Temperature and grape quality

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Berry quality, a complex concept, is essential to wine quality…

Chemical Composition

Sugars (Glucose&Fructose)

Acids (Malate&Tartrate)

Secondary metabolites (phenolics&volatile compounds)

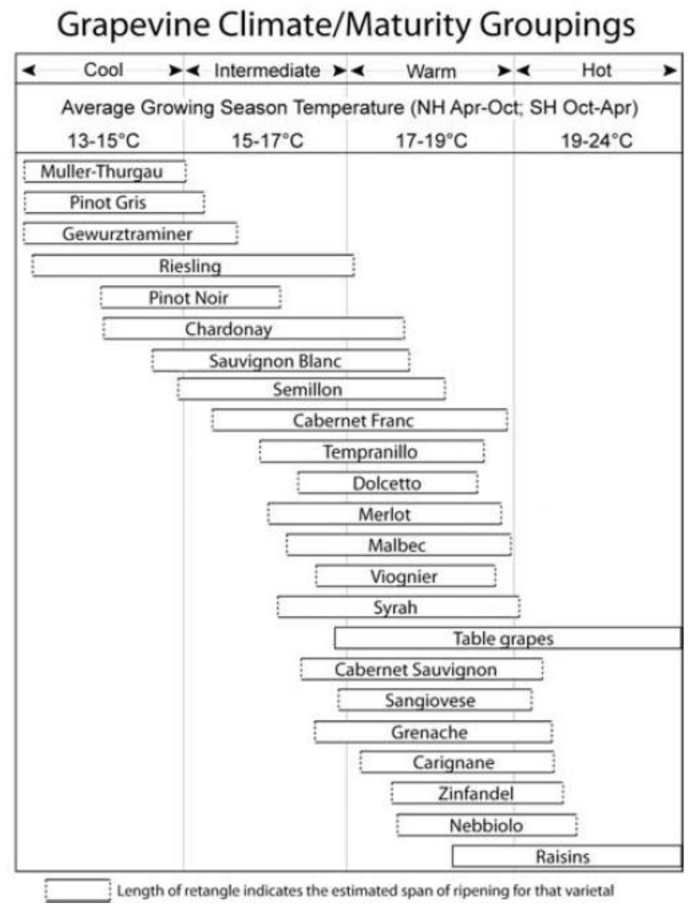
Wine Quality

Alcohol content

Flavors

Aromas

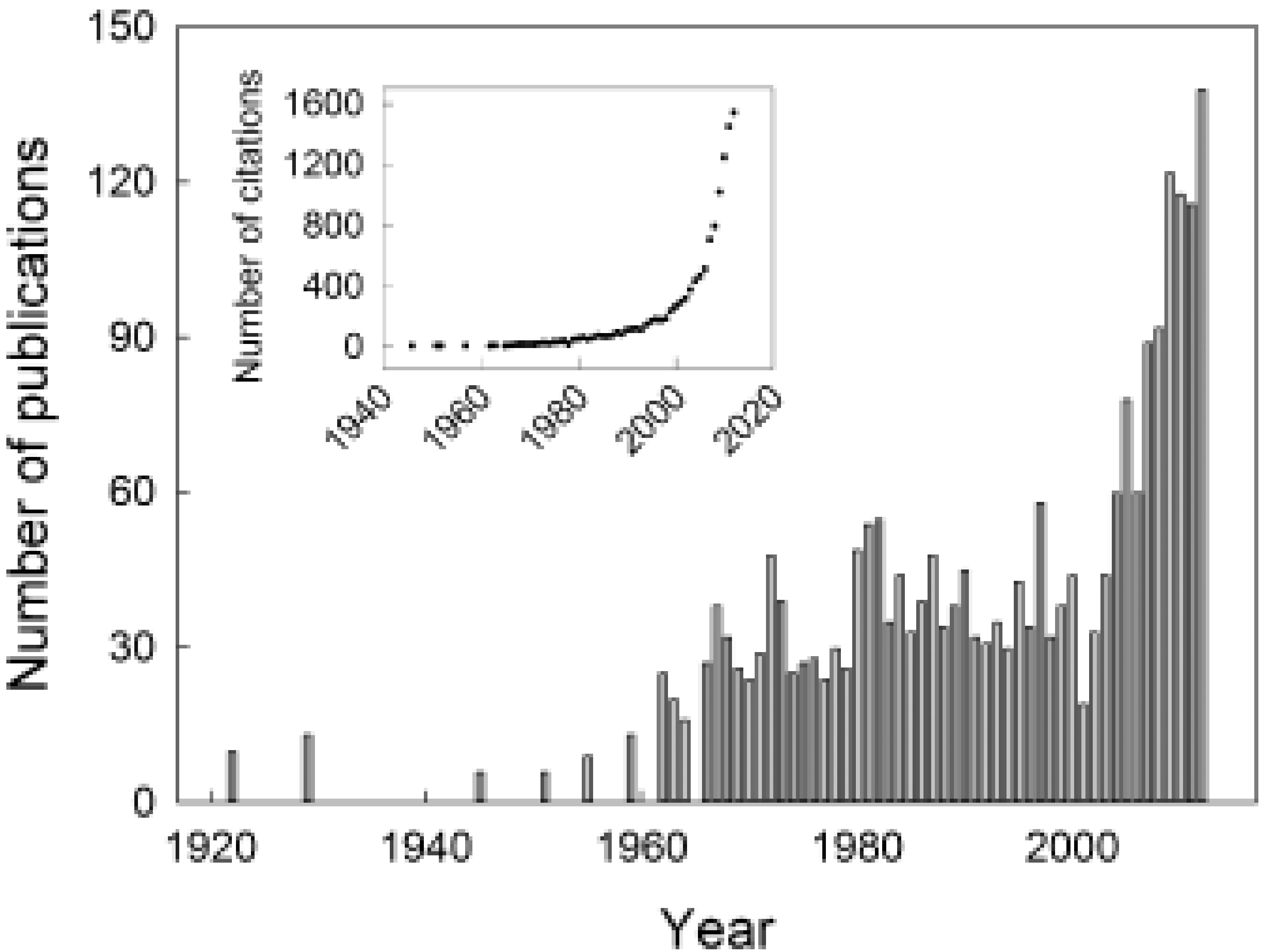
Color



Temperature plays an essential role in producing premium quality wine, depending on genotype.

Jones, 2006

Temperature + grapevine => 2753 papers



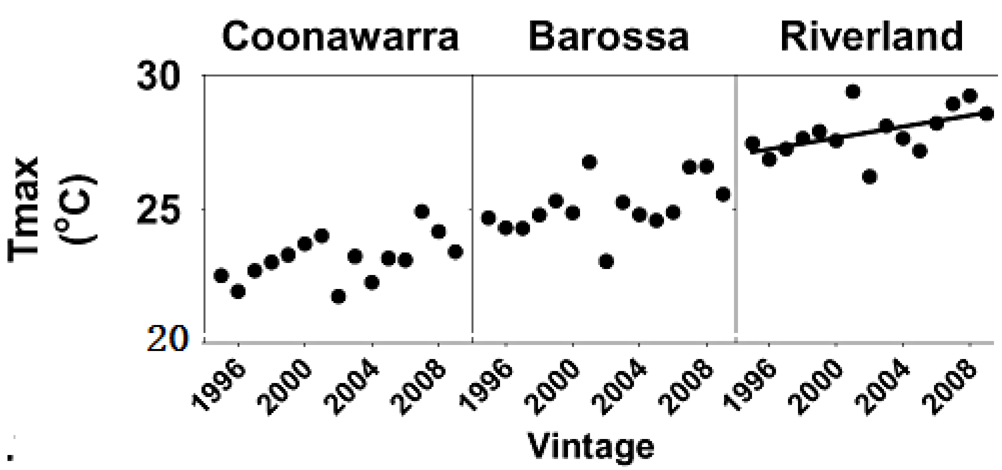
Bonada and Sadras, AJGW 2015, 21:1-17

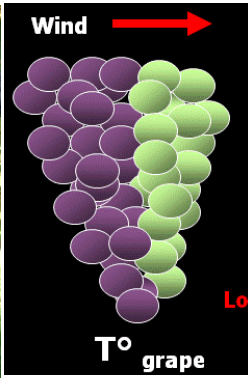
Outline

- Experimental Setups
- T vs sugars=>alcohol content
- T vs organic acids (malic& tartaric acids) =>freshness & balance
- T vs anthocyanins =>color
- T vs IBMP => aroma

