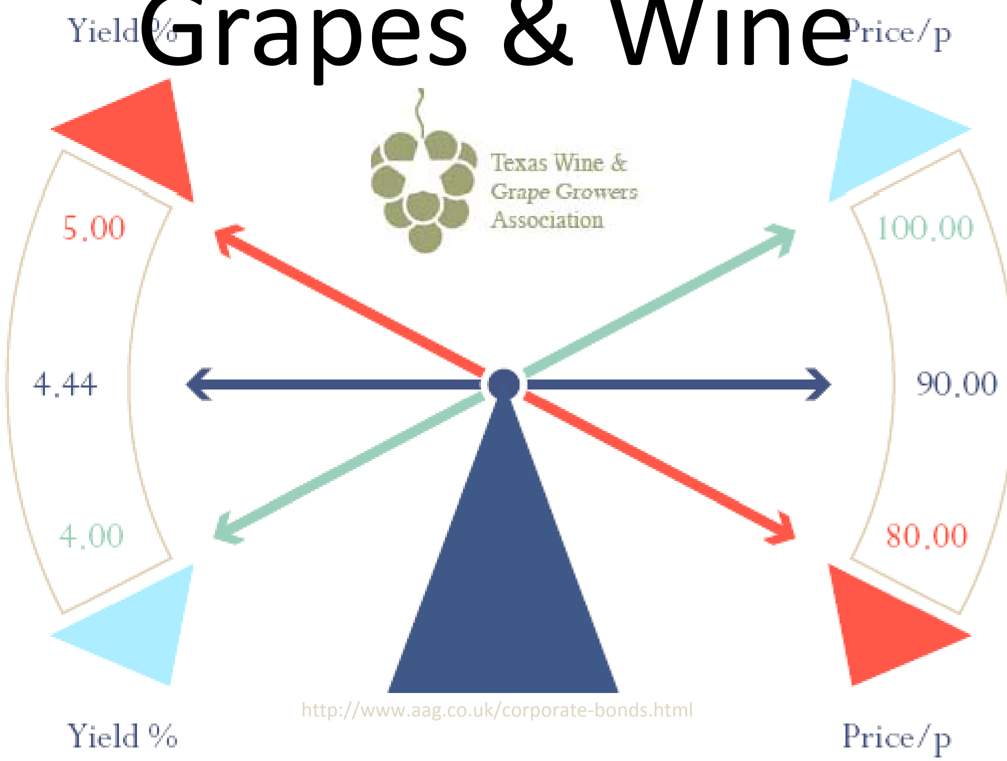
2011 TWGGA Grape Camp
Temperature Effects on Grapes & Wine



http://www.aag.co.uk/corporate-bonds.html

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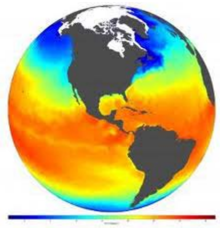
Texas Tech University Plant & Soil Science & AgriLIFE EXTENSION Texas A&M System

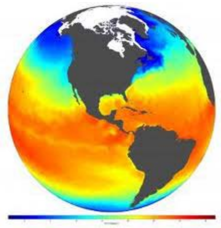
Temperature Effects?

- Vineyard- berry
- Cellar- wine
- Storage/Transportation- wine



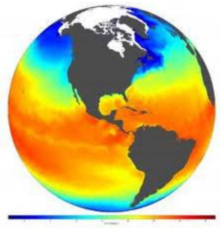
Climate: Temperature… …Moderation

- To fully ripen, grapes need a sufficient amount of heat during the growing season.
- Many of the vine's metabolic processes will slow or stop above a variety dependent temperature and below 10°C (50°F).
- Winter temperatures should be cold enough to encourage the vine to go dormant.
- Like so many aspects of quality grape growing regions, moderation is crucial.



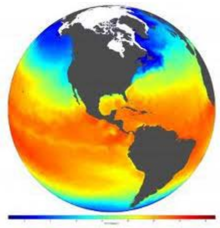
Climate: Temperature Classification

- EU
  - Zone A-C
- **UC Davis Degree-day system**
  - Heat summation= average daily temperature multiplied by the number of days in the growing season (April to October in the northern hemisphere)
  - As the vine does not grow when the temperature is less than 10°C only the temperatures above this value are considered.
- Allow different region to be compared but neither can totally define the climate as they do not take all of the climatic factors into consideration.



The Use of the UC Davis Heat Summation Scale in California

- The UC Davis heat summation scale is organized into five tiers. Region I is the coolest and Region V is the warmest. Units are in Celsius (Fahrenheit), with recommended grape varieties:
  - Region I: Below 1,400 (2,500) degree days;
    - Chardonnay, Pinot Noir, Gewurztraminer, Riesling
  - Region II: 1,400 – 1,600 (2,500-3,000) degree days
    - Cabernet Sauvignon, Merlot, Sauvignon Blanc
  - Region III: 1,600 – 1,900 (3,000-3,500) degree days
    - Zinfandel, Barbera, Gamay
  - Region IV: 1,900 – 2,200 (3,500-4,000) degree days
    - Malvasia, Thompson Seedless
  - Region V: Over 2,200 (4,000) degree days
    - Thompson Seedless, other table grapes
- When speaking about climate, it is important to distinguish the size of the area you are referring to. While entire regions are generalized by the UC Davis heat summation scale, there are often major differences within these areas.



