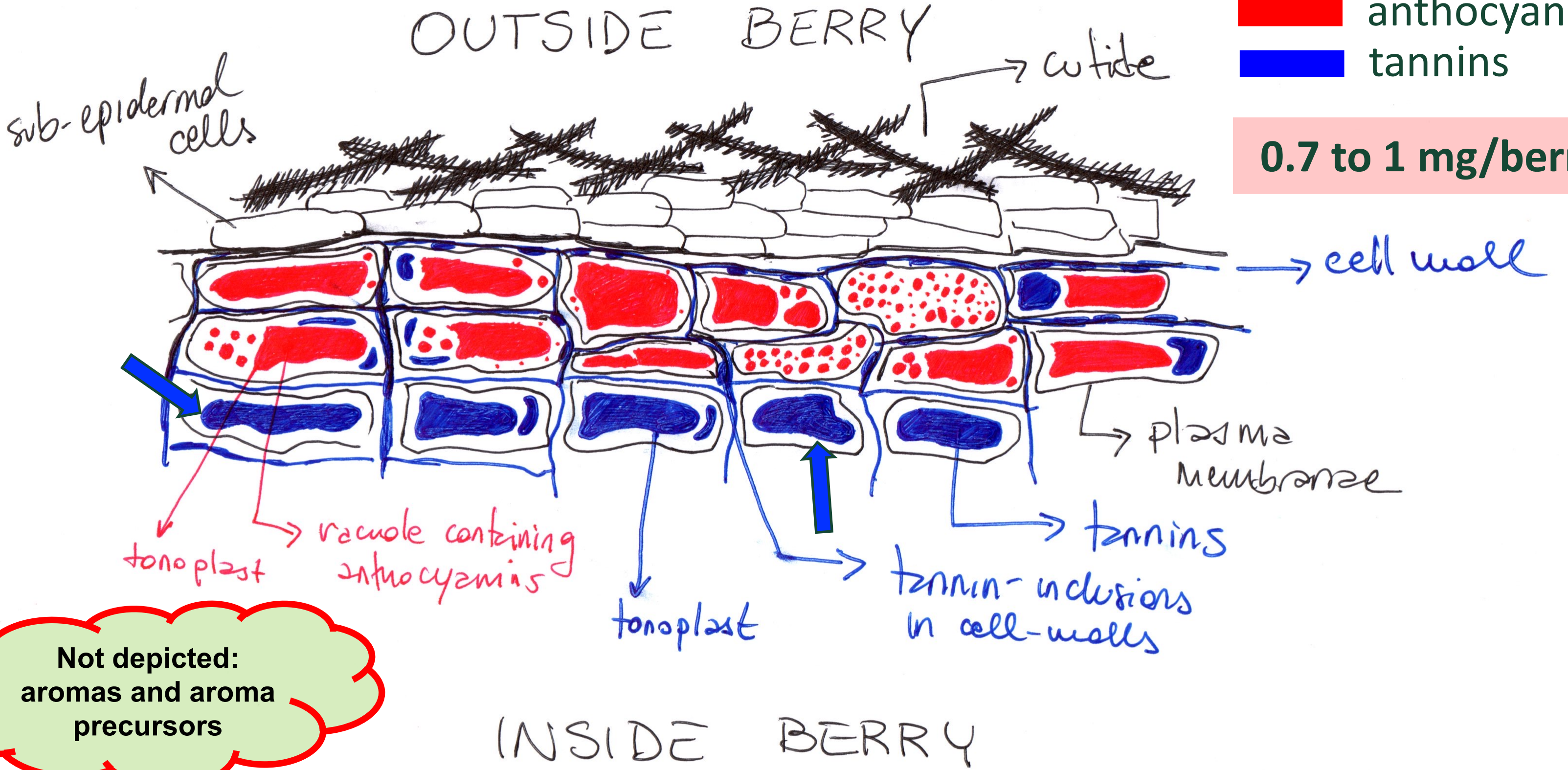
	Anthocyanins (mg/L)	SPP	LPP	TPP	Tannins (mg/L CE)	Total Phenolics (mg/L CE)	Retail price (USD)
Anthocyanins (mg/L)	1.00	0.43	0.09	0.30	0.22	0.11	-0.32
SPP	0.43	1.00	0.50	0.86	0.04	0.09	0.21
LPP	0.09	0.50	1.00	0.87	0.36	0.38	0.35
TPP	0.30	0.86	0.87	1.00	0.24	0.27	0.32
Tannins (mg/L CE)	0.22	0.04	0.36	0.24	1.00	0.92	0.29
Total Phenolics (mg/L CE)	0.11	0.09	0.38	0.27	0.92	1.00	0.32
Retail price (USD)	-0.32	0.21	0.35	0.32	0.29	0.32	1.00