Experimental setups

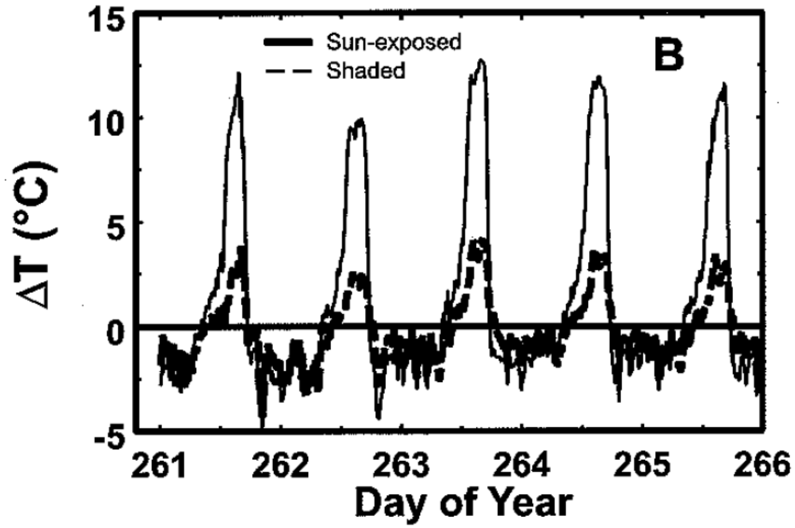
- Long-term time series, vintage-vintage, site and regions
- Whole plant heating– growth chamber
- Microclimate – shaded vs exposed within canopy
- Tarara’s chamber free system
- Sadras’ open top chamber system
- EGFV’ localized heating system





Sadras and Petrie 2011

Berry T differs (>5°C) among canopy position



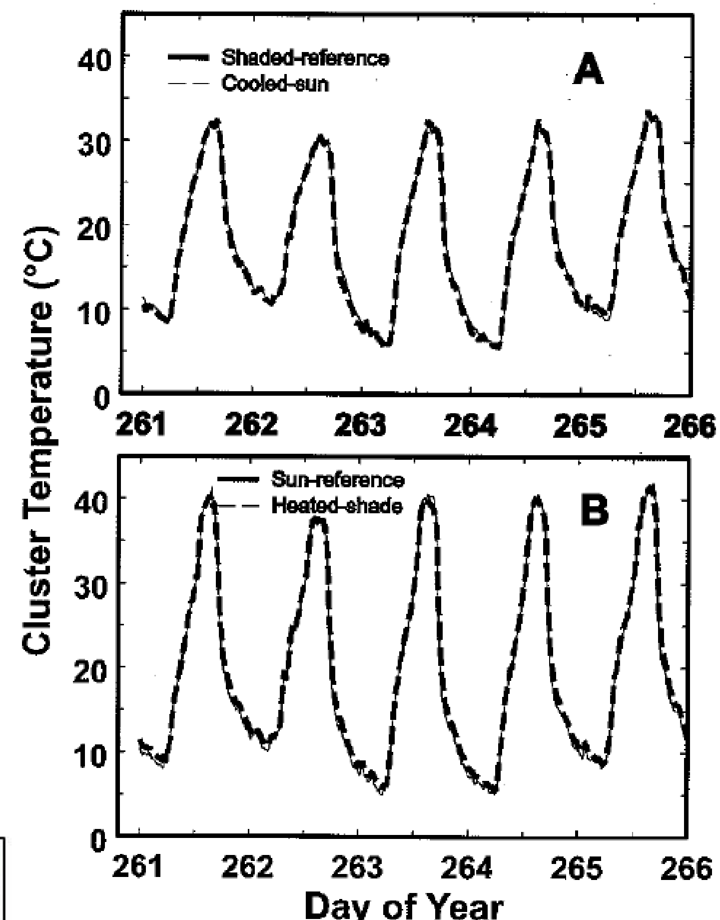


Fig. 4. Diurnal pattern of temperature for cooled (A) and heated (B) berries and their reference clusters, during a 5-day period following veraison.

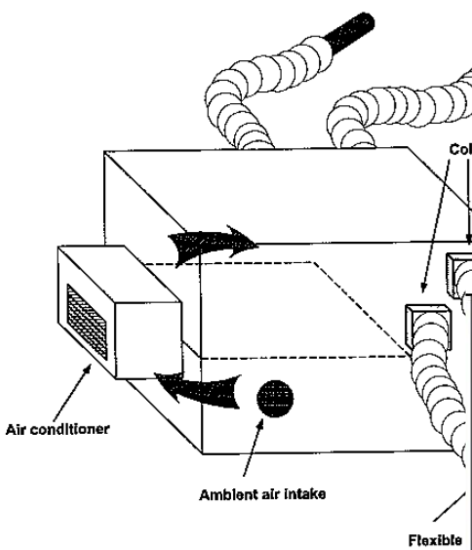


Fig. 1. Schematic diagram of the apparatus forced convection.

Tarara et al. 2000 AJEV 51:182-188
Sweetman et al., 2014 JXB

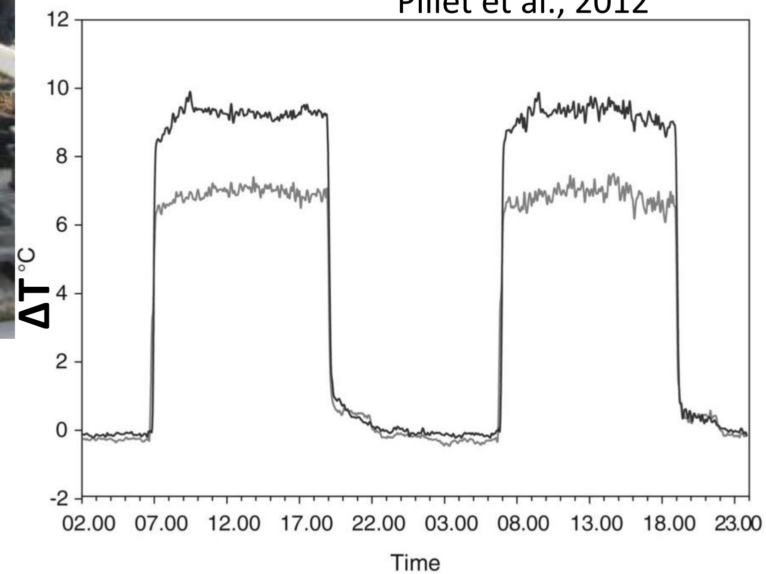
A large-scale, open-top system to increase temperature (+ 2°C) in realistic vineyard conditions

Sadras et al., AFM 2012, 154:187-194

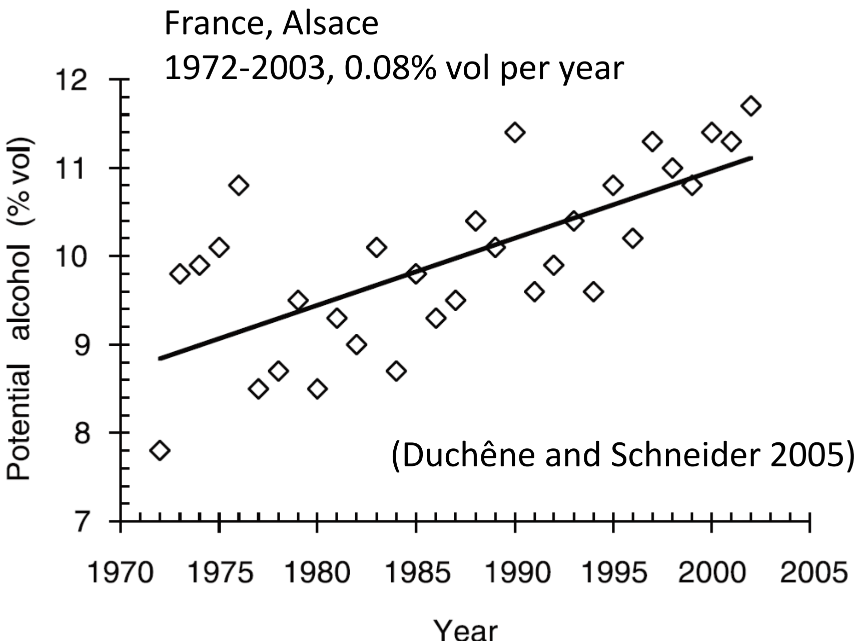
Localized heating in greenhouse (>5°C)