Growing Degree Days (>50°F, April 1st - October 31st)

http://www.wrcc.dri.edu

- High Plains
  - Brownfield: 2,399 (4,351) (1914-1954)
  - Plains: 2,353 (4,268) (1925-2010)
- Fredericksburg:
  - Fredericksburg: 2,967 (5,373) (1896-2010)

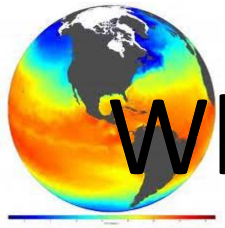
Region V: Over 2,204 (4,000) degree days

Fresno 2,584 (4,684)

No regions IV and V in France

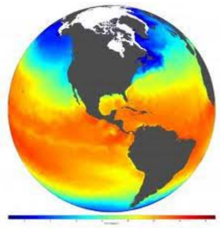
Region IV is similar to Spain (Port and Barbera)

Region V is similar to North Africa (Muscat and Verdelho)

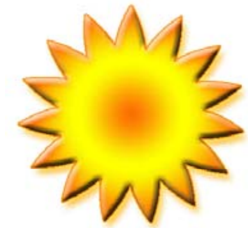


What does High Temperature Do?

- Impede or stop metabolism?
  - Flavor?
  - Color?
  - Structure (flavonoids/tannin)?
- Damage?



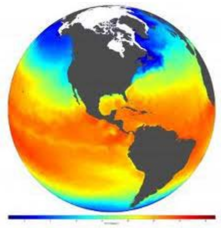
Hotter Places



- More sugar
  - More tons per acre
  - Ripe earlier
- Lower acid
  - Malic acid is respired
- Less color
- Less flavor/varietal distinctiveness

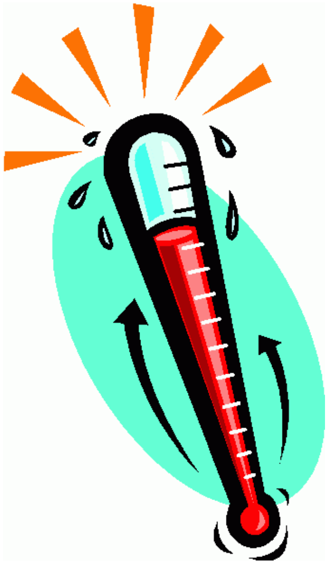
•Grapes for premium wine are not usually grown in very hot locations because they will lack distinctive varietal flavors.

•Hot areas are ideal for the production of **dessert wines**, however, because high sugar is desirable in order to achieve the high alcohol concentrations of these wines and varietal distinctiveness is not as important.



Very Hot

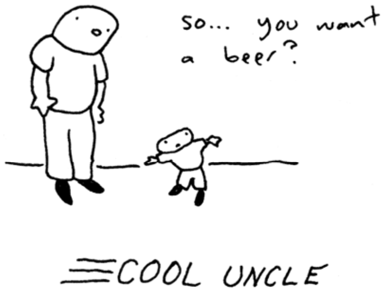
- Shriveled fruit
- Sunburn
- Sugar accumulation stops
- Physiologically the vine stops



Shrivel & Burn

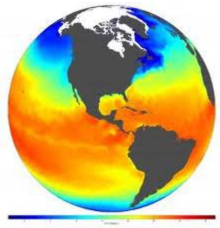
- Heat induced shriveling of grapes is often referred to as "sunburn" or heat injury.
- This type of damage generally occurs after a sudden rise in temperature and may occur at any time from fruit set to harvest.
- The type and extent of damage varies; single berries, parts or whole clusters may wilt, shrivel and dry.
- In some cases, damage occurs only to fruit that is directly exposed to sunlight. However, shaded fruit may also become damaged when temperatures exceed 40°C/104°F.
- Clusters in direct sunlight for more than 2 to 3 hours will likely experience sunburn even if vines are well irrigated. (Larry Williams in 2011. Smith, R. Beyond sunburn. Agriculture and Natural Resources, University of California.)
- Susceptibility to such heat damage is usually variety dependent.

Sunburned



Cooler Places

- Less sugar/slower accumulation
  - Yields lower
  - Sugar addition may be necessary
- More acid
  - Less malic acid respired
  - Wine will be more tart or sour tasting
- More color
- More flavor/**varietal distinctiveness**
- Overall, better quality areas



