Cold Climate Wine Styles

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What is a Cold Climate?

From a viticultural standpoint

Definitions of a Cool Climate

Amerine & Winkler 1944	Growing degree days (GDD)
Huglin 1978	Huglin Index
Becker 1984	Mean temperature of the warmest month < 20C
Jackson & Cherry 1988	Latitude-temperature index
Gladstones 1992	Biologically active degree days
Jackson & Lombard 1993	Alpha and beta zones
Reynolds 1997	Mean daily GDD veraison-harvest
Jones 2006	Average growing season temperature

Region	GDD (ºF)	Areas (Heat units in parentheses)	
		California (ºC)	Other (ºC)
I	< 2500 (850-1389 ºC)	Watsonville, Santa Cruz Co. (1160) Bonny Doon, Santa Cruz (1188) Gonzales, Monterey (1304) Peachland, Sonoma (1321)	Trier (944) Geisenheim (993) Reims (1010) Summerland, BC (1163) Geneva (1254) Beaune (1277) Bordeaux (1326) Geneva, NY (1332)
II	2501-3000 (1389-1667 ºC)	Santa Clara (1415) Palo Alto, San Mateo (1437) Soledad, Monterey (1598) Napa (1598) San Luis Obispo (1454) Sonoma (1637)	Vineland, ON (1404) Oliver, BC (1405) Sunnyside, WA (1426) Santiago (1504) Melbourne (1526) Pelee Island, ON (1636)
III	3001-3500 (1667-1944 ºC)	Oakville, Napa (1721) Healdsburg, Sonoma (1770)	Milano (1837) Tbilisi (1870)
IV	3501-4000 (1944-2222 ºC)	Davis, Yolo (2098) Lodi, San Joaquin (2009)	Cape Town (2065) Sydney (2098)
V	4001 (2222-2700 ºC)	Modesto, Stanislaus (2226)	Shiraz (2436)

Huglin 1978
Heliothermic Potential

- Huglin proposed a “Heliothermic Potential”, now known as the **Huglin Index**

$$\sum_{Apr\ 1}^{Sep\ 30} \max\ [(T_{mean} - 10) + (T_{max} - 10]) / 2] \bullet K$$

- T_{mean} = daily mean temperature
- T_{max} = daily maximum temperature
- Baseline temperature = 10 °C
- *K* = parameter dependent on the latitude of the location; the sum is multiplied by a factor *K* depending on the latitude of the location, taking into account the length of the day and sunshine hours in northern latitudes; e.g.:
  - K (40°) = 1.02
  - K (50°) = 1.06

Huglin Index for Several Grape Varieties

Huglin Index	Grape Variety
< 1500	no suggestions
1500 - 1600	Müller-Thurgau, Blauer Portugieser
1600 - 1700	Pinot blanc, Grauer Burgunder, Aligoté, Gamay noir, Gewürztraminer
1700 - 1800	Riesling, Chardonnay, Silvaner, Sauvignon blanc, Pinot noir, Grüner Veltliner
1800 - 1900	Cabernet Franc
1900 - 2000	Chenin blanc, Cabernet Sauvignon, Merlot, Sémillon, Welschriesling
2000 - 2100	Ugni blanc
2100 - 2200	Grenache, Syrah, Cinsaut
2200 - 2300	Carignan
2300 - 2400	Aramon

Jackson & Cherry 1988
The latitude-temperature index (LTI)

- Still uses the heat unit concept but adds to it latitude (hence daylength; as with Huglin), and MTWM
- The LTI combines these two, hence:

LTI = MTWM (60-latitude)

- Divides mostly “cool climate” regions into three groups based upon the varieties grown within them.
- Traditional cool climate regions all had LTI values < 380; those areas growing traditional cool climate cultivars all had LTI values < 275.