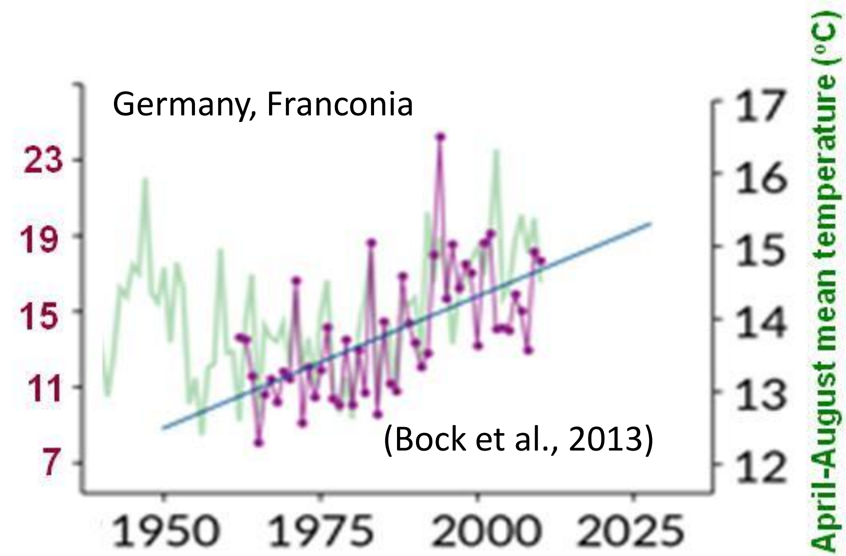
Ph. Pieri and D. Lecourieux 2009

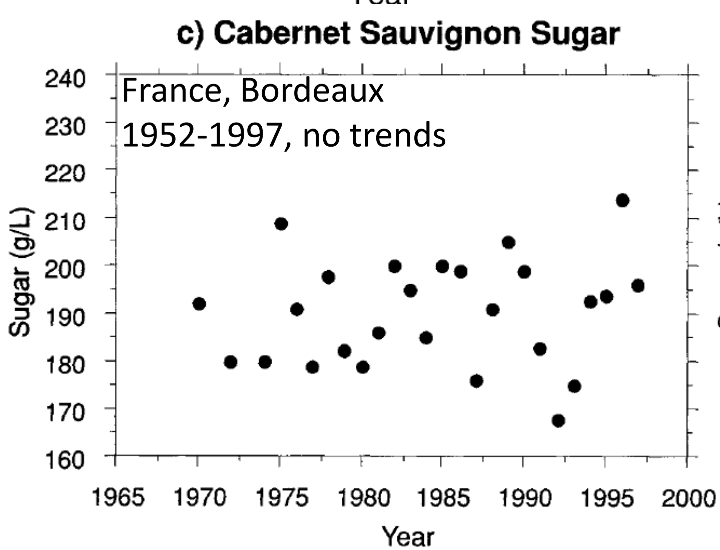
Pillet et al., 2012

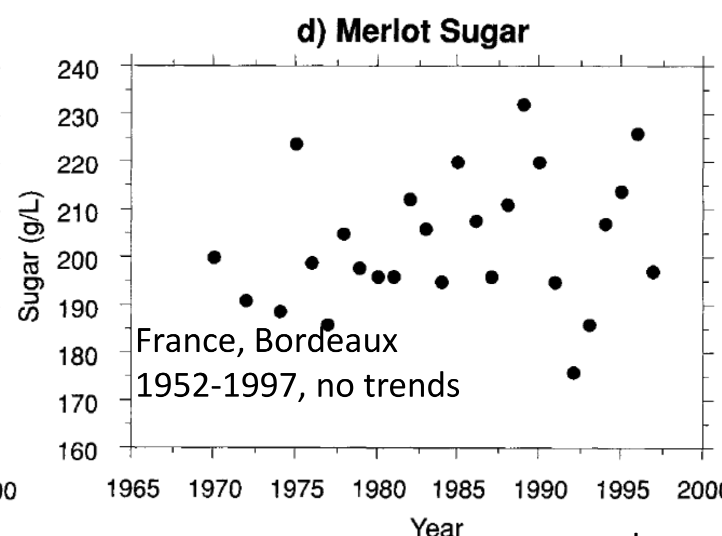


Sugar concentration (alcohol%) vs Temperature









Jones and Davis 2000

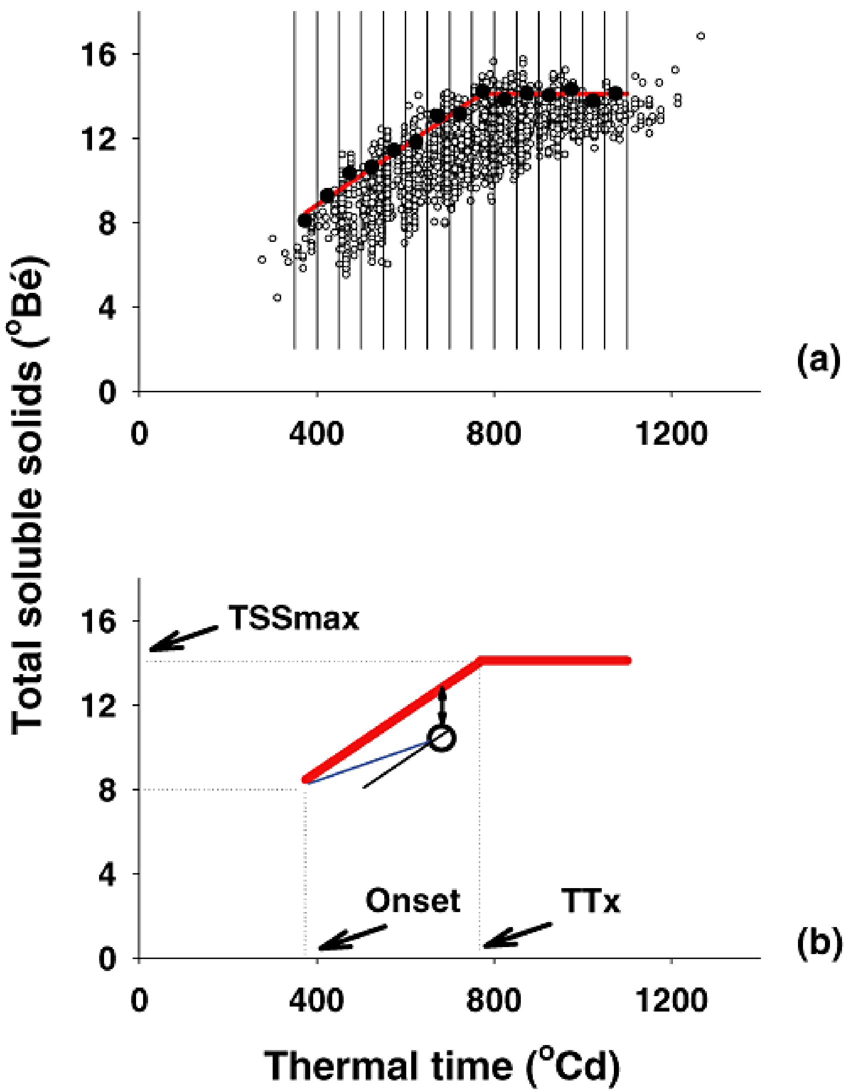
Sugar concentration (alcohol%) vs Temperature