Color scale: 1.0, 0.5, 0, -0.5, -1.0

Skin microstructure & chemistry

anthocyanins
tannins

0.7 to 1 mg/berry



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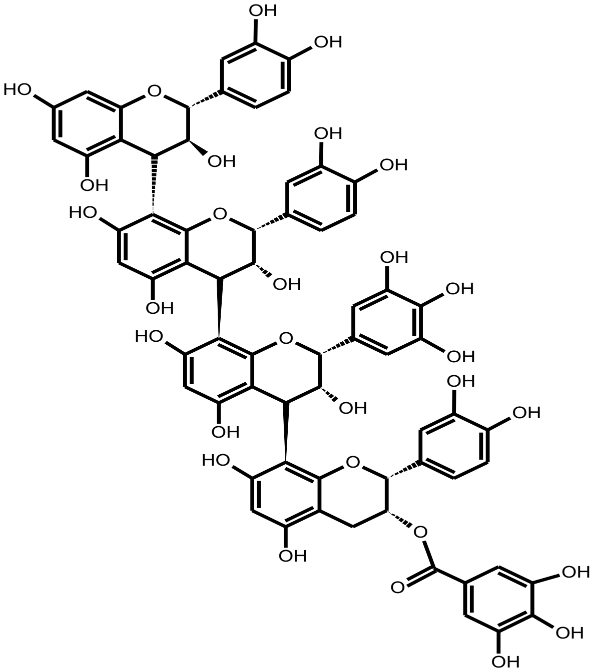
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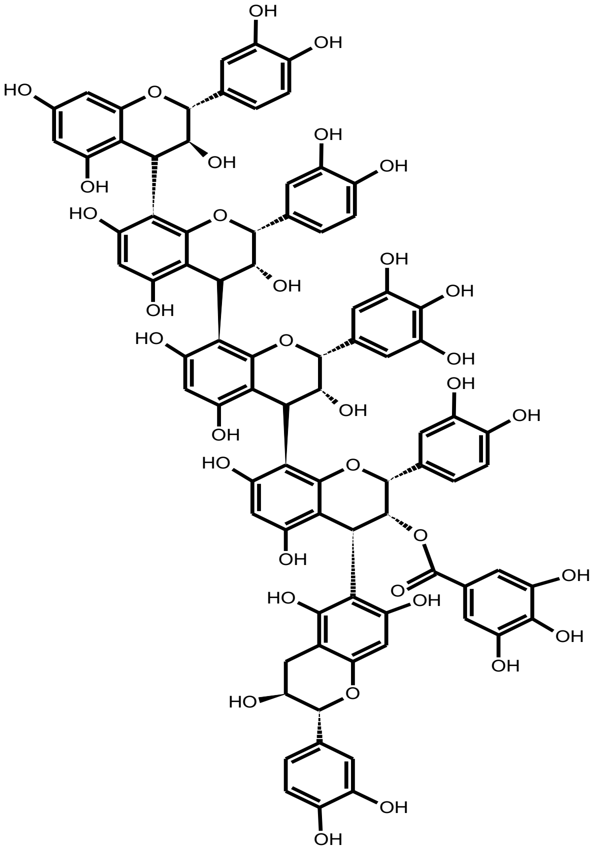
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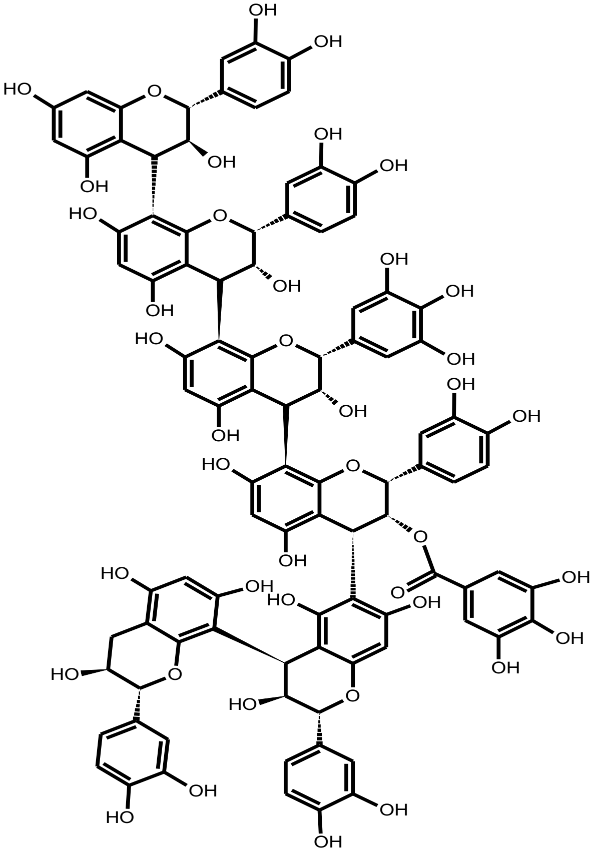
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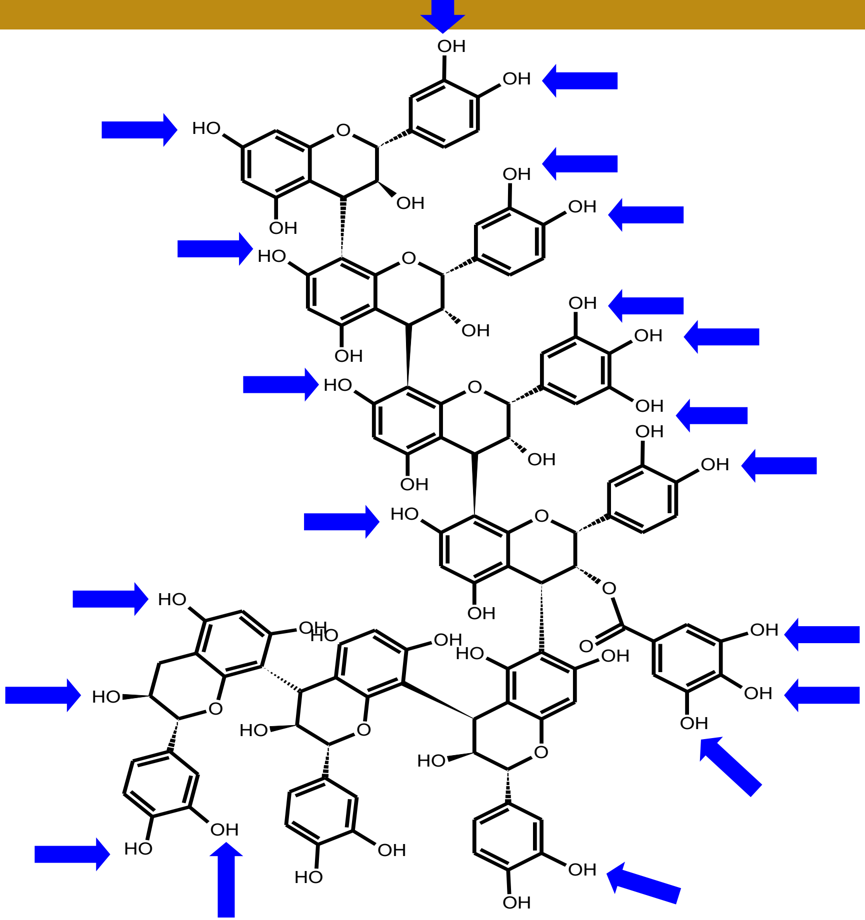

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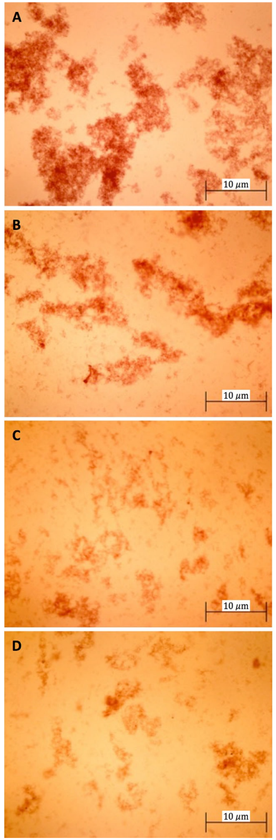