Jackson & Cherry 1988

LTI divided regional cool climates into three categories

Location group A	Location group B	Location group C
Kew, UK	Strasbourg, Alsace	Tours, Loire
Plymouth, UK	Dijon, Burgundy	Bordeaux
Geisenheim, Rheingau	Macon, Burgundy	Sauternes
Reims, Champagne	Stuttgart	Lugarno, Switzerland
Geneva, Switzerland	Vienna	Walla Walla, WA
Zurich, Switzerland	Portland, OR	Launceston, Tasmania
Kelowna, BC	Boise, ID	Nelson, New Zealand
Vancouver, BC	Baden	Blenheim, New Zealand
Mosel	Salem, OR	Christchurch, New Zealand
Ahr	Auxerre, Burgundy	Napier, New Zealand

Jackson & Cherry 1988

Varieties were matched with zonal groups

Variety group A		Variety group B	Variety group C	Variety group D
Gewurztraminer		Riesling	Merlot	Grenache
Madeleine Angevine		Pinot noir	Cabernet franc	Syrah
Reichensteiner		Chardonnay	Cabernet Sauvignon	Mourvedre
Perle	Aligote		Malbec	Zinfandel
Schonburger	Faberrebe		Sauvignon blanc	Thompson Seedless
Triomphe d'Alsace			Semillon	
Muller-Thurgau				
Pinot blanc	Kerner			
Pinot gris	Bacchus			
Pinot Meunier				
Chasselas	Scheurebe			
Sylvaner	Siegerrebe			
Chardonnay	Auxerrois			

Jackson and Lombard 1993
Alpha & Beta Zones

- **Applied to grapes**, they hypothesized that the best wines come from regions where the predominant grape varieties mature when mean temperatures are between 9 & 15C.
- These are **Alpha zones**, and they include the world's great winegrowing regions such as Burgundy, Bordeaux, Germany, etc.
- **Beta zones**: fruit matures at mean daily temperatures > 16C.
- Many fine winegrowing districts within the Beta zones too, but often the predominant varieties don't ripen at the very end of the season as in Alpha zones.
- Regions include: most of Italy, Barossa & Hunter Valleys, SW Australia, South Africa, interior California, the Middle East, much of former Yugoslavia.

Jackson and Lombard 1993
Alpha & Beta Zones

Alpha zones		**Beta zones**
Mature fruit at temperatures between 9-15C		*Mature fruit at temperatures > 16C*
Pinot noir	**Cabernet Sauvignon**	**Pinot noir, Cabernet Sauvignon, Riesling**
Burgundy, Alsace	Bordeaux	Southern France, Spain, Italy
Baden	Coonawarra	Southern Europe and north Africa
Marlborough	Hawkes Bay	Hunter Valley, Barossa Valley
Adelaide Hills	Napa Valley	South Africa
Willamette Valley, OR	Yakima Valley, WA	Central Valley, CA
Carneros, CA		Columbia River Valley, WA

Reynolds 1997

Mean GDD from veraison to harvest (MDVH)

Region	Cultivar	Annual GDD	GDD V→H	MDVH
Summerland, BC	Bacchus	1163	268	8.2
	Gewurztraminer		201	6.5
	Pinot noir		201	5.9
	Riesling		164	3.5
Southampton, UK	Bacchus	850	82	2.7
Colmar, Alsace	Gewurztraminer	1186	201	6.7
Portland, OR	Pinot noir	1179	161	5.3
Geisenheim, Rheingau	Riesling	1042	150	5.0
Bordeaux	Cabernet Sauvignon	1392	250	8.3
Griffith, NSW, Australia	Muscat Gordo Blanco	1756	270	9.0
Non-BC data courtesy of Gladstones (1992)				

But what is a "Cold Climate"?

I propose four possibilities based upon combinations of cold winters and/or lack of GDD, either or both of which limit success

	Summer		
Winter	Very warm (MTWM 21C +)	Warm (MTWM > 20C < 21C)	Cool (MTWM < 20C)
Very Cold Mean January minimum < -15C; Extreme winter minimum < -30C		North Dakota Nebraska Minnesota	
		Frontenac *Marquette* *La Crescent*	
Cold Mean January minimum < -9C; extreme winter minimum < -25C	Yakima Valley Southern Okanagan Valley	Northern Okanagan Valley Ontario	Nova Scotia
	Merlot, Chardonnay, Cabernet Sauvignon	*Merlot, Chardonnay, Cabernet Sauvignon*	*Riesling, Chardonnay*
Moderate Mean January minimum < -5; extreme winter minimum < -20	Mediterranean	Monterey, Lake Co. California	Sweden, Denmark, Belgium, Netherlands
	Syrah, Grenache, Mourvedre	*Merlot, Chardonnay, Cabernet Sauvignon*	*Ortega, Bacchus, Schonburger, Siegerrebe*