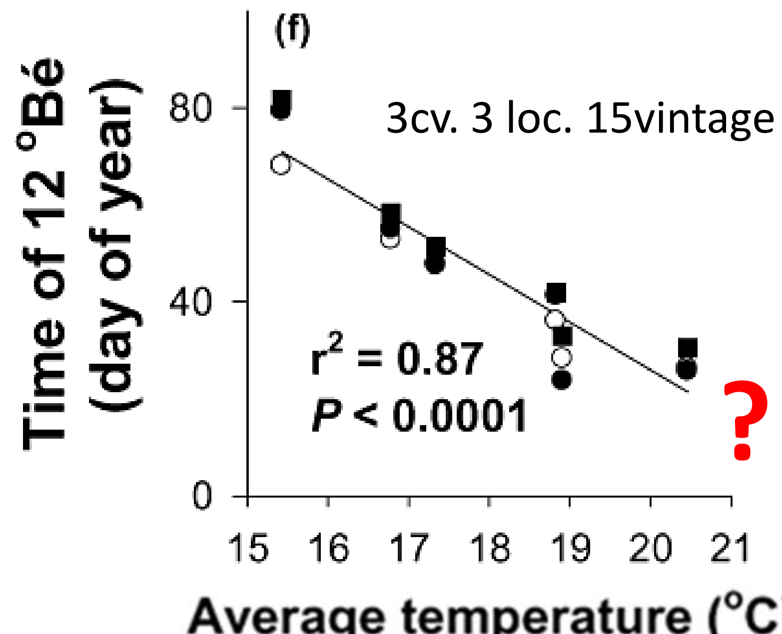
Quantifying the onset, rate and duration of sugar accumulation