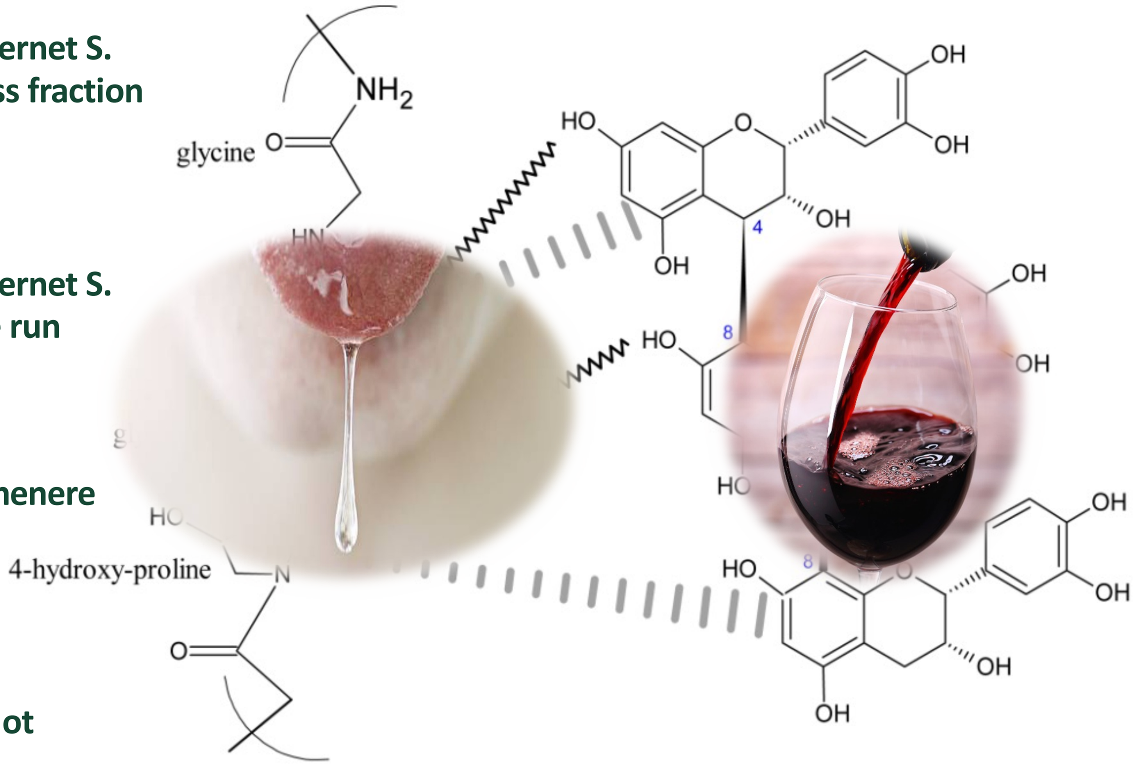
Cabernet S. Press fraction

Cabernet S. free run

Carmenere

Merlot

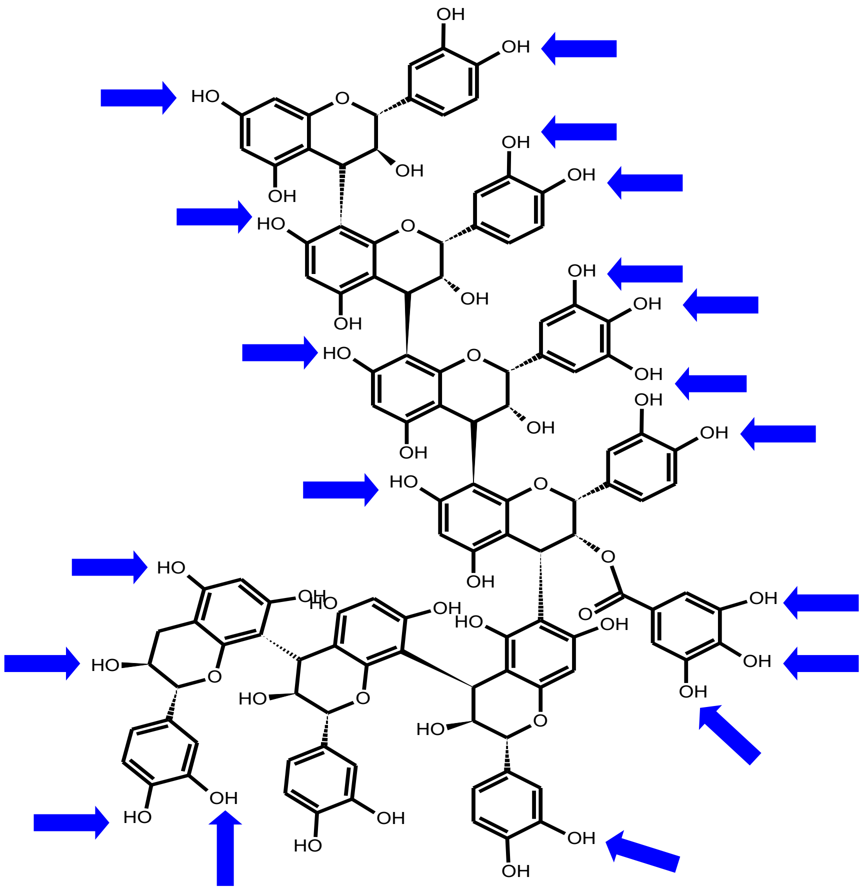
Brossard et al. (2016)



proline-rich protein

proanthocyanidin C1

Are skin tannins more astringent ?



Astringency: driving factors

Concentration

How much ?

Composition

- Polymer length (mDP)
- Skin/seeds
- Size distribution
- Polymeric pigments

Wine matrix

- Polysaccharides
- Mannoproteins
- Acidity
- Ethanol
- Residual sugars

Physiological factors

- Saliva flow rate
- Taste bud density
- PROP status
- Bias due to color
- CM associations

Astringency factors: hierarchy

(1)
Concentration

How much ?

(2)
Physiological factors

- Saliva flow rate
- Taste bud density
- PROP status
- Bias due to color
- CM associations

(3)
Composition

- Polymer length (mDP)
- Skin/seeds
- Size distribution
- Polymeric pigments

(4)
Wine matrix

- Polysaccharides
- Mannoproteins
- Acidity
- Ethanol
- Residual sugars

(*) yellow fonts: driving factors in each category

Astringency factors: hierarchy

Tannins bind to proteins in an opportunistic fashion following cooperative binding

>

Astringency factors: hierarchy

(1)
Concentration

How much ?

(2)
Physiological factors

- Saliva flow rate
- Taste bud density
- PROP status
- Bias due to color
- CM associations

(3)
Composition

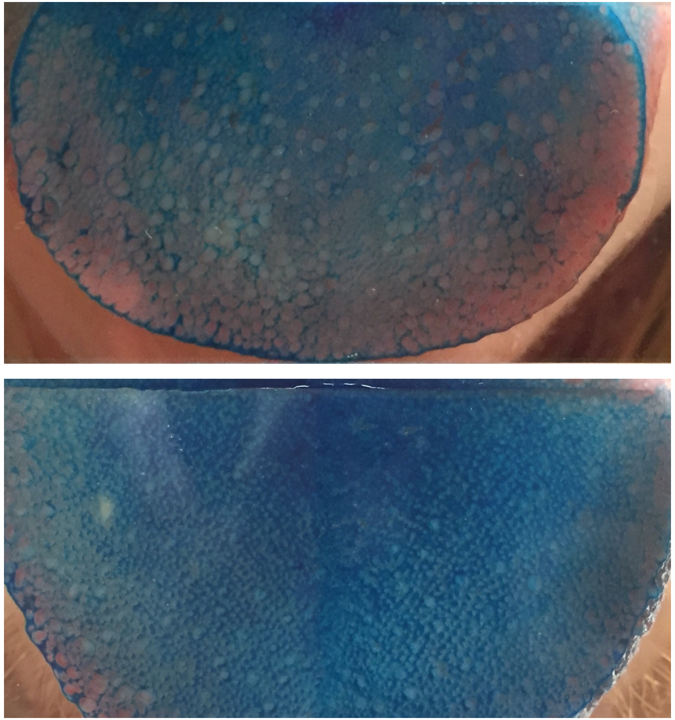
- Polymer length (mDP)
- Skin/seeds
- Size distribution
- Polymeric pigments

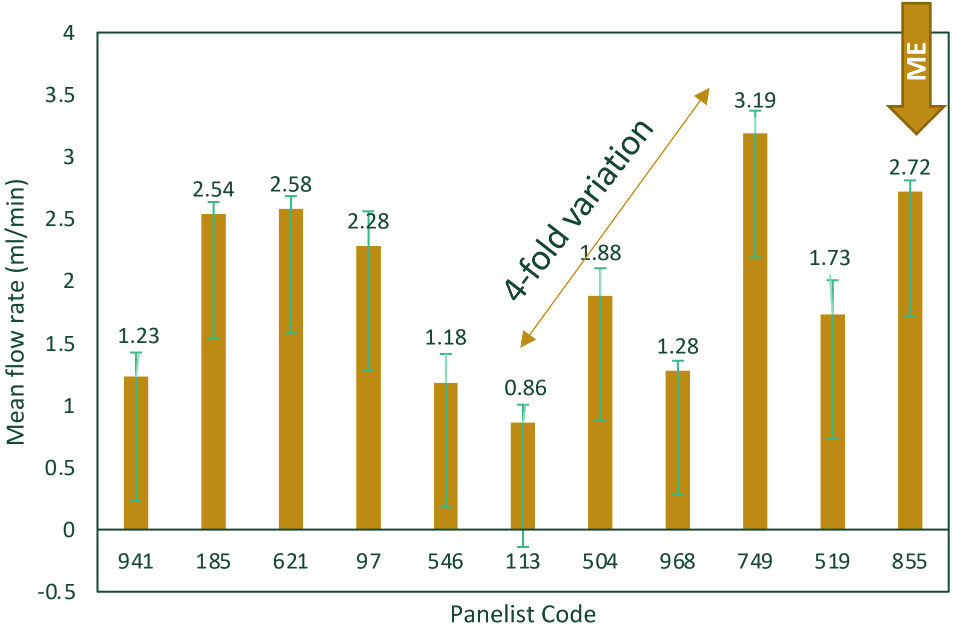
(4)
Wine matrix

- Polysaccharides
- Mannoproteins
- Acidity
- Ethanol
- Residual sugars

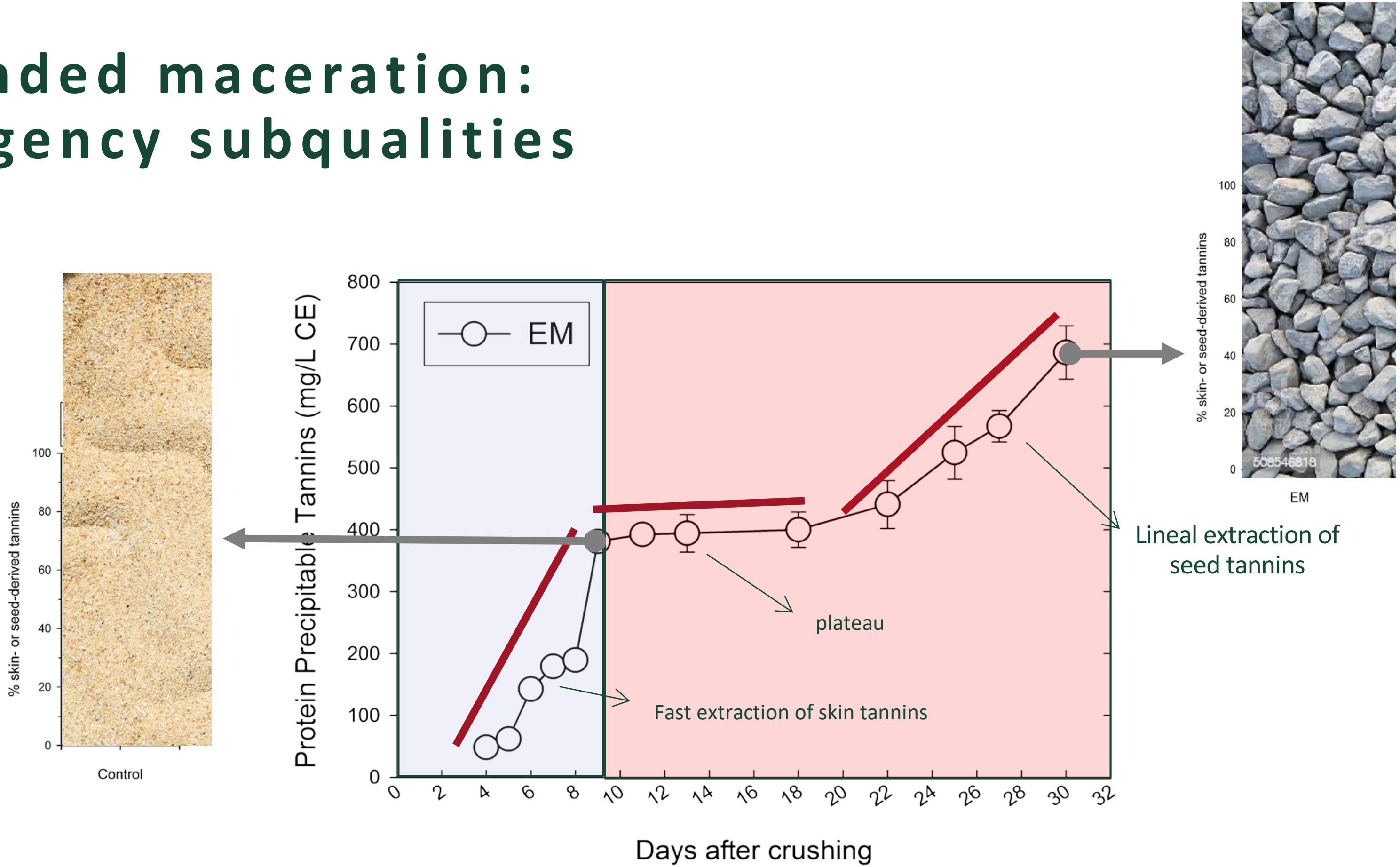
(*) yellow fonts: driving factors in each category