Effects of Different Climates

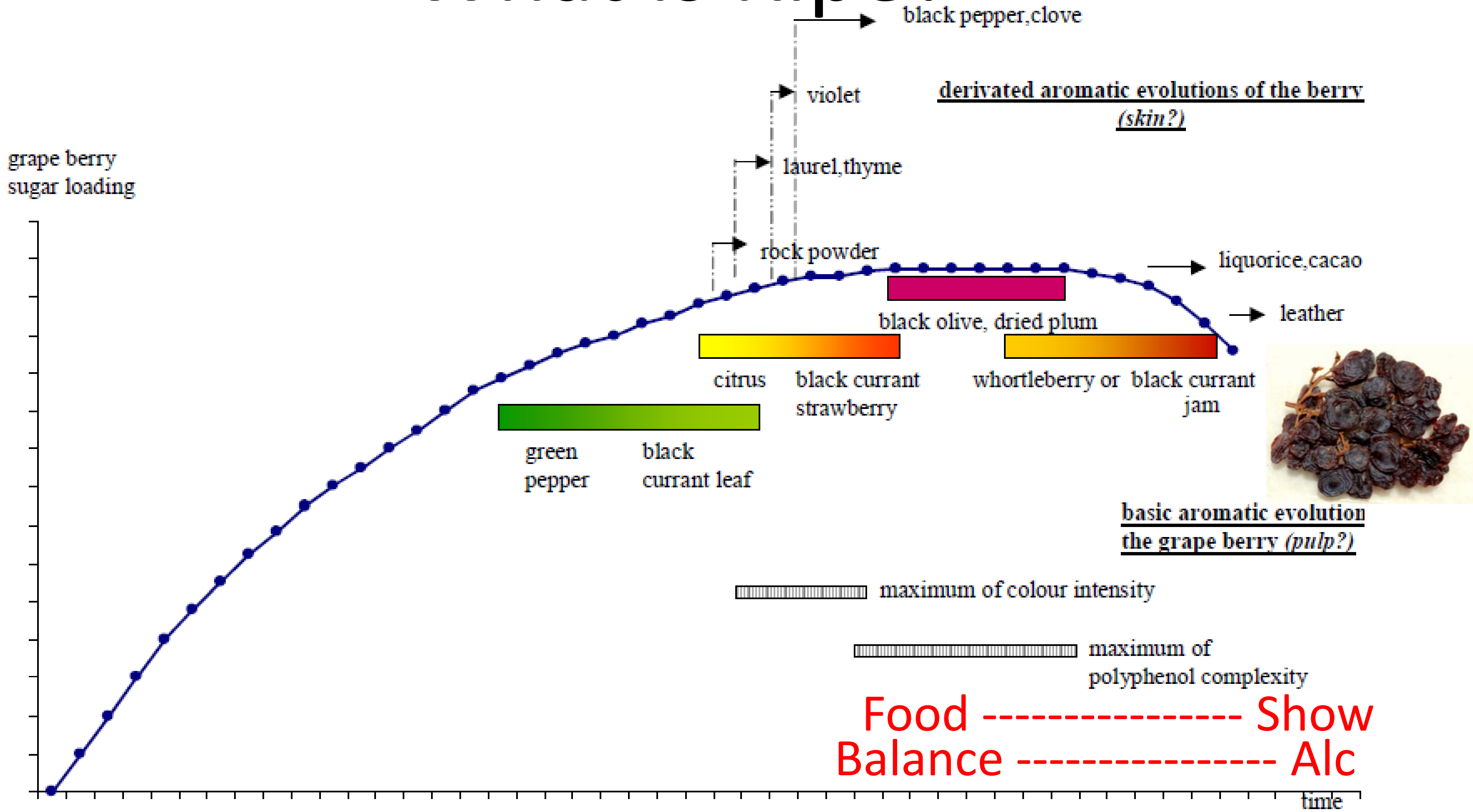
	WARMER	COOLER
SUGAR	higher	lower
ACID	lower	higher
COLOR	lower	higher
FLAVOR	lower	higher
YIELD	higher	lower
VALUE	LOWER	HIGHER

Varieties Have Different Heat Requirements

- Some need more heat to ripen
  - e.g. Cabernet Sauvignon, Zinfandel (warmer origins) **Tannat, Petit verdot, Mourvedre, Barbera**
- Some need less heat to ripen
  - e.g. Chardonnay, Pinot noir, Riesling (cooler origins)

Match varieties to site

What is Ripe?



UNFOLDING OF TYPICITY (links between aromatic impressions)
Complex SYRAH

Temperature & Berry Development

- Temperature influences both cell division and elongation in berries.
  - The optimum temperature for berry growth is between 68° and 77°F (20° and 25°C) or up to 86°F (30°C). (Dokoozlian 2000; Hale and Buttrose, 1974)
    - Also optimal for infection and disease
- Berry growth during the rapid growth stage I (just after bloom) is quite sensitive to temperature:
  - Temperatures in excess of 95°F (35°C) reduce growth rate and size at harvest.

Coombe, B. G. 1976. The development of fleshy fruits. Ann. Rev. Plant Physiol. 27:507–28.

Dokoozlian, N.K. 2000. Grape Berry Growth and Development (PDF). Pages 30-37 in: Raisin Production Manual. University of California, Agricultural and Natural Resources Publication 3393, Oakland, CA

Hale, C.R. and M.S. Buttrose. 1974. Effect of temperature on ontogeny of berries of *Vitis vinifera* L. cv. 'Cabernet Sauvignon'. J. Amer. Soc. Hort. Sci. 99:390–394.

Harris, J. M., P. E. Kriedemann, and J. V. Possingham. 1968. Anatomical aspects of grape berry Development. Vitis 7:106–19.

High Temperature & Berry Development

- Prolonged periods of excessively high temperatures following berry softening, however—for example, 3 to 4 consecutive days above 105°F (40.6°C)—may retard ripening.
- The effects of elevated temperatures on fruit ripening are temporary and, depending upon the degree of heat stress, sugar accumulation can resume normally once temperatures return to a normal range.

Coombe, B. G. 1976. The development of fleshy fruits. Ann. Rev. Plant Physiol. 27:507–28.
Dokoozlian, N.K. 2000. Grape Berry Growth and Development (PDF). Pages 30-37 in: Raisin Production Manual. University of California, Agricultural and Natural Resources Publication 3393, Oakland, CA
Hale, C.R. and M.S. Buttrose. 1974. Effect of temperature on ontogeny of berries of *Vitis vinifera* L. cv. 'Cabernet Sauvignon'. J. Amer. Soc. Hort. Sci. 99:390–394.
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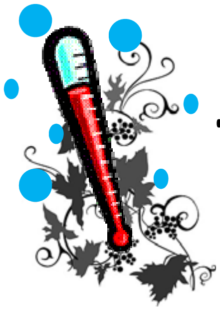


Temperature: Grape Response

- Transpiration/Evaporative Cooling
  - Heat energy is lost from leaves by transpiration
  - In transpiration, water passes from the leaf blade through stomates located on the underside of leaves prior to evaporation.
  - Berries have far fewer stomates than leaf blades, and by veraison stomates function is significantly reduced.
  - As maturing **berries** do not regularly transpire to remove heat, most of the heat absorbed by berries is removed through **convection by air movement.** (Mullins et al. 1992)
  - Transpiration is affected by **vine water status** and air movement inside the canopy

Mullins, M.G., A. Bouquet, and L.E. Williams. 1992. Biology of the Grapevine. Cambridge University Press, Cambridge, UK.

Grape Temperature

- Several factors affect berry surface temperature:
  - Wind velocity
  - Solar radiation at the berry surface
  - Cluster compactness

The surface temperature of fully exposed berries can be more than 18°F hotter than ambient under typical mid-summer conditions.