$$TSS = a + b\,TT \qquad \text{if } TT \le TTx$$

$$TSS = a + b\,TTx \qquad \text{if } TT > TTx$$

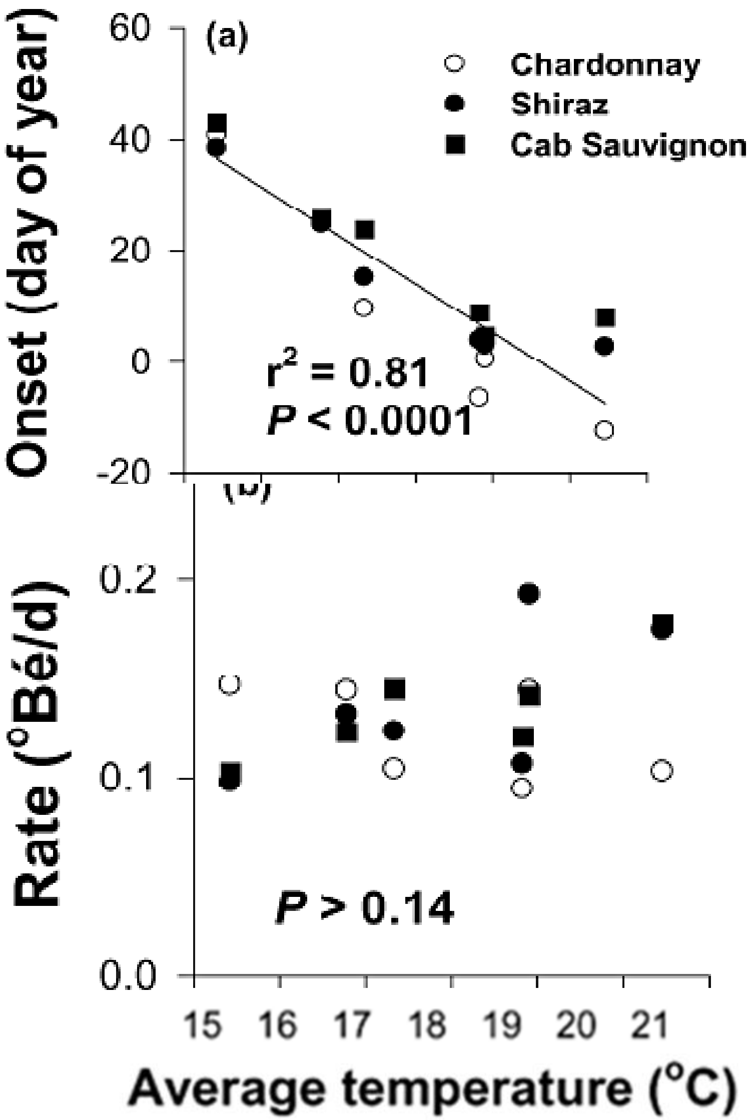
Onset=(8-a)/b

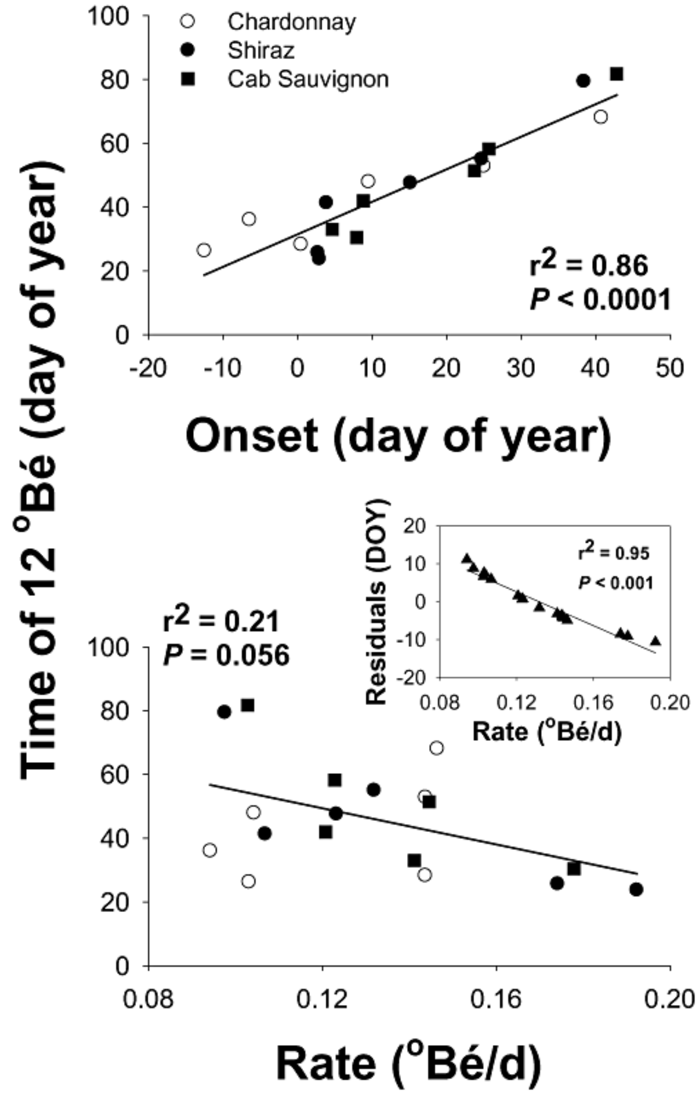




Sadras and Petrie 2011a AJGW

Sugar concentration (alcohol%) vs Temperature

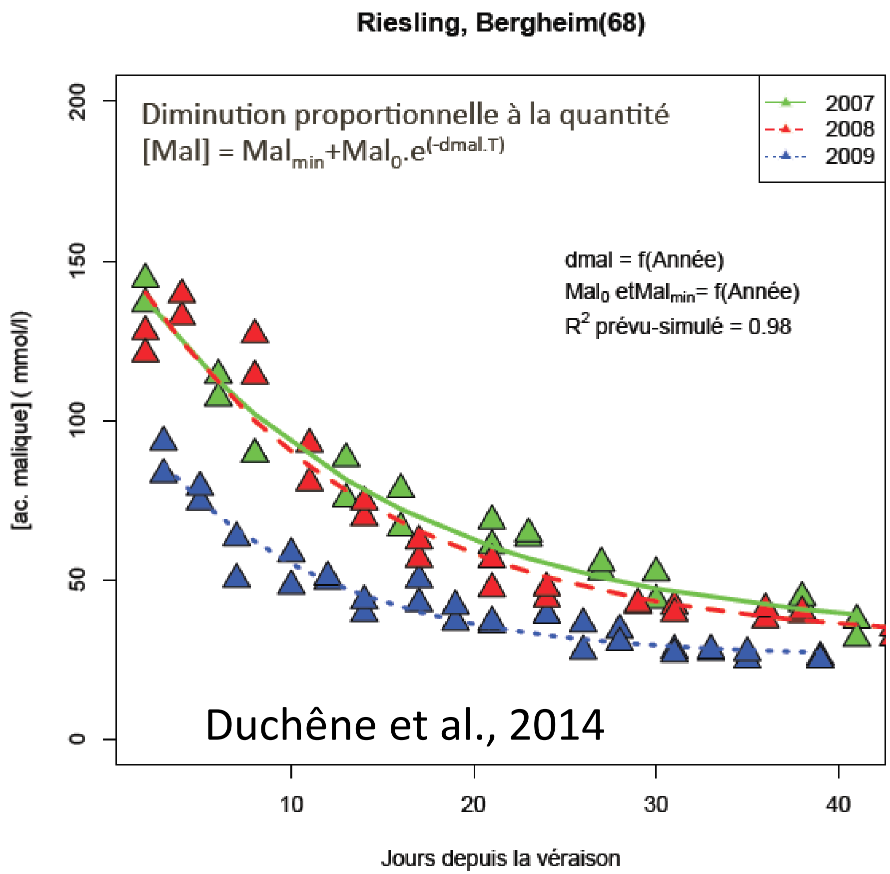


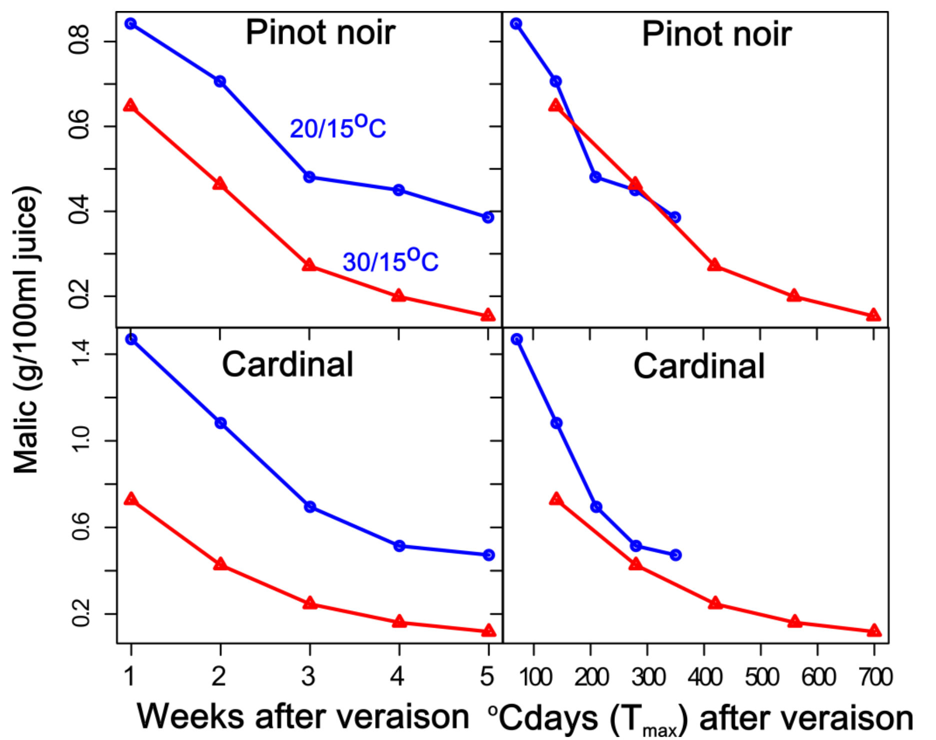


Shifts in onset accounted for 86% of the variation in the time of maturity (12°Bé or 21.8°Brix)

Sadras and Petrie 2011b

Malic acid vs Temperature

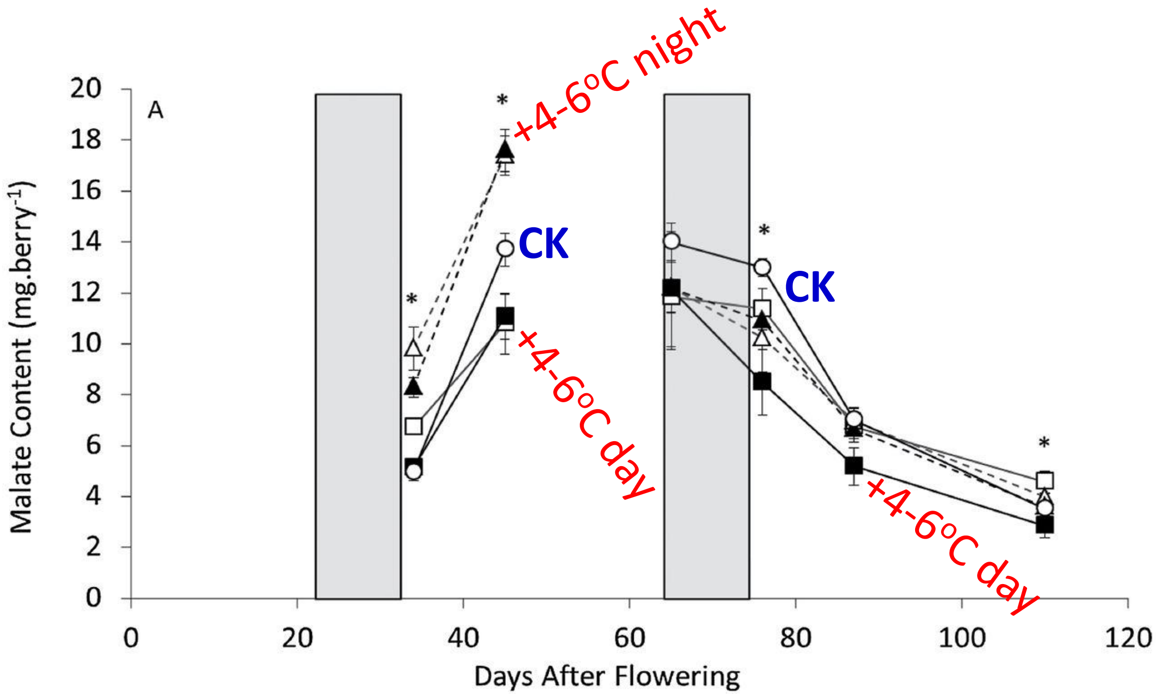


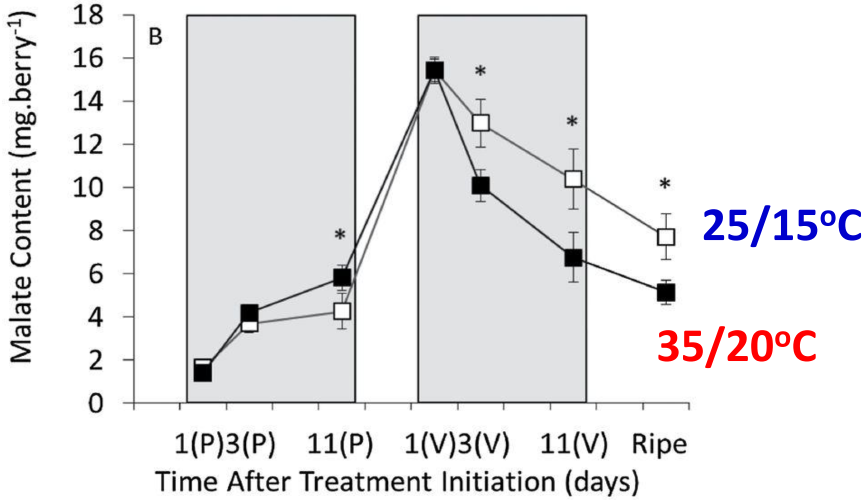


Re-analzyed based on Kliewer and Lider 1970

[Mal] at veraison, degree day of harvest, cultivar determine [Mal] degradation and [Mal] at harvest.