Climatic data for Selected “Cold Climate” sites

Location	Mean January low (°C)	Extreme winter low (°C)	Mean July (°C)
Malmo	-1.4	-18.4	18.4
Copenhagen	-1.7	-17.8	16.9
Oslo	-7	---	17
Amsterdam	0.8	-15	17.6
Brussels	0.7	-21	18.4
Warsaw	-4.2	-30.5	19.2
Talinn	-1	-31.4	16.5
Halifax	-8	-28.5	18.5
Montreal	-14	-37.8	21
Minneapolis	-14	-41	23.5
Kelowna	-3	-36.1	20.5
St. Catharines	-7	-25.7	22
Yakima	-4.8	-32	21.5

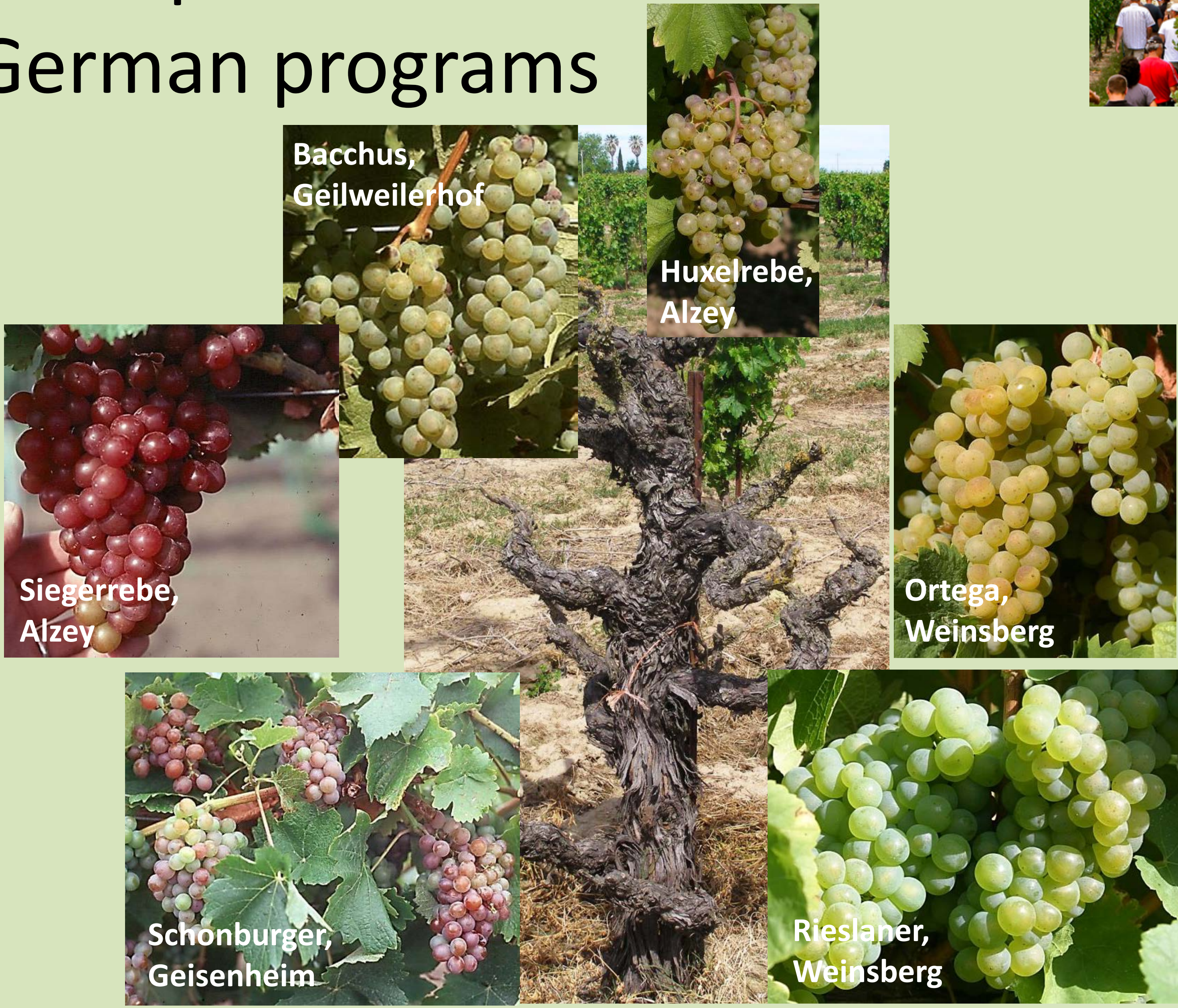
Wine Styles for Cold Climates

- Table wines from either early-maturing varieties or winter-hardy varieties (or both)
- Icewine
- Sparkling wines
- Appassimento and passito

