Effect of fermentation temperature on phenolic extraction and color of three clones of Pinot noir over two consecutive vintages

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Introduction

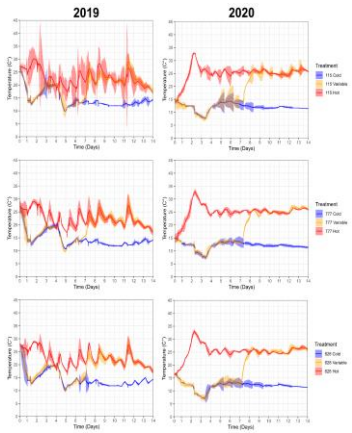
- Pinot noir is indigenous to the Burgundy region of France, dating back to the first century AD
- Pinot noir wines are relatively low in phenolic compounds in relation to other popular cultivars
- Phenolic compounds
  - Anthocyanins – found in skins, responsible for color
  - Tannins – found primarily in seeds, responsible for astringency
  - Polymeric pigment – covalent polymers of anthocyanins and tannins
- Many methods have been implemented to alter phenolic extraction of Pinot noir
  - Prefermentative cold soak
  - Whole cluster addition
  - Fermentation Temperature

Materials & Methods

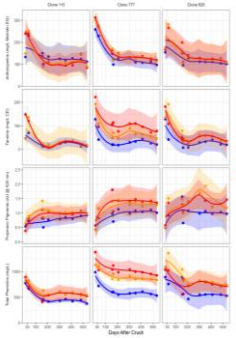
- 2019 and 2020 vintages
- Pinot noir clones 115, 777, 828
  - Sierra Madre Vineyard, Santa Maria, CA
  - 14-day maceration/fermentation
- Three temperature regimes
  - Cold (10°C) – cold room
  - Hot (25°C) – 2019: outside, 2020: hot room
  - Variable (10°C 7 days/25°C 7 days)
- Temperature measured via probes – 1 minute interval
- Phenolics and color measured throughout fermentation up to 12-months post-bottling
  - Spectrophotometer, Adams-Harbertson Method
  - HPLC – anthocyanins and flavonols

Figures

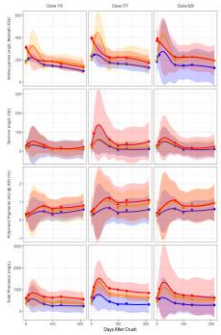
Temperature Probe Data



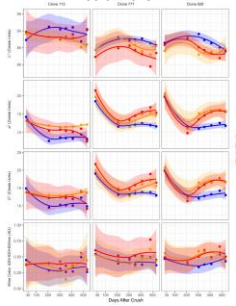
Phenolics 2019



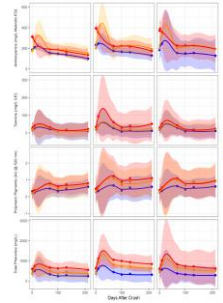
Phenolics 2020



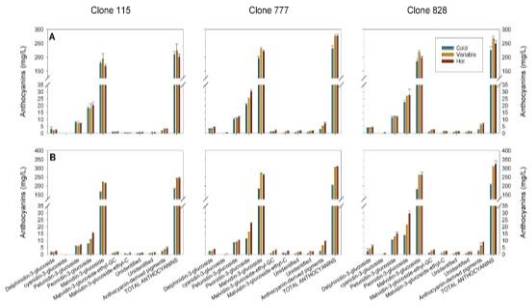
Color 2019



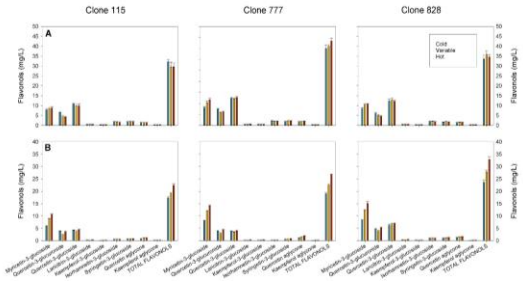
Color 2020



Anthocyanins via HPLC analysis



Flavonols via HPLC analysis



Tables

Table 3. Three-way ANOVA of phenolic concentrations taken at time of pressing during the 2019 and 2020 vintages. Average values of all replicates (n=3/vintage).