Grape Temperature: Microclimate/Exposure

Cluster exposure and thus berry temperature (and sunburn) is affected by several factors:

- Row orientation- E-W
- Trellis design- cross arms (especially if N-S)/shoot orientation
- Water management- soil and vine water status
- Pruning/leaf removal- less
- Sprinkler cooling- microsprinklers

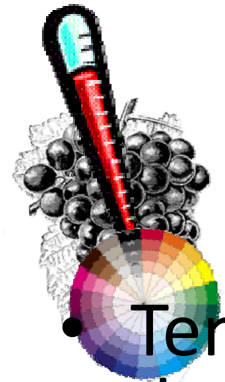
Reduce direct solar radiation on fruit and have adequate soil moisture when it is needed

Influence of Temperature on Metabolism

- Increased temperature normally increases the rate of metabolic processes
- Too high of a temperature can cause metabolic processes to significantly slow or stop. (Jones 1992)
  - ~30°C (86°F) in grapevines? (Coombe 1987)
  - >37°C (99°F) Sugar accumulation inhibited (Kliewer 1977)

Jones, H.G. 1992. Plants and Microclimate. A Quantitative Approach to Environmental Plant Physiology. Cambridge University Press, Cambridge, UK.
Kliewer, W.M. Influence of temperature, solar radiation, and nitrogen on coloration and composition of Emperor grapes. Am. J. Enol. Vitic. 28:96-103 (1977).
Coombe, B.G. 1987. Influence of temperature on composition and quality of grapes. Acta Hortic. 206:23-35.

Influence of Temperature on Color/Anthocyanins



- Temperature is more important than light in developing color.
  - Anthocyanin content in Cabernet Sauvignon was greater at 20°C than at 30°C. (Buttrose et al. 1971)
  - Artificially cooling exposed Merlot fruit increased anthocyanins while heating the shaded fruit reduced anthocyanins. (Spayd et al. 2002)
  - Using a lightproof box to exclude light from Syrah without modifying temperature and humidity- anthocyanin biosynthesis was little affected. (Downey et al 2004)

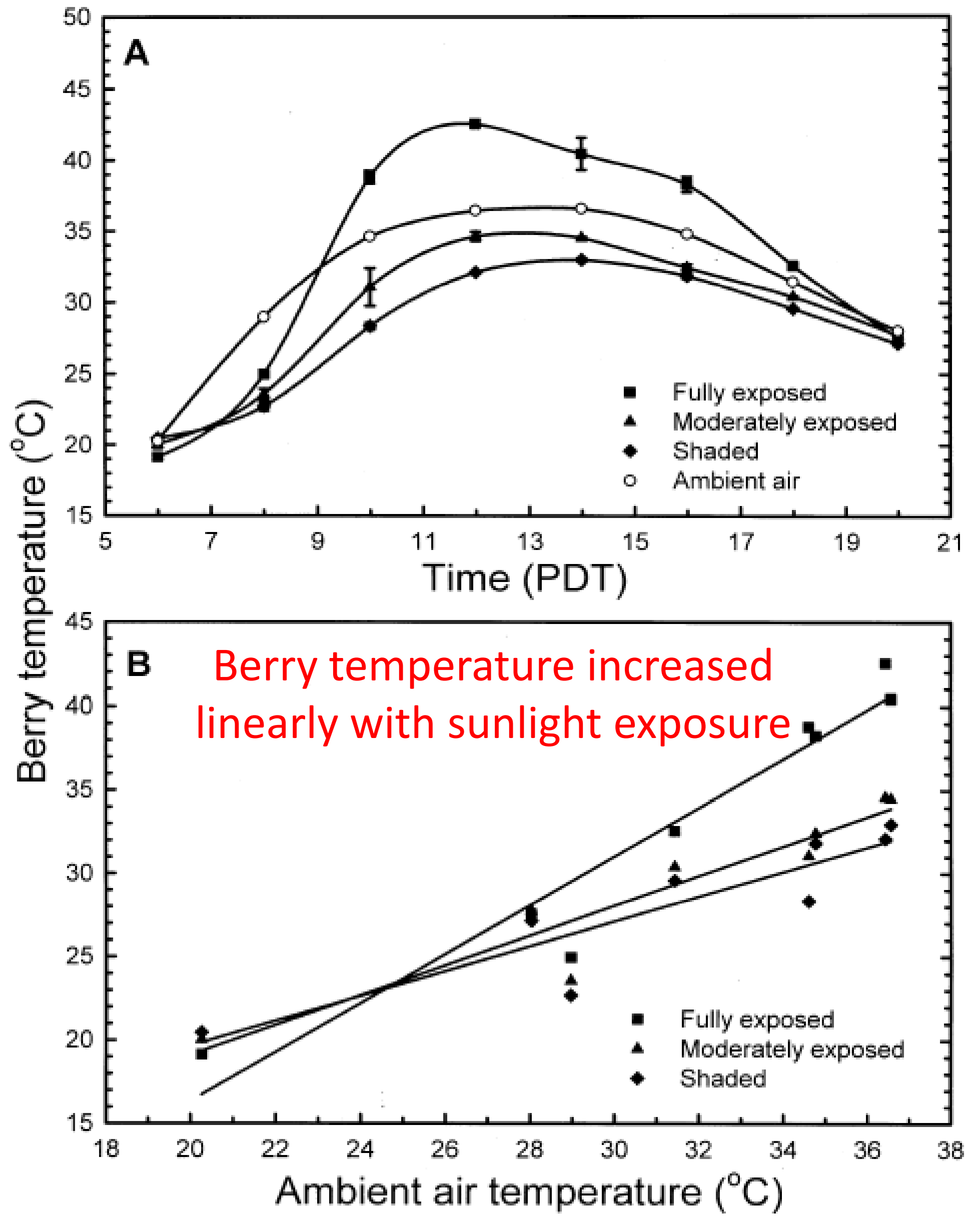
Buttrose, M.S., C.R. Hale, and W.M. Kliewer. 1971. Effect of temperature on the composition of 'Cabernet Sauvignon' berries. Am. J. Enol. Vitic. 22:71-75.
Downey, M.O., J.S. Harvey, and S.P. Robinson. 2004. The effect of bunch shading on berry development and flavonoid accumulation in Shiraz grapes. Aust. J. Grape Wine Res. 10:55-73.
Spayd, S.E., J.M. Tarara, D.L. Mee, and J.C. Ferguson. 2002. Separation of sunlight and temperature effects on the composition of *Vitis vinifera* cv. Merlot berries. Am. J. Enol. Vitic. 53:171-181.