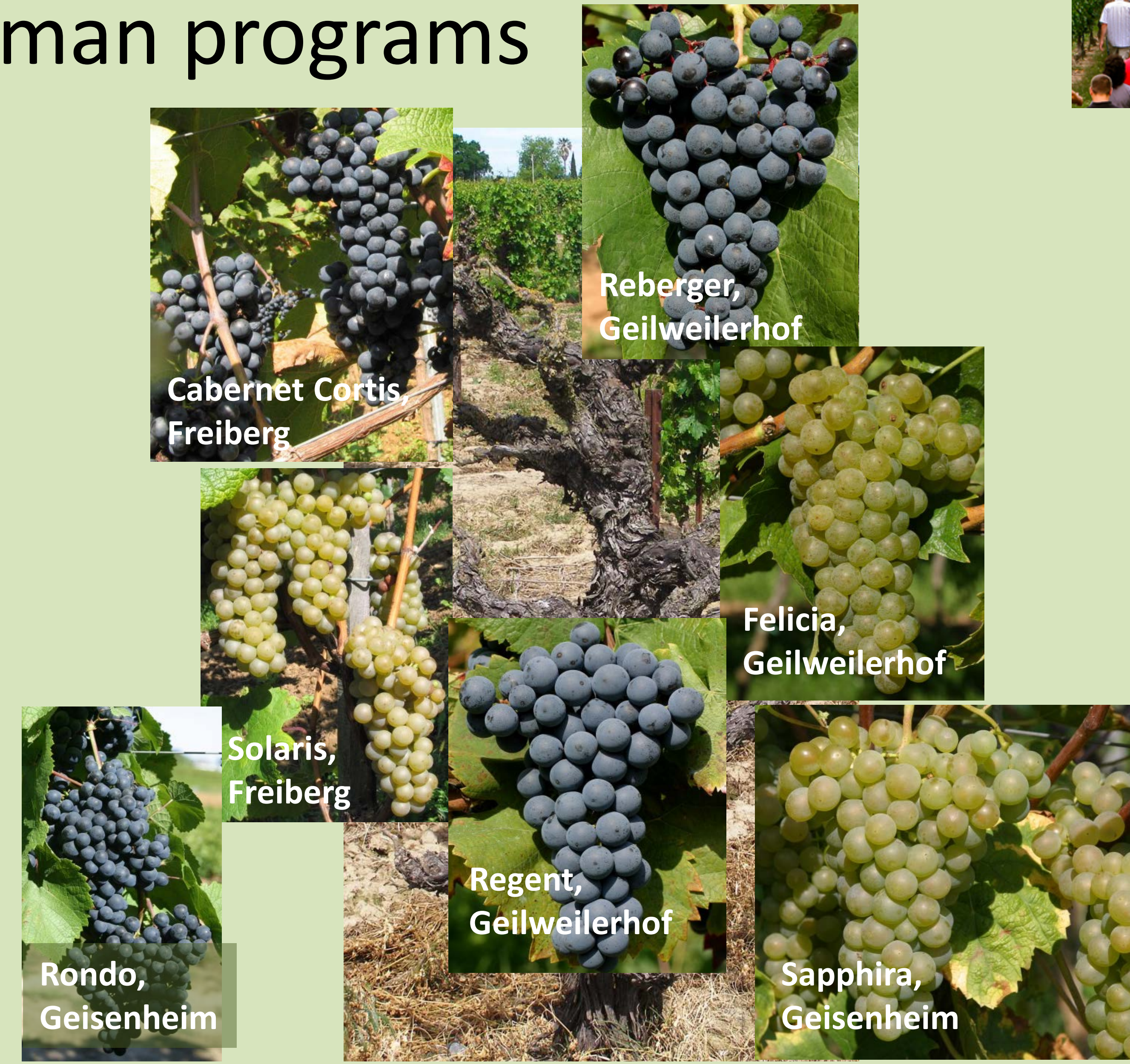
Table wines from either early-maturing varieties or winter-hardy varieties (or both)