Malic acid vs Temperature

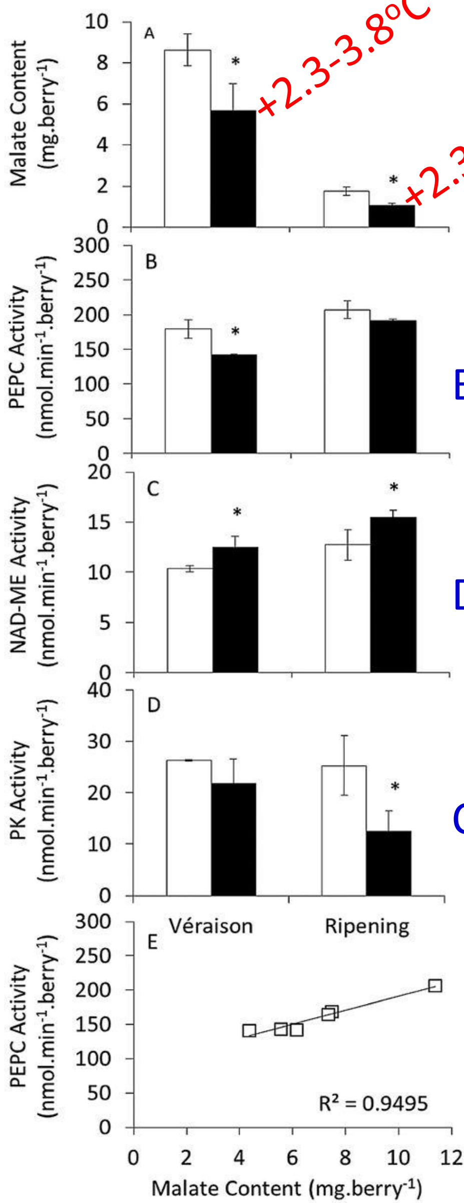




- High (night)T before veraison increased Malic acid
- High T after veraison decreased Malic acid

Sweetman et al. 2014 JXB

Malic acid vs Temperature



+2.3-3.8°C

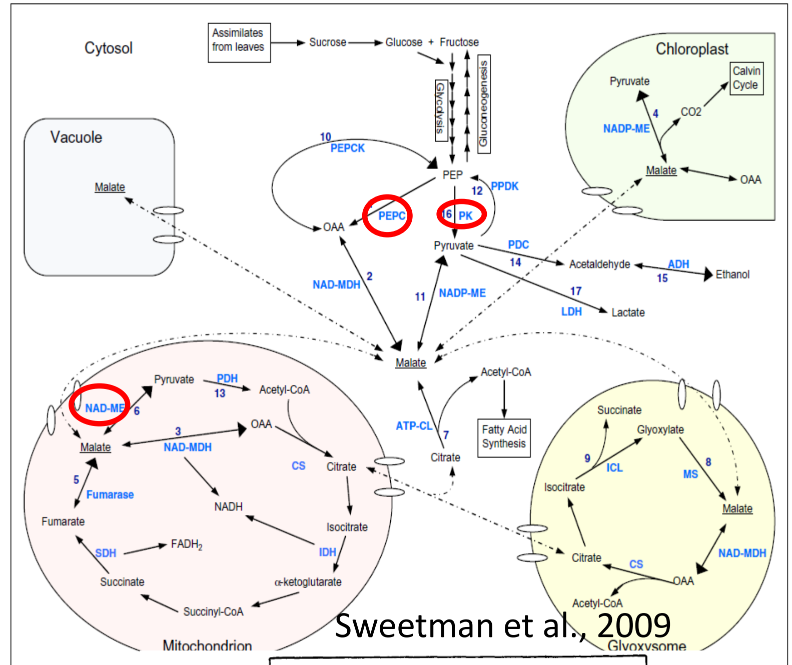
+2.3-3.8°C

Biosynthesis

Degradation

Competition

Sweetman et al., 2014



Sweetman et al., 2009

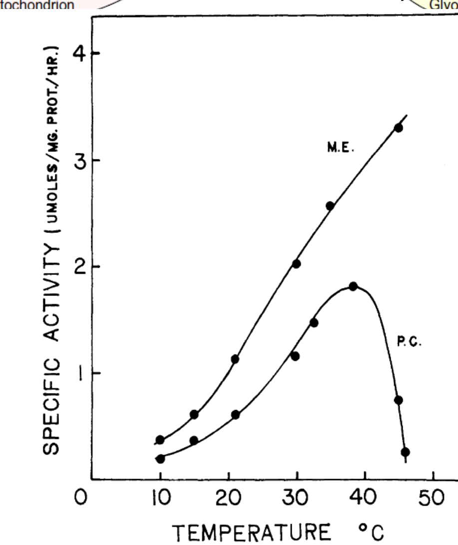
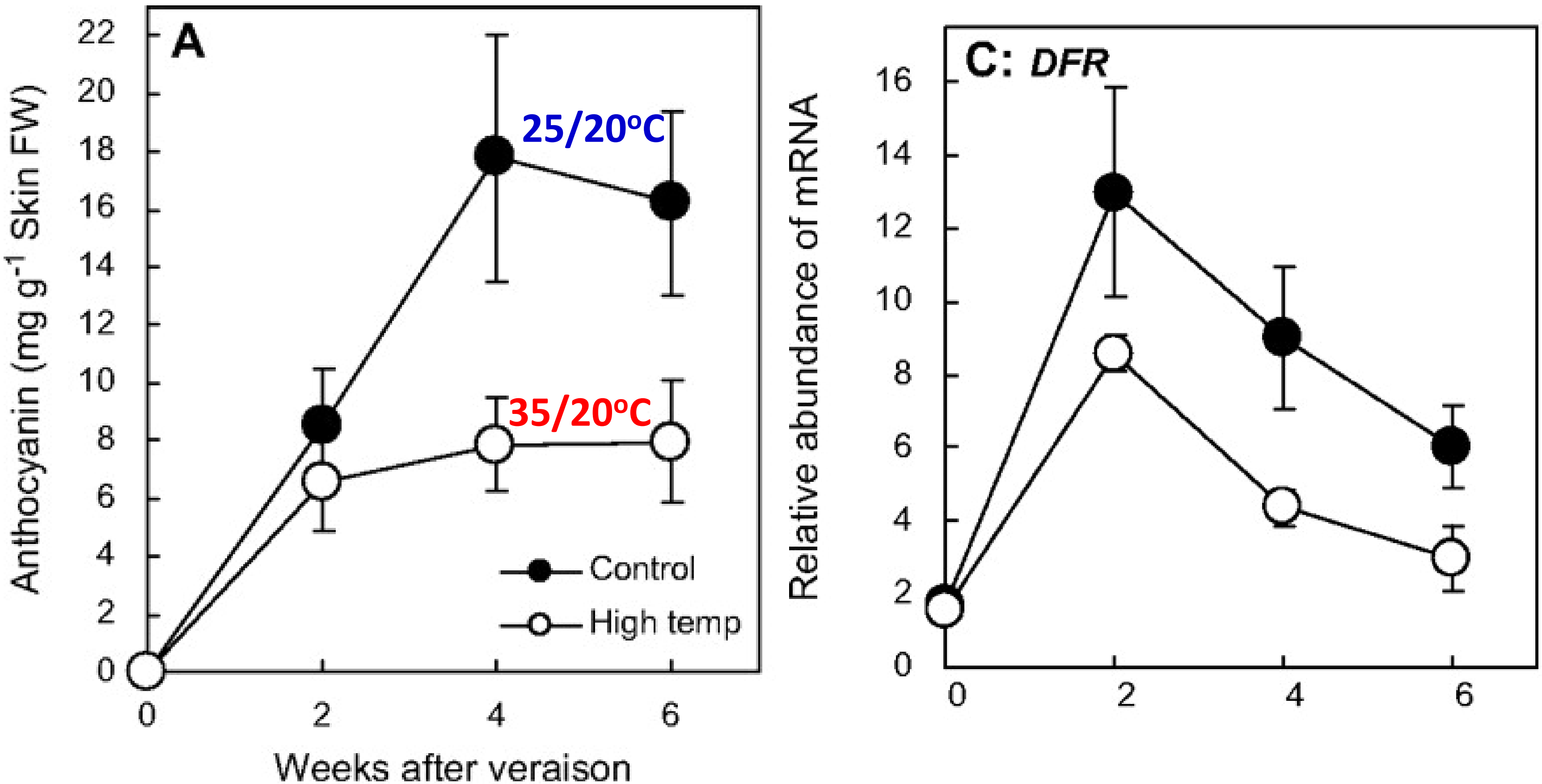


FIG. 1. *In vitro* temperature responses of PEP carboxylase (P.C.) and malic enzyme (M.E.) activities extracted from immature grape berries.