Summary of Environmental Effects on Grape Berry Size and Color

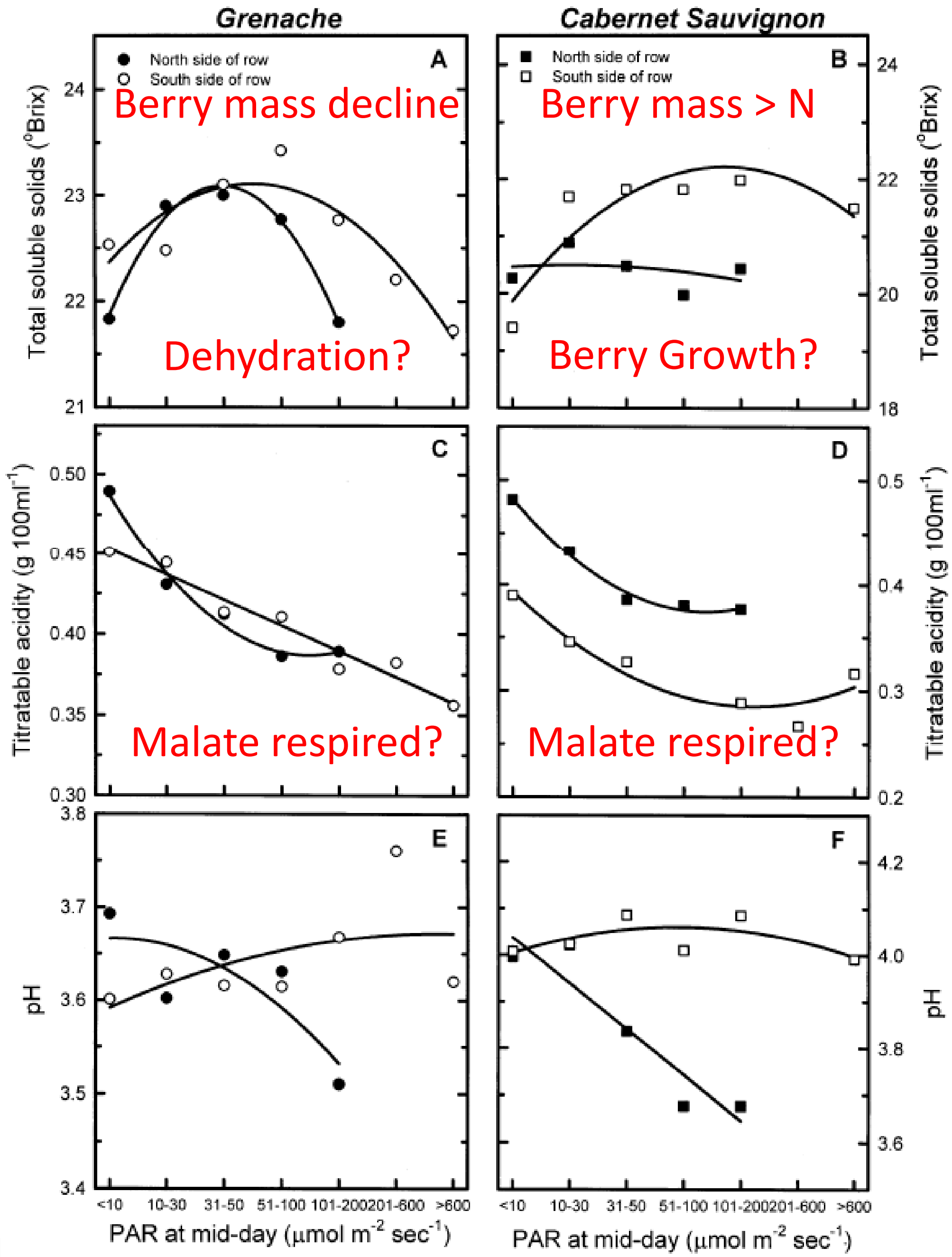
- Warmer climates produce less color in berries
  - Extreme or high heat produces much less color
- High Heat & Water Stress may cause small berries during stage I berry growth
  - cannot be reversed by subsequent cooling or watering.
- Small berries have more skin to must volume ratio
  - Small berries contribute more skin components (red wine) including color on a volume basis.
- **Small berry size may, in effect, neutralize the effects of producing less color in warmer climates depending upon when in the development of the berry the stress occurred.**

Diurnal variation in the daytime ambient air and berry temperature

Bergqvist et al, 2001, AJEV.