- Intraspecific varieties from German programs
- Interspecifics from Germany
- Interspecifics from Switzerland and Denmark
- Cold-tolerant interspecifics from Minnesota

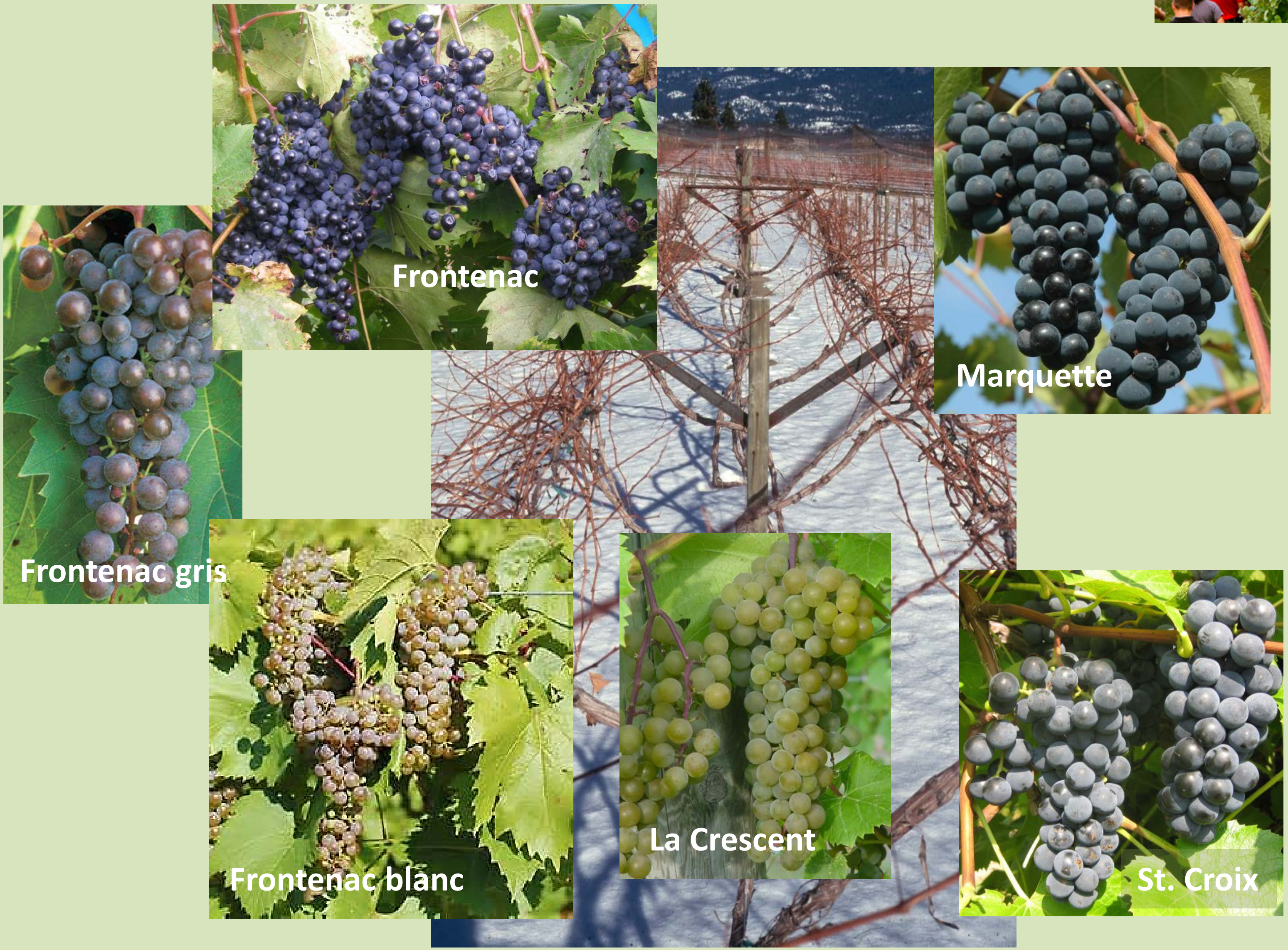
Intraspecific varieties from German programs