Lakso and Kliewer, 1975

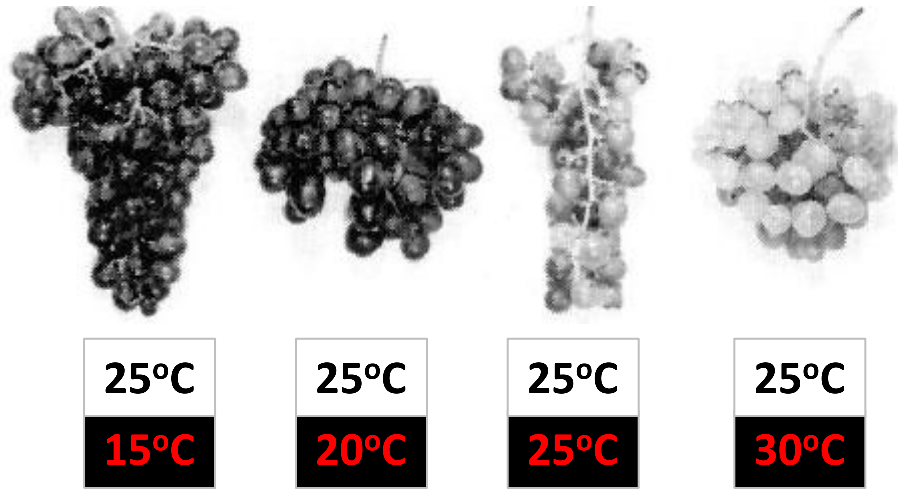
Anthocyanins vs Temperature



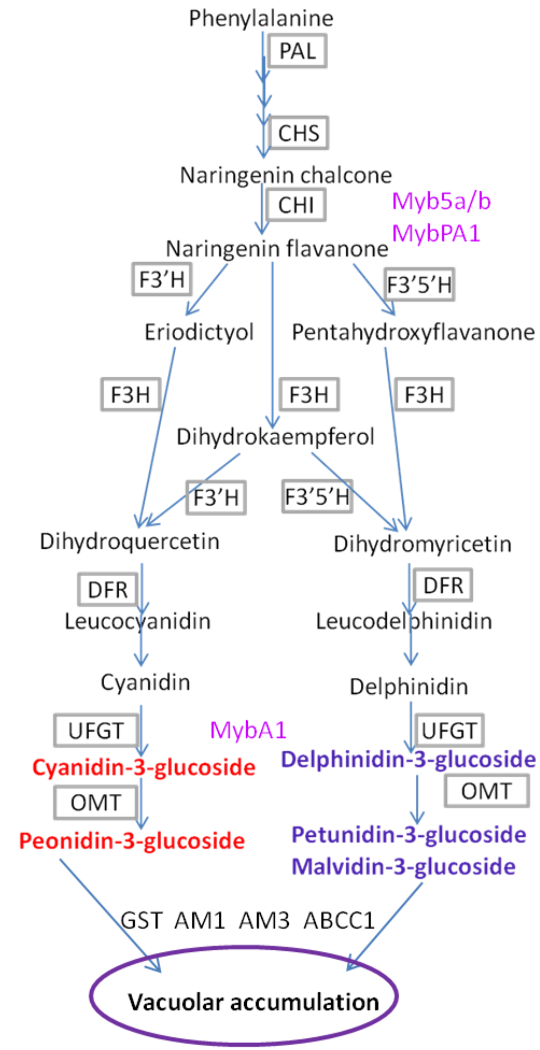
Biosynthesis was inhibited, degradation was accelerated!

Mori et al., 2007 JXB 58 : 1935-1945

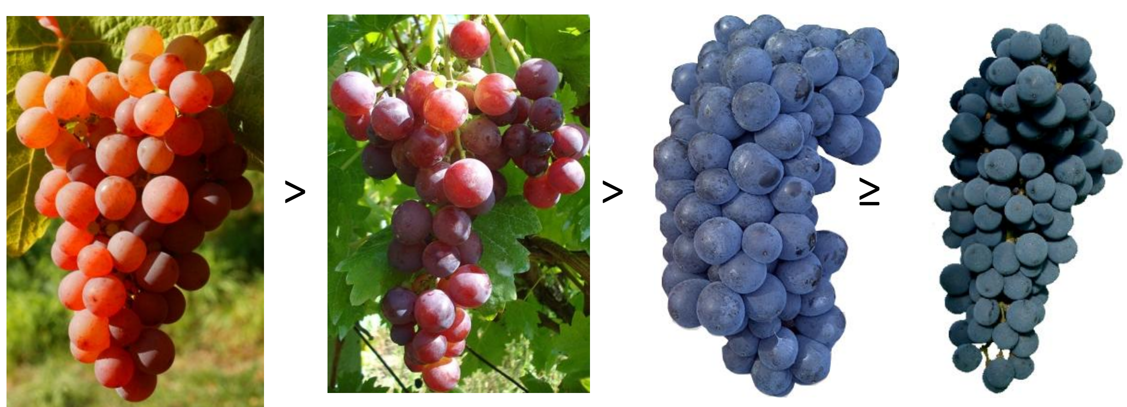
Anthocyanins vs Temperature



Kliewer and Torres 1972



Sensitivity to high temperature

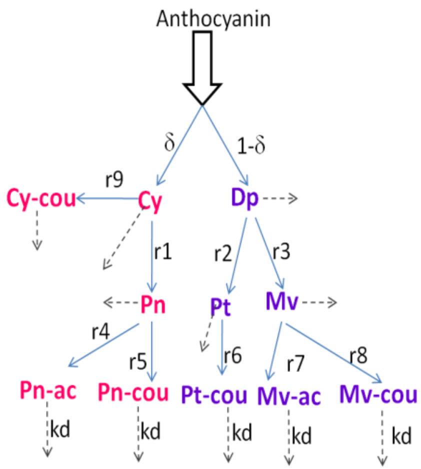


cv. Tokay cv. Cardinal cv. Pinot Noir cv. Cabernet Sauvignon

Kliewer and Torres 1972

Anthocyanins vs Temperature

Anthocyanin composition model



$$\frac{dTA}{dt} = \frac{dTAobs}{dt} + kdTA$$

$$\frac{dCy}{dt} = \delta \frac{dTA}{dt} - (r1 + r9 + kd)Cy$$

$$\frac{dDp}{dt} = (1 - \delta) \frac{dTA}{dt} - (r2 + r3 + kd)Cy$$

$$\frac{dPn}{dt} = r1Cy - (r4 + r5 + kd)Pn$$

$$\frac{dPt}{dt} = r2Dp - (r6 + kd)Pt$$

$$\frac{dMv}{dt} = r3Dp - (r7 + r8 + kd)Mv$$

$$\frac{dPn\_ac}{dt} = r4Pn - kdPn\_ac$$

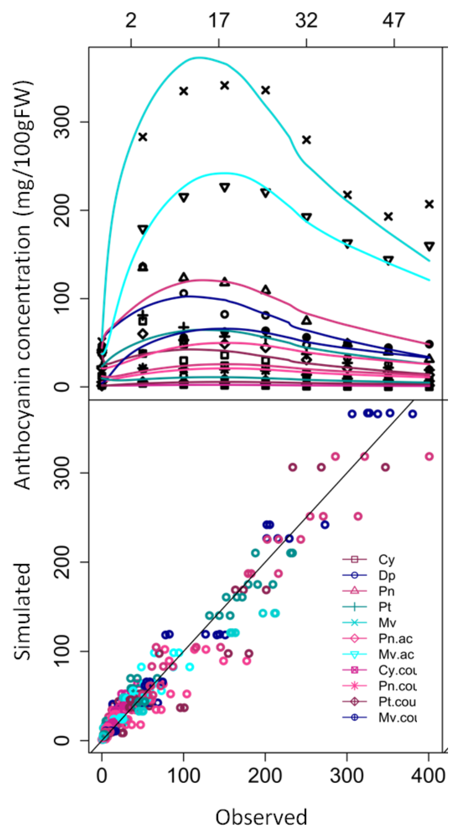
$$\frac{dPn_{cou}}{dt} = r5Pn - kdPn_{cou}$$

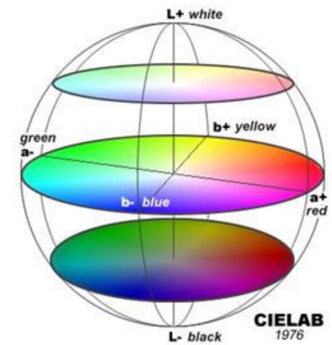
$$\frac{dPt\_cou}{dt} = r6Pt - kdP\_cou$$