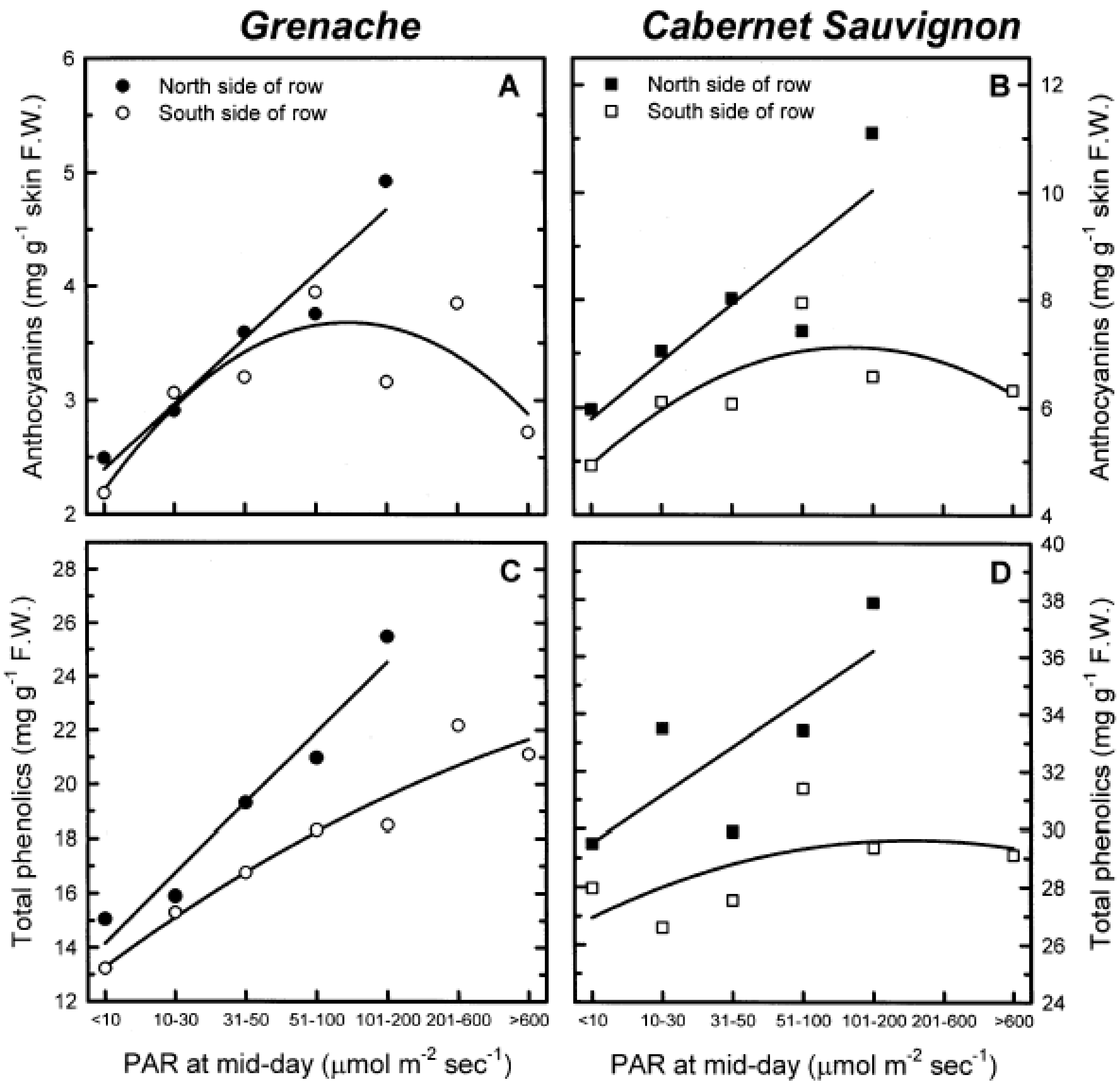


Influence of cluster sunlight (and heat) exposure on Juice

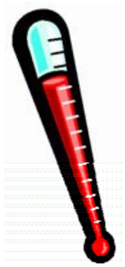


Bergqvist et al, 2001, AJEV.

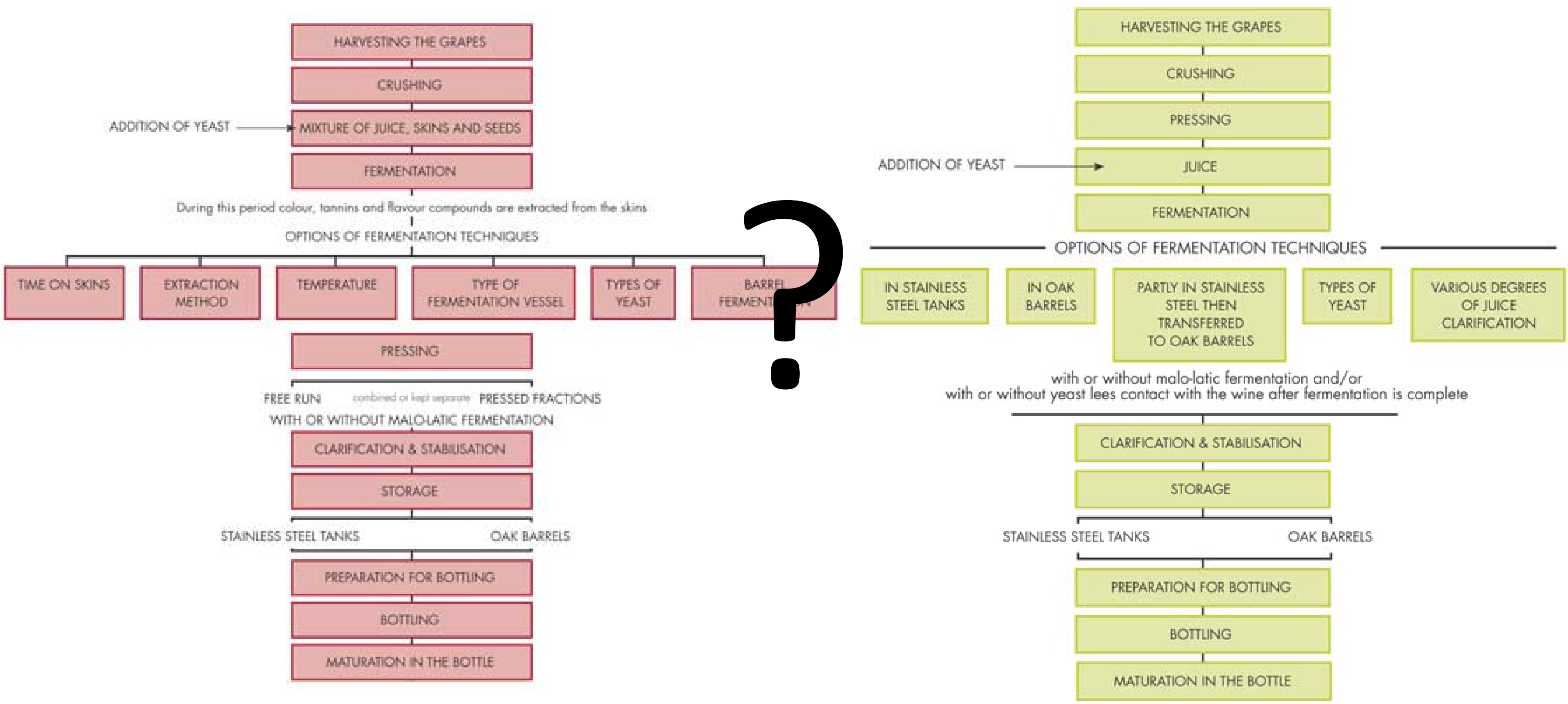
Influence of cluster sunlight exposure on the anthocyanin and total phenol concentrations