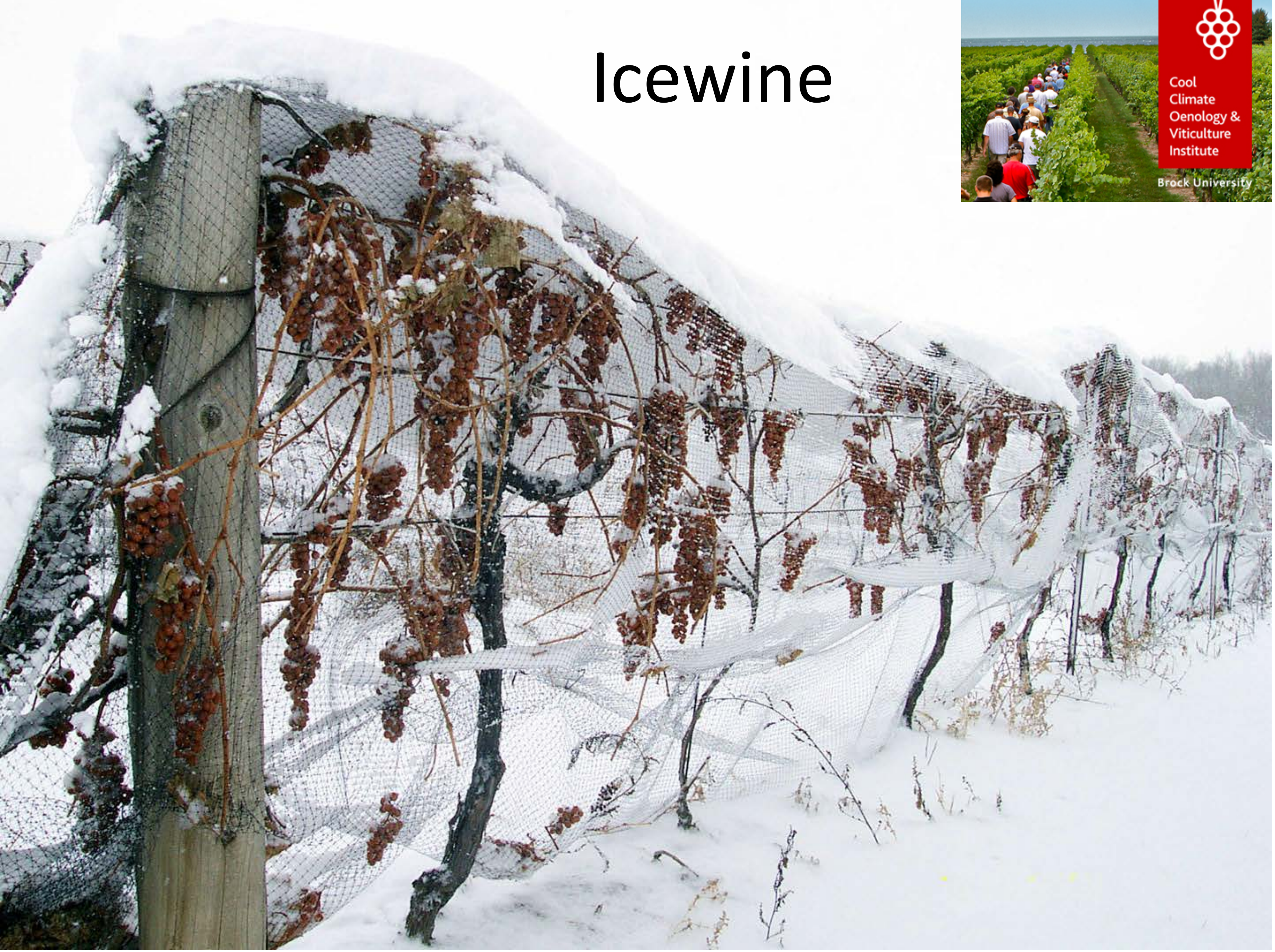
Interspecific varieties from German programs



Interspecific varieties from programs in Minnesota & Wisconsin



Icewine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The grapes

Ideal characteristics:

- Winter hardiness
- Natural high acidity
- Late ripening
- Tough skins & stems
- Disease-resistance
- Desirable fruit aromatics

The winners

- Vidal
  - (Ugni Blanc x Seibel 4986)
- Riesling
- Gewürztraminer
- Chardonnay
- Pinot Blanc
- Ehrenfelser
- Kerner
- Cabernet Franc

When to harvest?