	Anthocyanins (mg/L)	SPP (AU)	LPP (AU)	TPP (AU)	Tannins (mg/L)	Total Phenolics (mg/L)
Vintage						
2019	210 b	0.45 a	0.06 a	0.50 a	136 a	1001 a
2020	294 a	0.41 b	0.00 b	0.41 b	45 b	765 b
p-values	**<0.0001**	**<0.0001**	**<0.0001**	**<0.0001**	**<0.0001**	**<0.0001**
Clone						
115	211 c	0.40 b	0.01 b	0.41 b	56 c	718 c
777	305 a	0.44 a	0.04 a	0.48 a	121 a	1024 a
828	241 b	0.45 a	0.03 a	0.48 a	56 b	907 b
p-values	**<0.0001**	**<0.0001**	**0.002**	**<0.0001**	**<0.0001**	**<0.0001**
Treatment						
Cold	208 c	0.37 b	0.03 b	0.40 c	68 c	723 c
Variable	265 b	0.45 a	0.01 b	0.46 b	81 b	894 b
Hot	284 a	0.46 a	0.05 a	0.51 a	123 a	1031 a
p-values	**<0.0001**	**<0.0001**	**0.000**	**<0.0001**	**<0.0001**	**<0.0001**
Interactions						
Vintage x Clone	**<0.0001**	**<0.0001**	**0.013**	**<0.0001**	**<0.0001**	0.055
Vintage x Treatment	**<0.0001**	**<0.0001**	**0.003**	**<0.0001**	**<0.0001**	**<0.0001**
Clone x Treatment	**<0.0001**	**<0.0001**	0.143	**<0.0001**	**0.000**	**<0.0001**
Vintage x Clone x Treatment	**<0.0001**	**<0.0001**	0.337	**<0.0001**	**<0.0001**	**0.018**

Bold numbers show values at or below Fisher's LSD of p<0.05. Different letters indicate significant differences. SPP: small polymeric pigments; LPP: large polymeric pigments; TPP: total polymeric pigments;); AU: absorbance units, measured at 520 nm.

Table 6. Three-way ANOVA of color analysis taken at pressing during the 2019 and 2020 vintages. Average values of all replicates (n=3/vintage).

	L* (CU)	a* (CU)	b* (CU)	C* (CU)	h* (CU)	420+520+620nm (AU)	420/520nm (AU)
Vintage							
2019	85.931 a	17.801 b	3.369 b	18.172 b	11.366 b	0.490 b	0.722 b
2020	84.033 b	18.390 a	4.159 a	18.903 a	12.862 a	0.586 a	0.783 a
p-values	**<0.0001**	**0.012**	**<0.0001**	**0.001**	**0.000**	**<0.0001**	**0.001**
Clone							
115	87.724 a	14.078 c	4.250 a	14.738 c	16.152 a	0.452 b	0.807 a
777	83.286 b	19.530 b	4.178 a	19.995 b	12.133 b	0.598 a	0.753 b
828	83.936 b	20.679 a	2.864 b	20.891 a	8.027 c	0.585 a	0.665 c
p-values	**<0.0001**	**<0.0001**	**<0.0001**	**<0.0001**	**<0.0001**	**<0.0001**	**<0.0001**
Treatment							
Cold	86.685 a	16.053 c	3.767 a	16.581 c	13.701 a	0.475 c	0.759 ab
Variable	84.890 b	17.733 b	3.600 a	18.175 b	11.382 b	0.543 b	0.758 a
Hot	83.371 c	20.502 a	3.924 a	20.958 a	11.229 b	0.596 a	0.713 b
p-values	**<0.0001**	**<0.0001**	0.334	**<0.0001**	**<0.0001**	**<0.0001**	**0.015**
Interactions							
Vintage x Clone	**0.005**	**0.001**	0.155	**0.001**	**<0.0001**	0.426	0.356
Vintage x Treatment	**<0.0001**	**<0.0001**	**0.028**	**<0.0001**	0.083	**<0.0001**	0.091
Clone x Treatment	**0.000**	**0.000**	0.076	**0.000**	0.142	**0.002**	0.173
Vintage x Clone x Treatment	0.247	0.161	**0.014**	0.303	**0.010**	0.572	0.217

Bold numbers show values at or below Fisher's LSD of p<0.05. Different letters indicate significant differences. L*: lightness; a*: red/green; b*: yellow/blue; C*: chroma; h*: hue angle; nm: nanometers; CU: CIELab Units; AU: absorbance units.