Astringency factors: hierarchy





Extended maceration: astringency subqualities

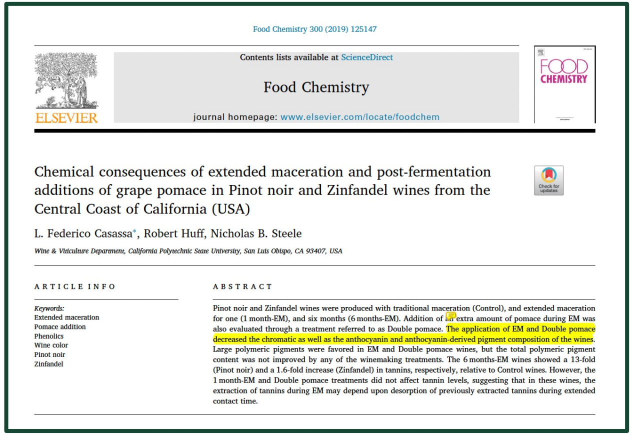


Casassa *et al*. (2013), Australian Journal of Grape and Wine Research

cv. Merlot

How to build mouthfeel and texture in Pinot noir

- Building mouthfeel and texture on Pinot noir is hard
- Options
  - EM → bitterness, less color


Food Chemistry 300 (2019) 125147

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ELSEVIER

Chemical consequences of extended maceration and post-fermentation additions of grape pomace in Pinot noir and Zinfandel wines from the Central Coast of California (USA)

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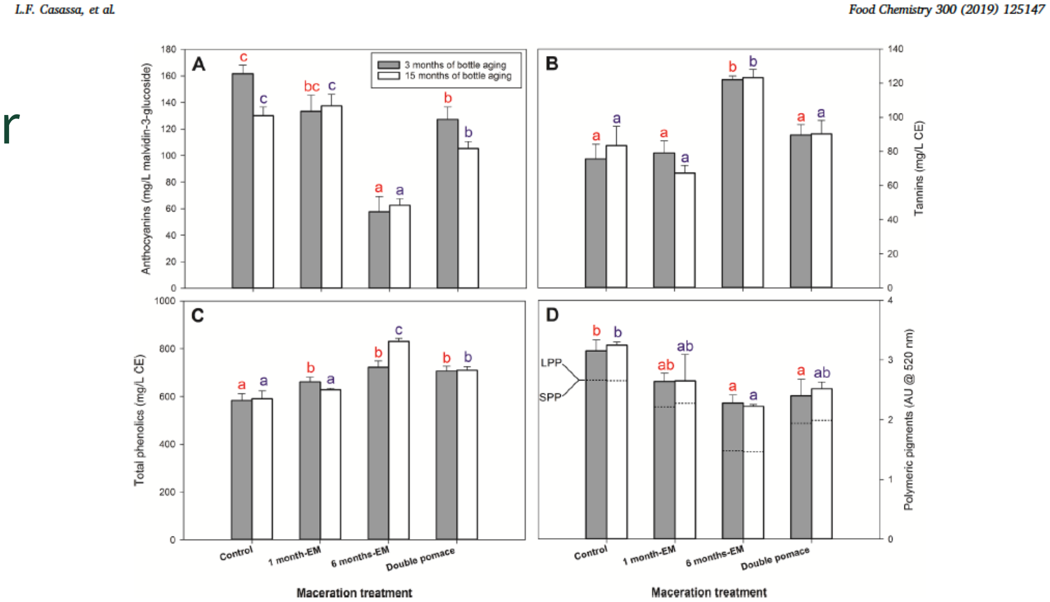
Wine & Viticulture Department, California Polytechnic State University, San Luis Obispo, CA 93407, USA

ARTICLE INFO

Keywords:
Extended maceration
Pomace addition
Phenolics
Wine color
Pinot noir
Zinfandel

ABSTRACT

Pinot noir and Zinfandel wines were produced with traditional maceration (Control), and extended maceration for one (1 month-EM), and six months (6 months-EM). Addition of an extra amount of pomace during EM was also evaluated through a treatment referred to as Double pomace. The application of EM and Double pomace decreased the chromatic as well as the anthocyanin and anthocyanin-derived pigment composition of the wines. Large polymeric pigments were favored in EM and Double pomace wines, but the total polymeric pigment content was not improved by any of the winemaking treatments. The 6 months-EM wines showed a 13-fold (Pinot noir) and a 1.6-fold increase (Zinfandel) in tannins, respectively, relative to Control wines. However, the 1 month-EM and Double pomace treatments did not affect tannin levels, suggesting that in these wines, the extraction of tannins during EM may depend upon desorption of previously extracted tannins during extended contact time.



Casassa et al, 2019

How to build mouthfeel and texture in Pinot noir

- Building mouthfeel and texture on Pinot noir is hard
- Options
  - EM → bitterness, less color
  - Add stems
  - Add WC
  - Lees ?
  - What else ?