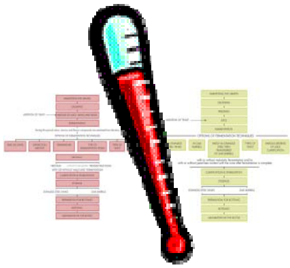


Bergqvist et al, 2001, AJEV.



Influence of Temperature on Winemaking

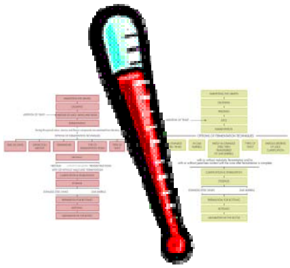




Winemaking Options?

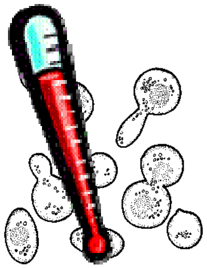
	WARMER	COOLER
SUGAR	higher	lower
ACID	lower	higher
COLOR	lower	higher
FLAVOR	lower	higher
YIELD	higher	lower
VALUE	LOWER	HIGHER

- Alcohol:
  - Adjustment by de-alcoholization
  - Yeast selection: ferment sugar to other metabolites than ethanol e.g. glycerol.
- pH:
  - Adjustment by acidification or electrodialysis?
- Technological wines?
  - Grape must + coloration + aromatization +…?



Effect of FERMENTATION TEMPERATURE

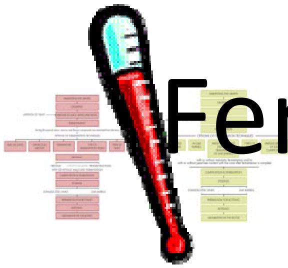
- Whites (Killian, E.; Ough, C. S. Am J Enol Vitic 1979, 30, 301-305)
  - Maximum amount of esters are produced by 9-12% ethanol.
  - At lower fermentation temperatures, although the rate of production of esters is slowed, the more volatile esters responsible for fermentation bouquet are better retained. (i.e., ethyl butyrate, isobutyl acetate, isoamyl acetate and hexyl acetate).
- Reds (J. Food Sci. 59:405, 1994)
  - Higher fermentation temperatures generally recommended for reds, but the literature is not conclusive.
  - Lower fermentation temperature and shorter skin contact time of rose vinification produced higher concentrations of esters and acids than in red wine.



Fermentation Energy Output

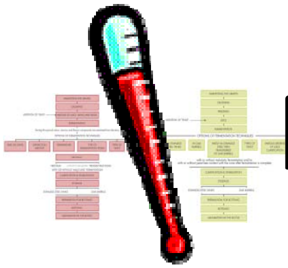
- To grow and divide
- Stored as ATP (22 kcal)
- Most (34 kcal) lost as HEAT:
  - 1° Brix drop ⟶ 1.3°C (2.3°F) rise
  - What will the final temp of a wine be if:
    - Starting must 13°C (55°F), 22°Brix (assuming no heat loss)?

      13 + (1.3 x 22) = 41°C or 55 + (2.3 x 22) = 105°F
- Yeast die at about 38°C (100°F) limiting maximum fermentation temperature



Fermentation Heat is Important!

- Stuck Fermentation (Red & White)
  - The heat produced in fermenting must can get high enough to inhibit the yeast and stop the fermentation
  - Cooling systems needed for white and sometimes red wine fermentations – climate/ambient conditions dependent
- Extraction (Red)
  - Warm must fermentation is crucial for adequate extraction of color and tannin
- Volatile Retention (White)
  - Heat must be removed (refrigeration) for low temperature fermentations



Fermentation Temperature

- White fermentation temperatures
  - Ferment at lower temp. than red wines to preserve volatile components
- Red fermentation temperatures
  - Higher temp. for extracting phenolic components from skins and seeds

Wine Storage/Transportation

Storage & Transport

- Quality reductions in wine due to **excessive temperature** are mainly caused in transport, not in storage at the retailer.
- About 90% of quality faults in wine are caused by excessive heat at some stage between producer and consumer.
- Assessments of tasters are a better tool for measuring faults than chemical analysis.
- Location of the container in the vessel has a big impact on temperature development.
- "Warehousing" on a dock is a significant cause of quality loss.
- Use of reefers (cooled containers) might be an opportunity for avoiding heat problems, albeit with greater cost and a 30% capacity penalty.