Table 8. Calculation of ΔE*, the distance between two colors in the CIELab space. Analysis between all treatment groups, both vintages as well as individual vintages, taken at time of pressing. A ΔE*≥2.0 represents two colors that can be distinguished with the naked eye. Average value of all replicates (n=3/vintage).

	Both Vintages				2019				2020			
	L* (CU)	a* (CU)	b* (CU)	ΔE*	L* (CU)	a* (CU)	b* (CU)	ΔE*	L* (CU)	a* (CU)	b* (CU)	ΔE*
All Clones												
Cold	86.685	16.053	3.767		86.024	17.493	3.717		87.346	14.612	3.818	
Variable	84.890	17.733	3.600	**2.464**	85.026	17.795	3.880	0.733	83.954	17.671	4.121	**4.578**
Cold	86.685	16.053	3.767		86.024	17.493	3.717		87.346	14.612	3.818	
Hot	83.371	20.502	3.924	**5.550**	85.943	18.116	3.330	0.748	80.799	22.888	4.527	**10.577**
Variable	84.890	17.733	3.600		85.026	17.795	3.880		83.954	17.671	4.121	
Hot	83.371	20.502	3.924	**3.175**	85.943	18.116	3.330	0.412	80.799	22.888	4.527	**6.111**
115												
Cold	88.084	13.102	4.092		87.293	14.211	4.415		88.875	11.993	3.768	
Variable	88.124	13.232	4.406	0.343	89.066	13.183	3.893	**2.115**	87.182	13.280	4.919	**2.418**
Cold	88.084	13.102	4.092		87.293	14.211	4.415		88.875	11.993	3.768	
Hot	86.962	15.901	4.251	**3.019**	89.693	13.222	3.992	**2.630**	84.232	18.579	4.509	**8.092**
Variable	88.124	13.232	4.406		89.066	13.183	3.893		87.182	13.280	4.919	
Hot	86.962	15.901	4.251	**2.915**	89.693	13.222	3.992	0.636	84.232	18.579	4.509	**6.078**
777												
Cold	85.742	16.598	4.250		84.324	18.489	4.510		87.159	14.707	3.991	
Variable	83.412	19.317	3.541	**3.650**	84.296	19.681	3.013	1.913	82.528	18.953	4.068	**6.284**
Cold	85.742	16.598	4.250		84.324	18.489	4.510		87.159	14.707	3.991	
Hot	80.704	22.676	4.744	**7.910**	82.272	21.446	3.517	**3.734**	79.135	23.906	5.972	**12.367**
Variable	83.412	19.317	3.541		84.296	19.681	3.013		82.528	18.953	4.068	
Hot	80.704	22.676	4.744	**4.480**	82.272	21.446	3.517	**2.732**	79.135	23.906	5.972	**6.299**
828												
Cold	86.229	18.458	2.960		86.454	19.781	2.227		86.004	17.136	3.694	
Variable	83.133	20.659	2.854	**3.795**	84.115	20.521	2.332	**3.456**	82.151	20.779	3.376	**5.312**
Cold	86.229	18.458	2.960		86.454	19.781	2.227		86.004	17.136	3.694	
Hot	82.447	22.929	2.776	**5.859**	85.863	19.679	2.423	0.631	79.031	26.178	3.130	**11.432**
Variable	83.133	20.659	2.854		84.115	20.521	2.332		82.151	20.779	3.376	
Hot	82.447	22.929	2.776	**2.381**	85.863	19.679	2.423	1.942	79.031	26.178	3.130	**6.241**

Bold numbers show values at or above ΔE*≥2.0 between the two treatments. CU: CIELab Units.

Conclusions

- Fermentation temperature is significant in relation to phenolic extraction of Pinot noir
- Time under higher temperatures is significant for tannin extraction, and therefore polymeric pigment formation
- Consistency of higher temperatures (daytime heating/constant heating) is crucial in outcome of phenolic extraction