Casassa et al, 2019

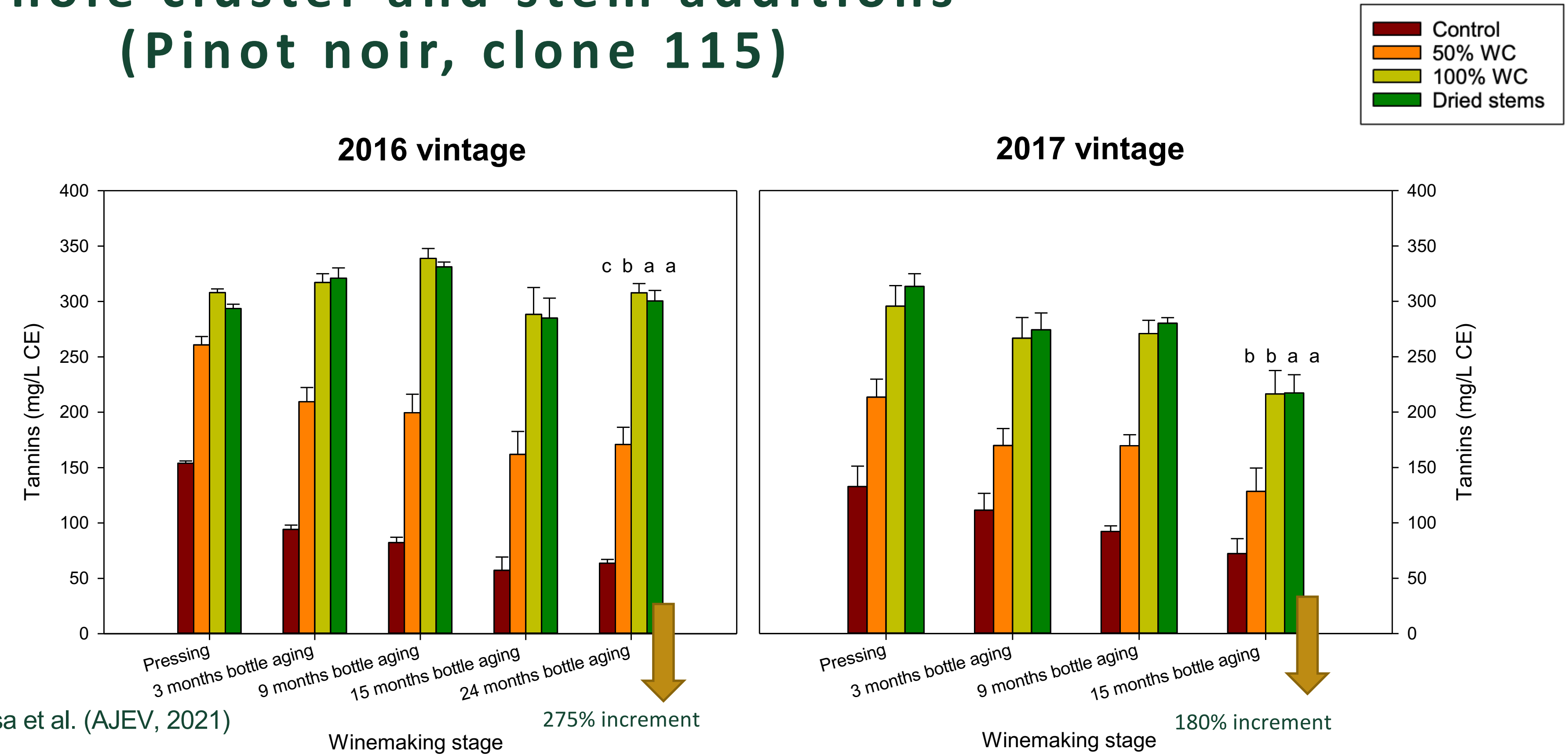
Whole cluster and stem additions (Pinot noir, clone 115)

Prior drying

After drying

Casassa et al. (AJEV, 2021)

Whole cluster and stem additions (Pinot noir, clone 115)



Casassa et al. (AJEV, 2021)

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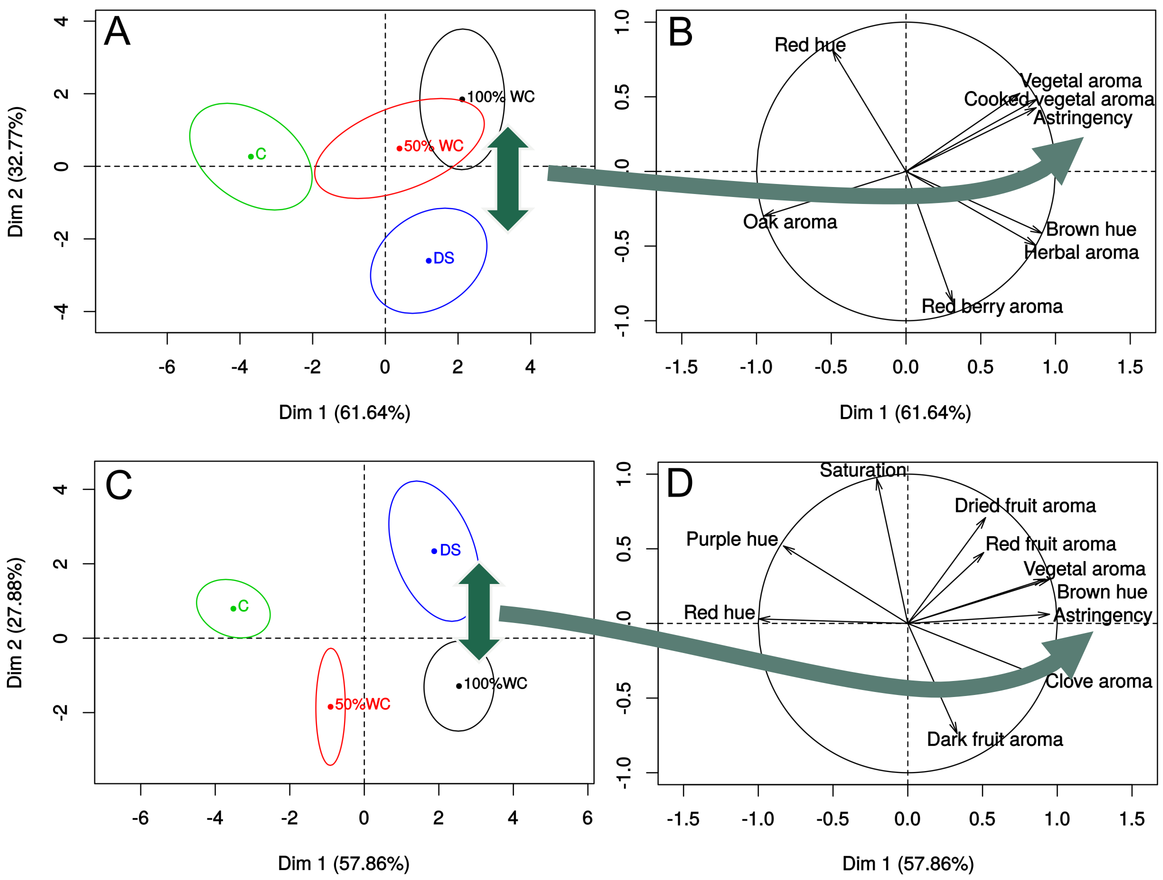
2016 Vintage

2017 Vintage



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Casassa et al. (AJEV, 2021)

How to build mouthfeel and texture in Pinot noir

- Building mouthfeel and texture on Pinot noir is hard
- Options
  - EM → bitterness, less color
  - Add stems
  - Add WC
  - Lees ?
  - What else ?
  - You can just ferment warmer

Fermentation and punch down regime (Pinot noir, clone 667, Bassi vineyard)

Lots fermented in triplicate at 3 temperatures, 50 ppm SO_2 @ crushing

HOT ferment (82-90 F)

- 2 punchdowns/day (PD)
- NO punchdown (NO PD)

COLD ferment (53-62 F)

- 2 punchdowns/day (PD)
- NO punchdown (NO PD)

COLD/HOT ferment (7 days cold, 7 days hot)

- 2 punchdowns/day (PD)
- NO punchdown (NO PD)