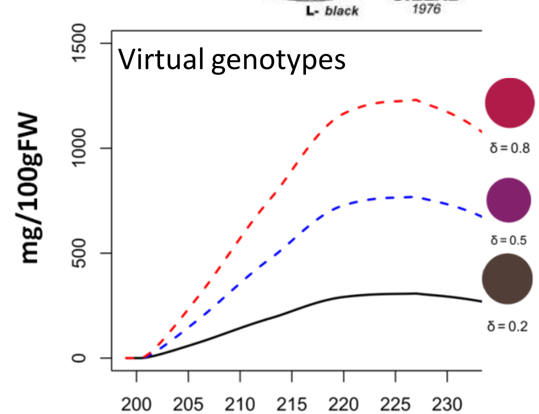
$$\frac{dMv\_ac}{dt} = r7Mv - kdMv_{ac}$$

$$\frac{dMv\_cou}{dt} = r8Mv - kdMv\_cou$$

$$\frac{dCy\_cou}{dt} = r9Cy - kdCy\_cou$$



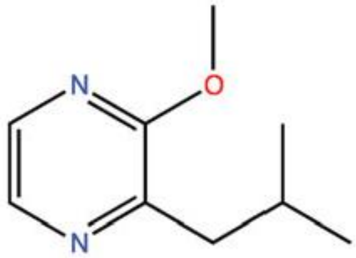




- ➢The model can simulate anthocyain composition under various genotype x environment combinations;
- ➢Model parameters can be considered as dissected traits
- ➢Temperature effects to be integrated!

Dai et al., unpublished

IBMP vs Temperature



3-isobutyl-2-methoxypyrazine
(IBMP)

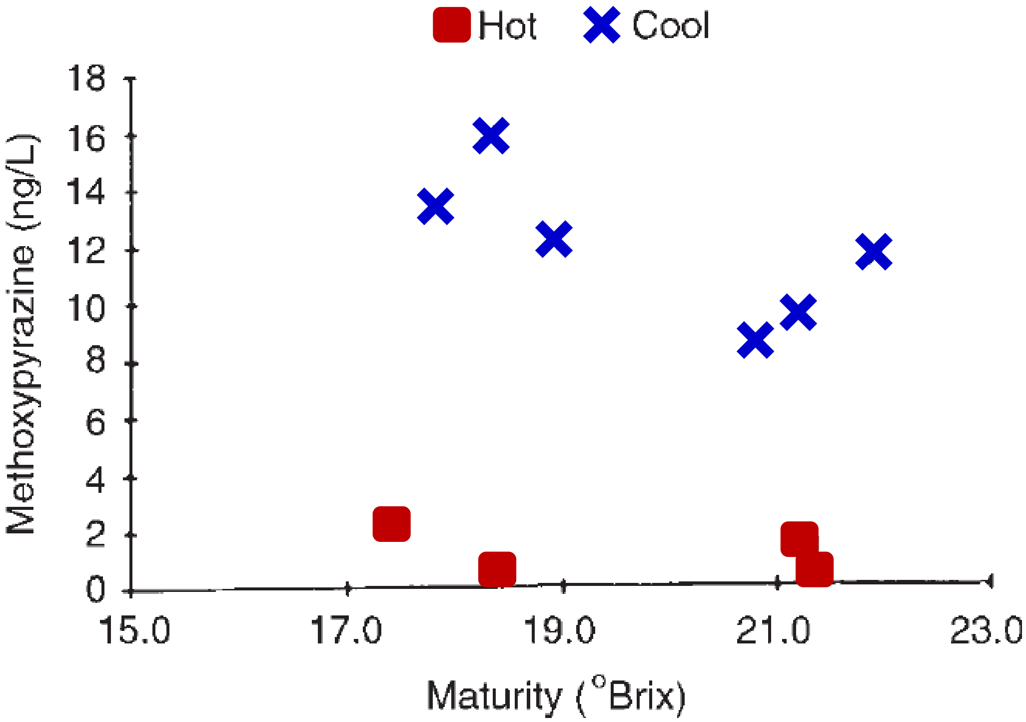
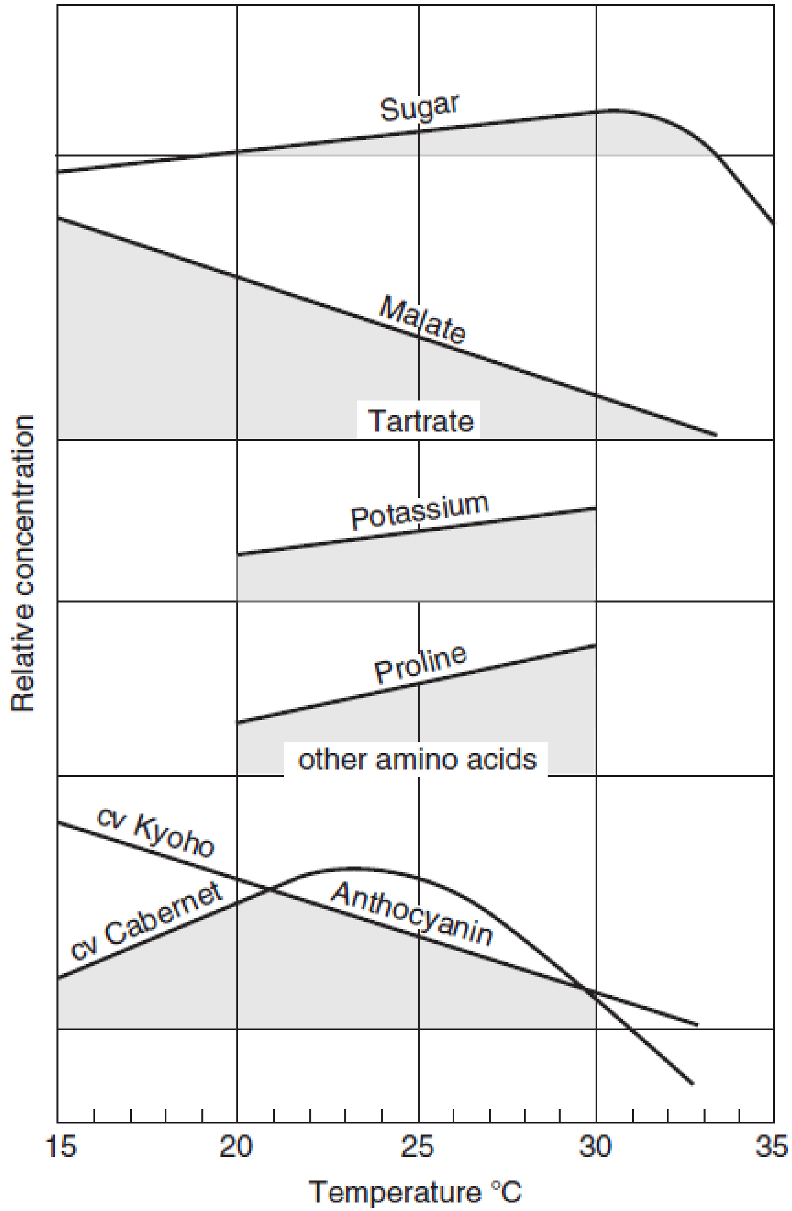


Figure 3.47 Influence of hot and cool climates on the content of methoxypyrazine in 'Sauvignon blanc' grapes. (From Allen and Lacey, 1993, reproduced by permission)

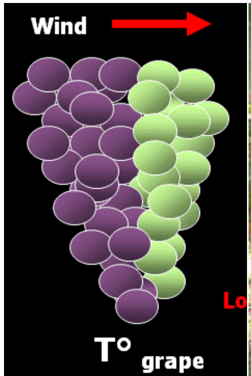
Relative sensitivity of berry composition to T



Coombe 1987 Acta Horticulturae 206:23-35

Conclusion

- High T increases or not affect [sugars];
- High T affects the onset of sugar accumulaton with little effect on the rate.
- High T decreases [Malic acid] after vraison; and night high T has different effect than day high T on [Malic acid];
- High T decreases [Anthocyanins];
- High T decreases [IBMP];
- Blances among metabolites should be further studied.



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Thank you for your attention!

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