(Laffer 2004)

Wine Transportation

- The main cause for temperature variations inside shipping containers is direct solar radiation
  - Sunlight can heat the inside of the container to temperatures of up to 30°C above ambient.
- Protection of the container from direct sun light is crucial.
  - If the container is stored below deck during a sea voyage, the temperature stays inside a benign range even without any additional protection.
  - Extensive exposure to solar radiation is almost unavoidable on land.
  - Liners can make a significant difference for containers exposed to direct sun.
- Use temperature loggers
  - To identify potential problems in the transport chain and
  - To enforce quality standards on the shipping companies.

Container Temperatures

- Exposed/above deck/On land
  - Roof
    - 50 - 70°C or up to 30°C above ambient
  - Interior
    - 30 - 35°C
  - General:
    - -15°C uninsulated, -4°C insulated. >45°C
- Below Deck
  - 30 - 35°C
- Refrigerated Containers:
  - ➢ 5°C and 10°C (Canada OLCB), Max 19°C

Container Transportation

- US. 23% of shipments are in temperature-controlled containers (Meyer 2002)
- Most of the relevant sources indicate that the impact of environmental conditions can be controlled by using temperature controlled containers (TCCs) and/or different types of insulation in standard containers.

Effects of Temperature on Bottled Wine during Transportation

1. Organoleptic defects:
   – These defect affect sensory properties of the wine like taste, color and odor and include oxidation, lack of fruit and change in aroma components, loss of CO_2
2. Chemical defects:
   – These are measurable chemical changes in the wine like acetate esters rapidly hydrolyzed (loss of fruitiness), **increased ethyl carbamate**
3. Physical defects:
   – Include defects like pushed cork, protein haze, sediment and leaking.

Effects of Temperature on Bottled Wine during Transportation

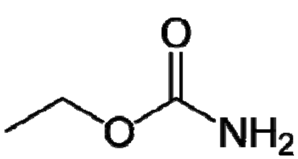
1. Organoleptic defects:
2. Chemical defects:
3. Physical defects:

Another problem is the over-stabilization of wine in order to prepare it for extreme temperatures.

- Strips flavor
- Increases cost
- Creates solid wastes (bentonite)
- Makes damage in the wine harder to spot optically

Effects of Temperature on Bottled Wine during Transportation

- **Increased ethyl carbamate**
  - Canada limited at 30 ppb in wines and 100 ppb in fortified wines.
    - The Ontario Liquor Control Board has a lower ethyl carbamate limit when testing pre-shipment products (85% of the maximum allowable limit) to allow for the shipping/ overheating factor.
    - Products are frequently rejected at the pre-shipment stage because the ethyl carbamate levels are already close to the maximum limit.
  - **The chemical reaction between urea and ethanol increases exponentially with temperature. It is therefore essential that a wine containing elevated levels of urea is not exposed to elevated temperatures (above 37.8°C/100°F) during storage or shipment.**



What you can Do?

- In order to produce wines with a bottle maturation bouquet and simultaneously preserve a degree of young wine bouquet, wines should be stored at **constant temperatures lower than 20°C.**
- In order to assure vintner or shipper protection, samples of wine should be preserved at controlled temperatures for reference.
  - Color, free and total SO_2 and clarity should be recorded.
  - Documented sensory comments should be kept. Comparisons should be made with shipped samples if there is a suspicion of poor travel conditions.

What you can Do? cont.

- Ensure that approved standards and practices are in place for packaging and shipping/transportation of wine. All role players must participate and agree on the standards.
- Determine door-to-door responsibility for wine shipments- INCLUDING shipping agencies to conform with standards.
- Optimize packaging and shipping/transportation configurations.
- Establish guidelines for temperature control mechanisms e.g. temperature controlled containers, templiners, etc.
- Use data loggers in all shipments.
- Thermochromic color changing labels?

Meyer, D. 2002. A study of the impact of shipping/transportation conditions and practices on wine. Wyn

PakSense tag. Eric Risb rg / AP

What you can Do? cont.

- Samples of wine should be preserved at controlled temperatures for reference. Comparisons should be made with shipped samples if evidence exists that the wine was exposed to extreme conditions.
- Keep abreast of health requirements, e.g. **ethyl carbamate**, because enforcement of standards by other countries may be used as a marketing advantage.
- Set and enforce standards for corks. Investigate cork pushing and its effects.
- Investigate stabilization practices once shipping conditions are known.
- Supply guidelines to the user chain regarding storage temperature.

Meyer, D. 2002. A study of the impact of shipping/transportation conditions and practices on wine. Wynboer. December.

Citations: Viticulture

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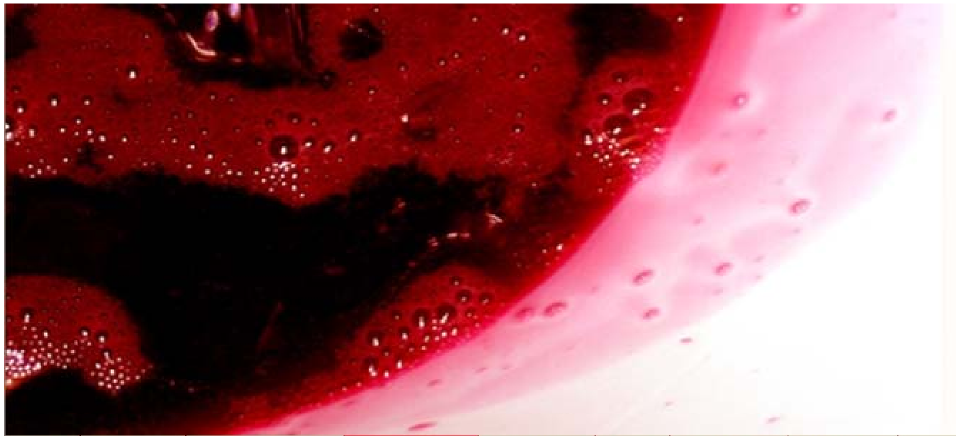

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