Temperature evolution

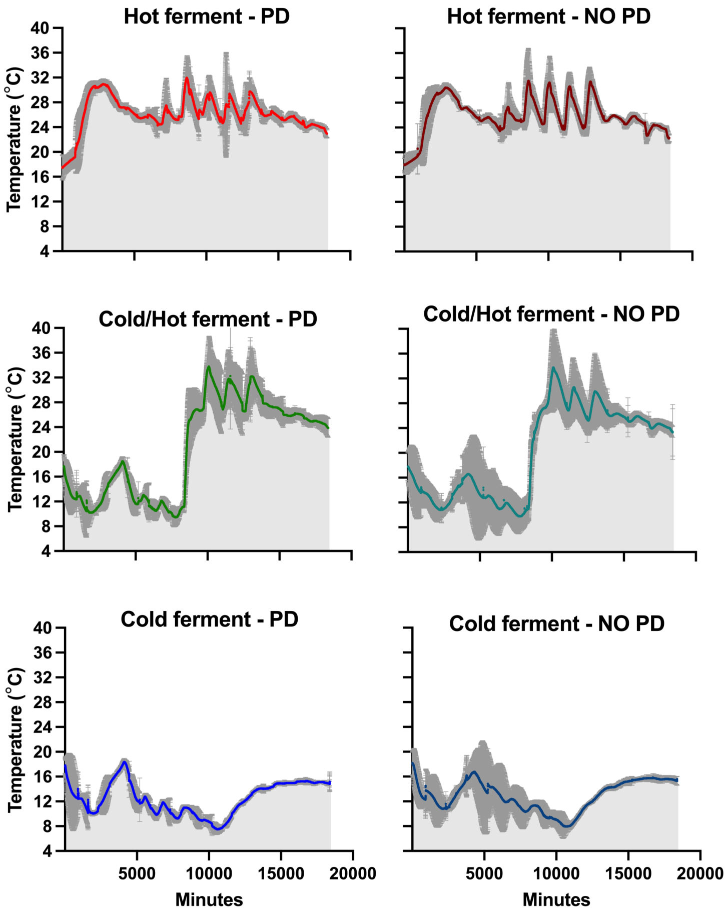
Very consistent temp curves

Hots: peak of 99 F

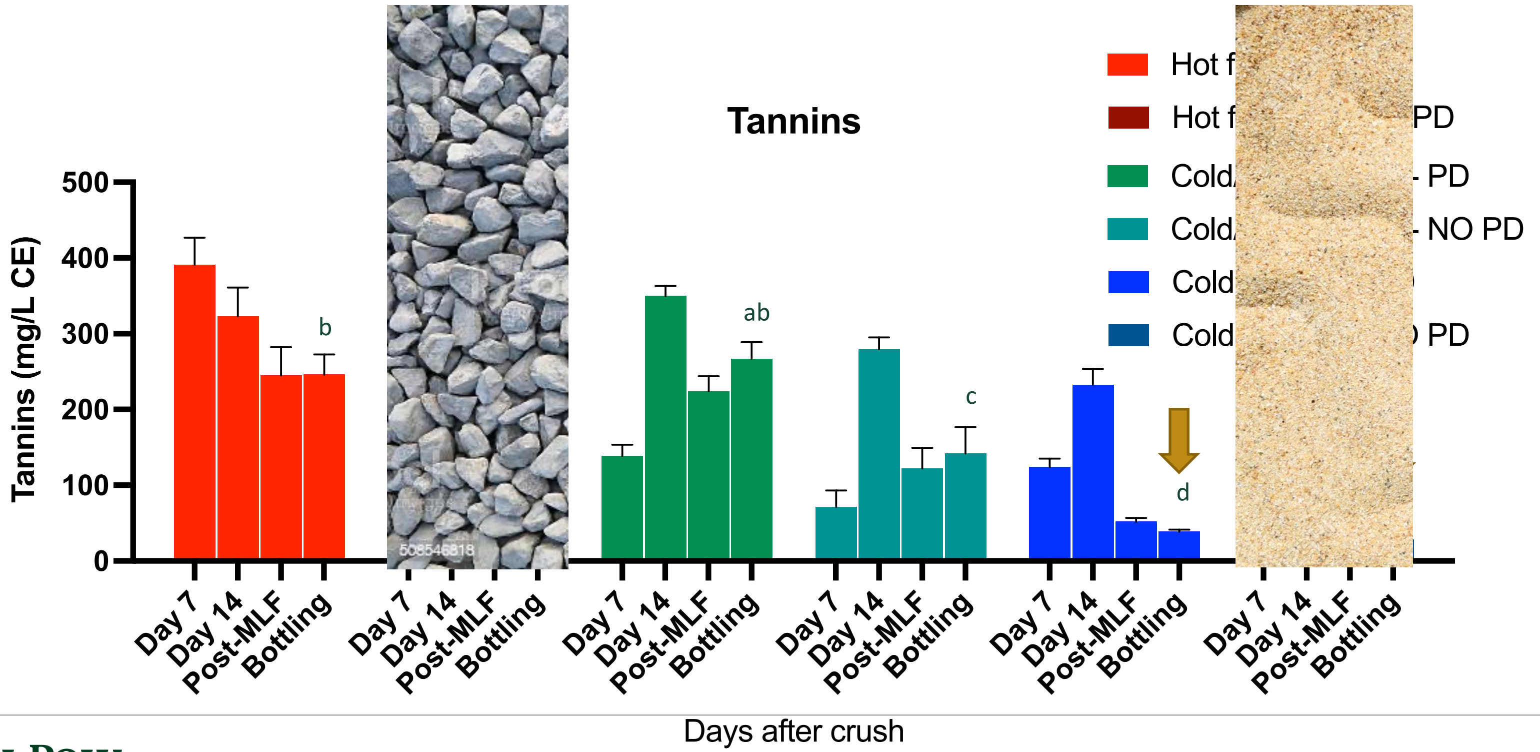
Colds: never above 68 F

Inoculated for MLF (VP-41), post AF

Wines bottled Feb 2022



Tannins: higher in HOT NO PD treatments



Polymeric pigments

SPP: do not precipitate protein

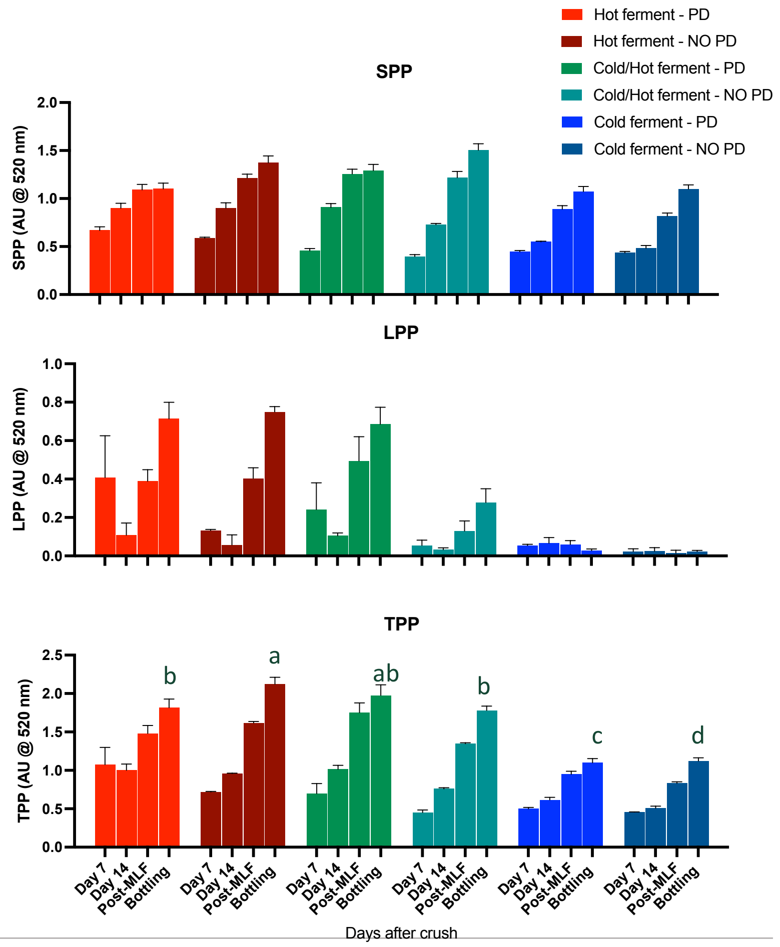
LPP: precipitate protein

TPP: LPP + SPP

Positive mouthfeel characteristics

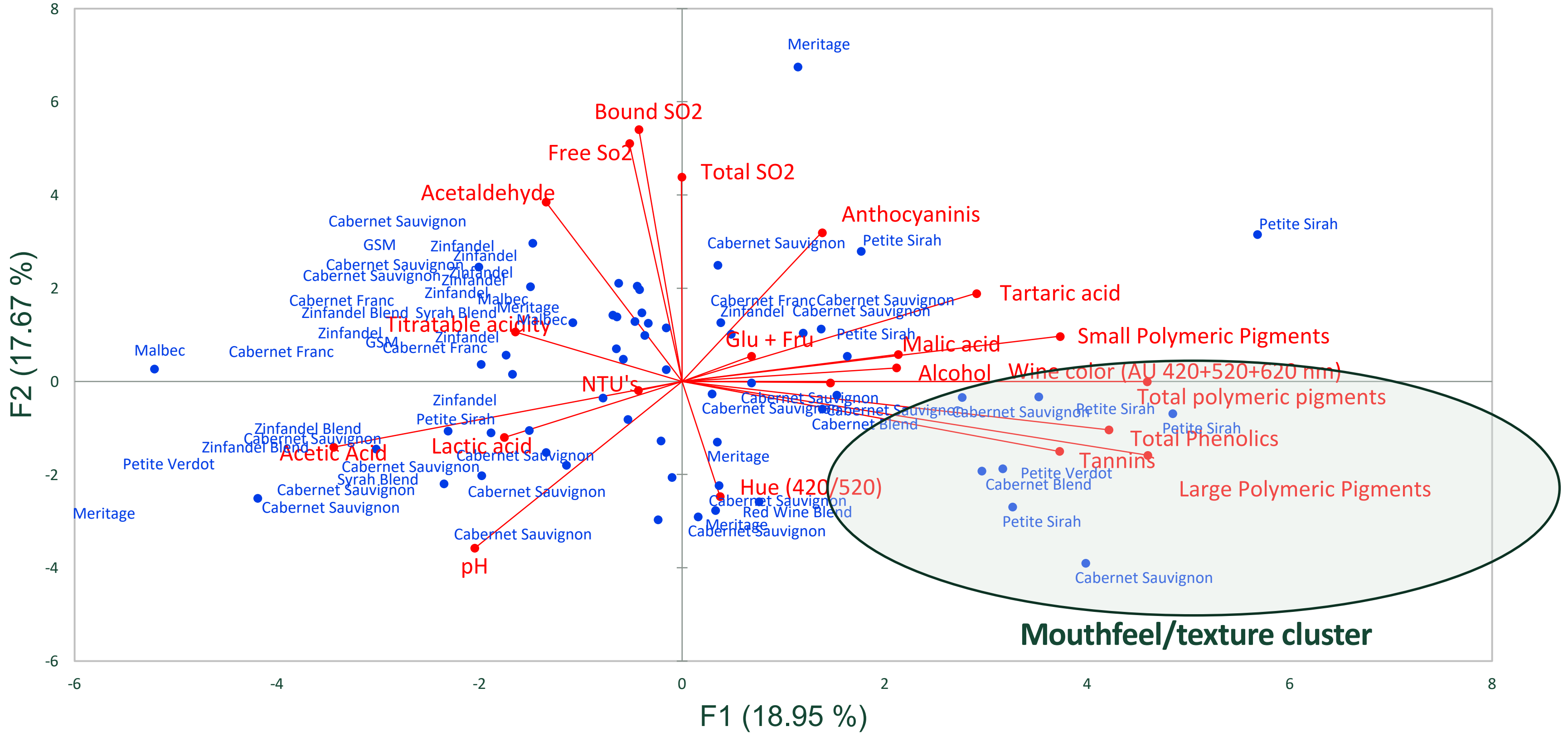
HOTs produced more (twice as colds)

Fermenting COLD: recipe to get LOW LPP

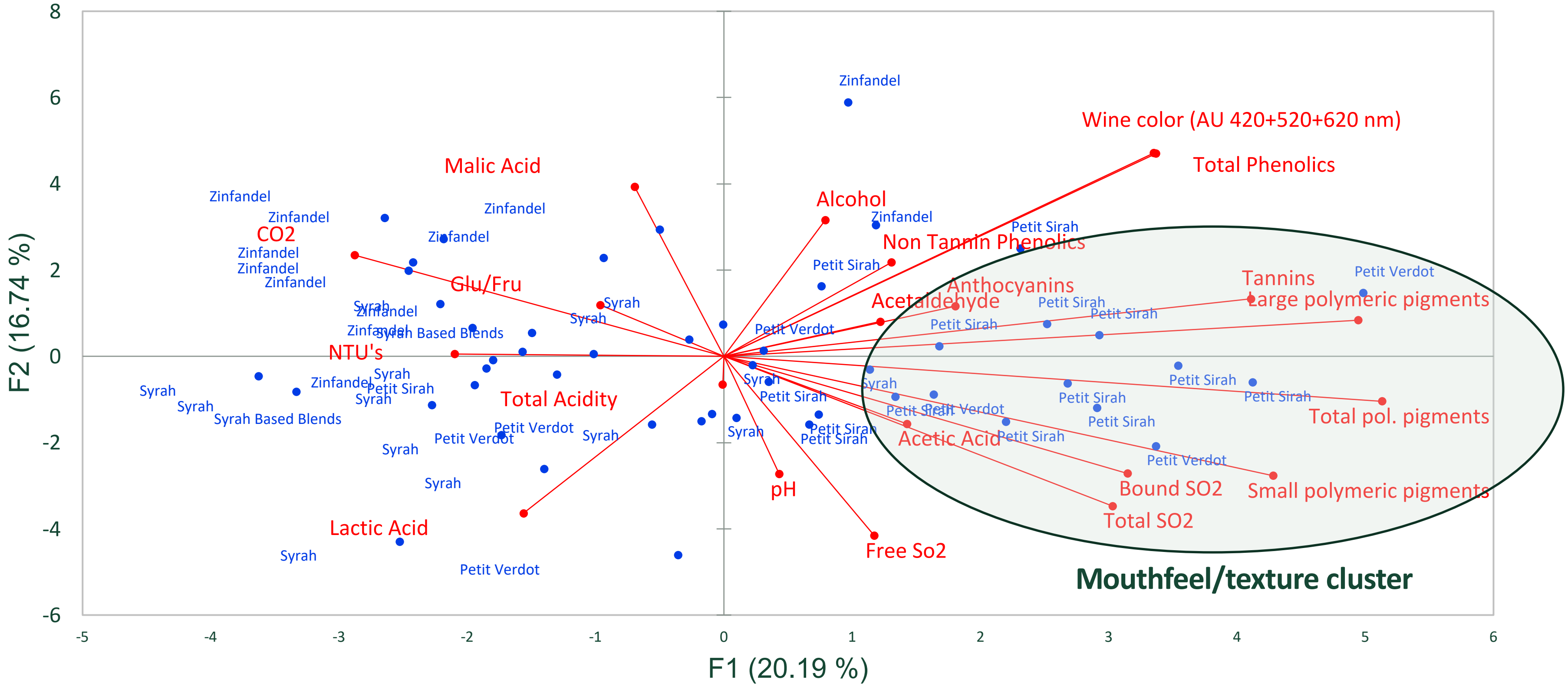


Certain varietals lend themselves to more positive mouthfeel/textural characteristics

60 commercial wines Central Coast appellation (2018)



50 commercial wines Central Coast appellation (2019)



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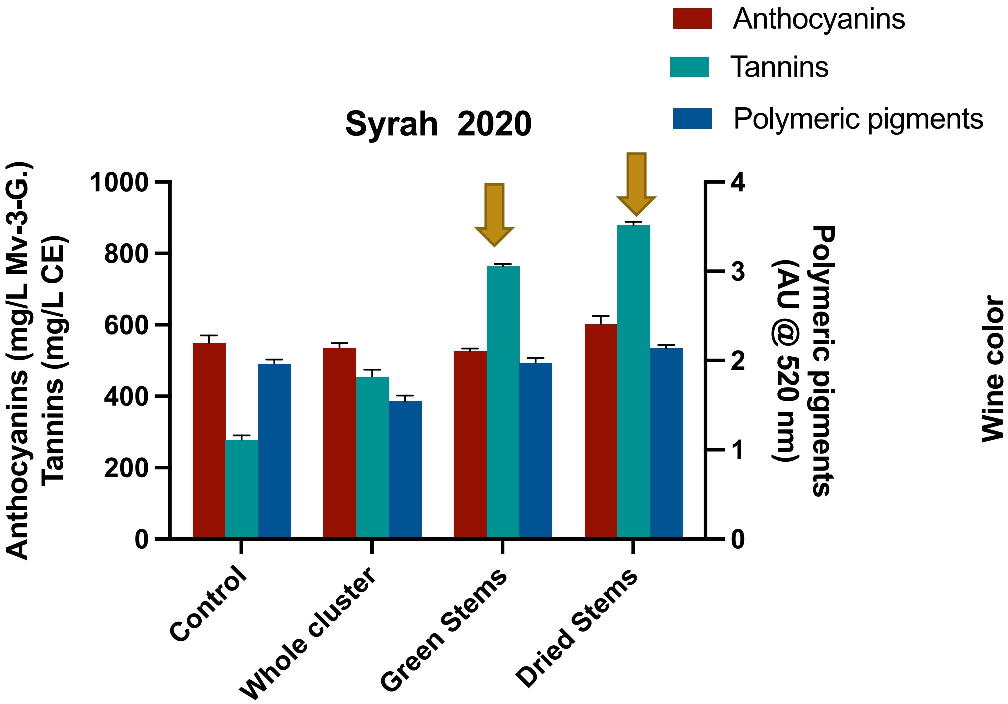
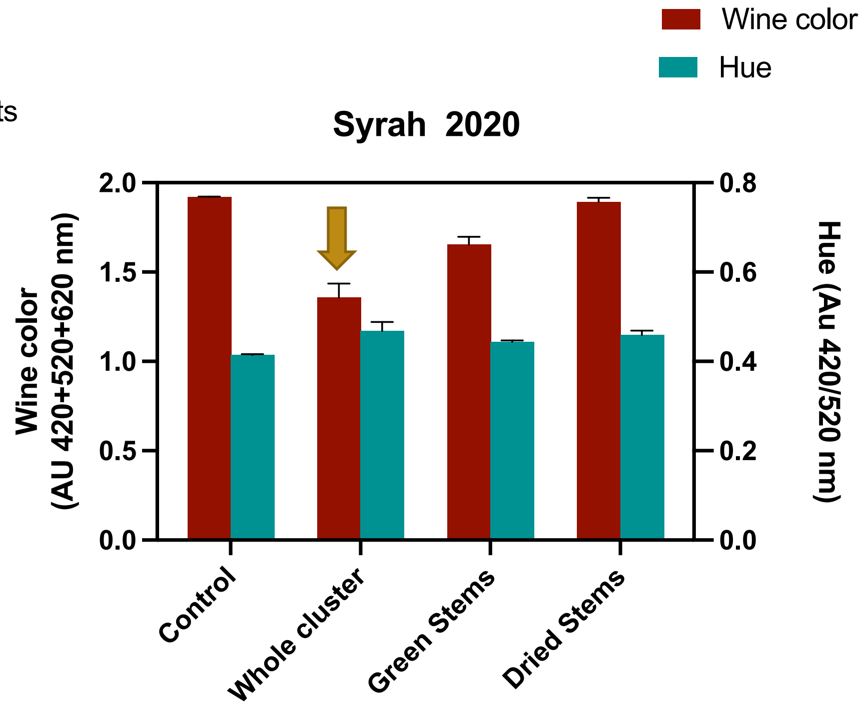
Case study: Syrah

- Syrah: Rancho Real (Santa Maria Valley AVA), clone 828
- Winemaking treatments
  - Control
  - Whole cluster (foot stomped)
  - Green stems (100%)
  - Dry Stems (100%)

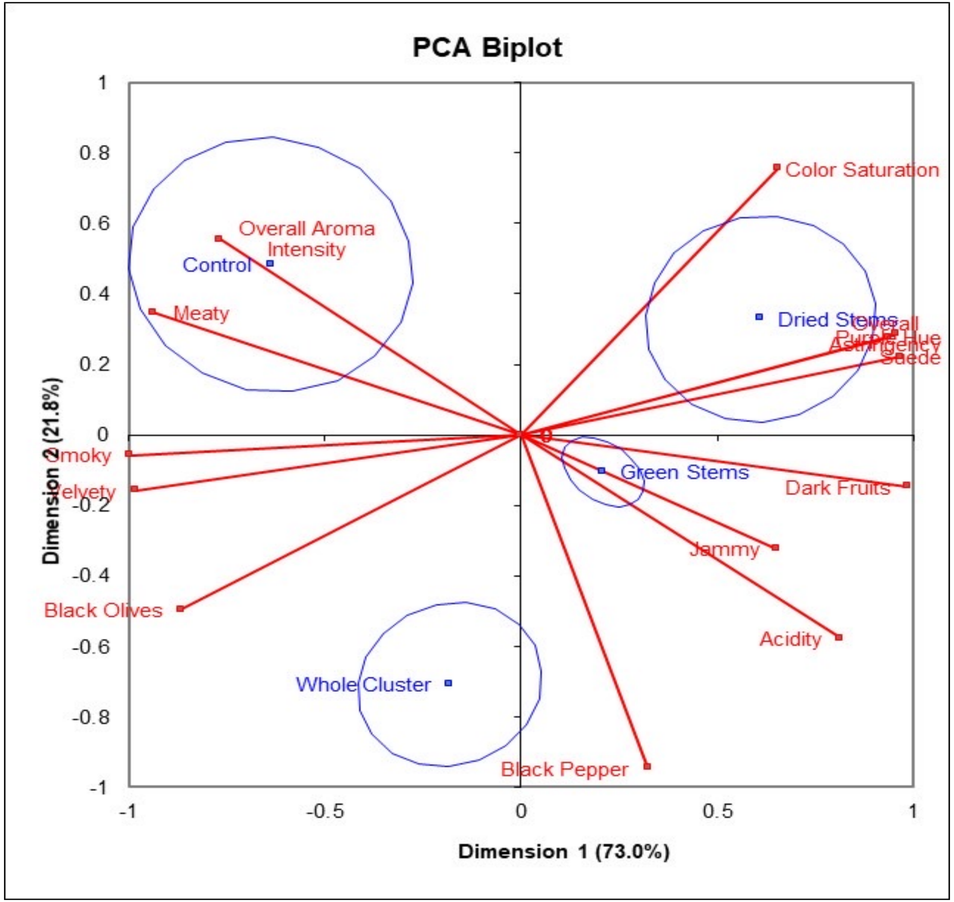
Syrah (phenolics @ pressing)





Syrah (sensory)

- WC: black pepper character, less color
- Green stems: acidity, jammy
- Dried stems: Suede-type astringency



Conclusions

- **Flavan-3-ols**: bitterness, cap management (disruption)

- **Anthocyanins**: color and polymeric pigments

- **Tannins**
  - Opportunistic binding driven by concentration - Act cooperatively
  - Astringency non-proportional to tannin content – good understanding of how key winemaking practices affect content, but consider astringency subqualities

- **Mouthfeel and the "weight" of the wine on the palate is a multimodal sensation**
  - Polymeric pigments and tannins: astringency subqualities
  - Mouthfeel attributes driven by varietals and winemaking techniques
  - Key to build mouthfeel: minimize flavan-3-ols, maximize polymeric pigment formation, extract tannins preferentially if they are high MW

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Chapter 6

Flavonoid Phenolics in Red Winemaking

L. Federico Casassa

Additional information is available at the end of the chapter

http://dx.doi.org/10.5772/67452

Abstract

This chapter reviews the chemical diversity of flavonoid phenolics in grapes (*Vitis vinifera* L.) with impact on the sensory properties of red wines. Anthocyanins, flavan-3-ols, tannins, and polymeric pigments are discussed from a chemical, technological, and sensory perspective. Anthocyanins, responsible for the color of red wines, reach a peak of extraction after 4 or 5 days of maceration, followed by a decrease in their concentration as maceration progresses. Flavan-3-ols and oligomeric tannins from skins are responsible for bitterness and extracted within the first days of maceration, whereas extraction of seed-derived tannins requires longer maceration times. Matrix effects, including the presence of anthocyanins, polysaccharides, and other cell-wall components affect the rate of retention of tannins into wine. Polymeric pigments, bearing astringent and bitter properties different from those of intact tannins, are formed from covalent reactions between anthocyanins and tannins, putatively accounting for the changes in mouthfeel and textural properties of red wines during maceration and aging. Different maceration techniques applied during red wine production affect the rate, quantity, and the chemical composition of wine phenolics. Understanding of the factors that modulate phenolic retention into wine should allow the winemaker to adjust maceration variables to meet stylistic and/or commercial specifications.

Keywords: flavonoid, phenolic, anthocyanins, flavan-3-ols, tannins, polymeric pigments, maceration, sensory analysis

1. Introduction

The term "phenolics," however overarching, generally bears a positive connotation for grape growers and winemakers alike. In spite of the use (and abuse) of the concept that touts phenolics as naturally occurring, health-promoting compounds in plant-derived food and beverages, it is in wine, like in perhaps no other beverage, where this term has been so widely

Extraction, Evolution, and Sensory Impact of Phenolic Compounds During Red Wine Maceration

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Keywords

red wine production, anthocyanins, proanthocyanidins, polymeric pigments, color, mouthfeel

Abstract

We review the extraction into wine and evolution of major phenolic classes of sensory relevance. We present a historical background to highlight that previously established aspects of phenolic extraction and retention into red wine are still subjects of much research. We argue that management of the maceration length is one of the most determining factors in defining the proportion and chemical fate of phenolic compounds in wine. The extraction of anthocyanins, flavonols, flavan-3-ols, and oligomeric and polymeric proanthocyanidins (PAs) is discussed in the context of their individual extraction patterns but also with regard to their interaction with other wine components. The same approach is followed to present the sensory implications of phenolic and phenolic-derived compounds in wine. Overall, we conclude that the chemical diversity of phenolic compounds in grapes is further enhanced as soon as vacuolar and pulp components are released upon crushing, adding a variety of new sensory dimensions to the already present chemical diversity. Polymeric pigments formed by the covalent reaction of anthocyanin and PAs are good candidates to explain some of the observed sensory changes in the color, taste, and mouthfeel attributes of red wines during maceration and aging.