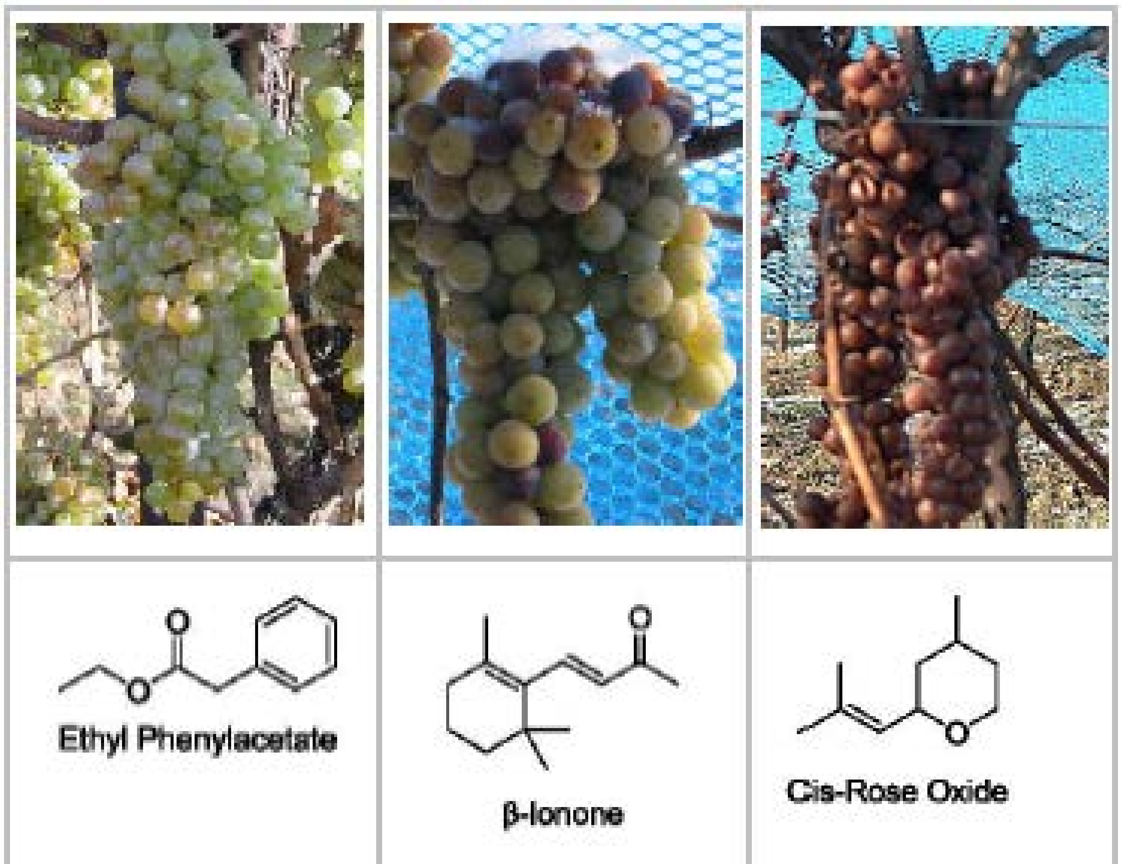
Considerations:

- Sugar levels in Fall play minor role in final juice sugar conc
  - Temp at harvest major determinant
  - (Prior dehydration from hang-time, weather, botrytis)
- grape sugar conc increases with decreased temp, which freezes out H_2O
- Min. temp of -8 C (17.6 F) or colder
- Much below -13 C not practical

  - Harvest temps Niagara: typically -9 to -11 C, yielding 39 - 46 Brix (174 - 208 Oechsle)
  - –Yields highly variable
- Dates vary across Canada & from vintage to vintage
  - Ontario: end of Dec - mid Jan common
  - As late as end March !
  - BC earlier: often November
- A number of berry freeze/thaw cycles appear
  - important for flavour development …

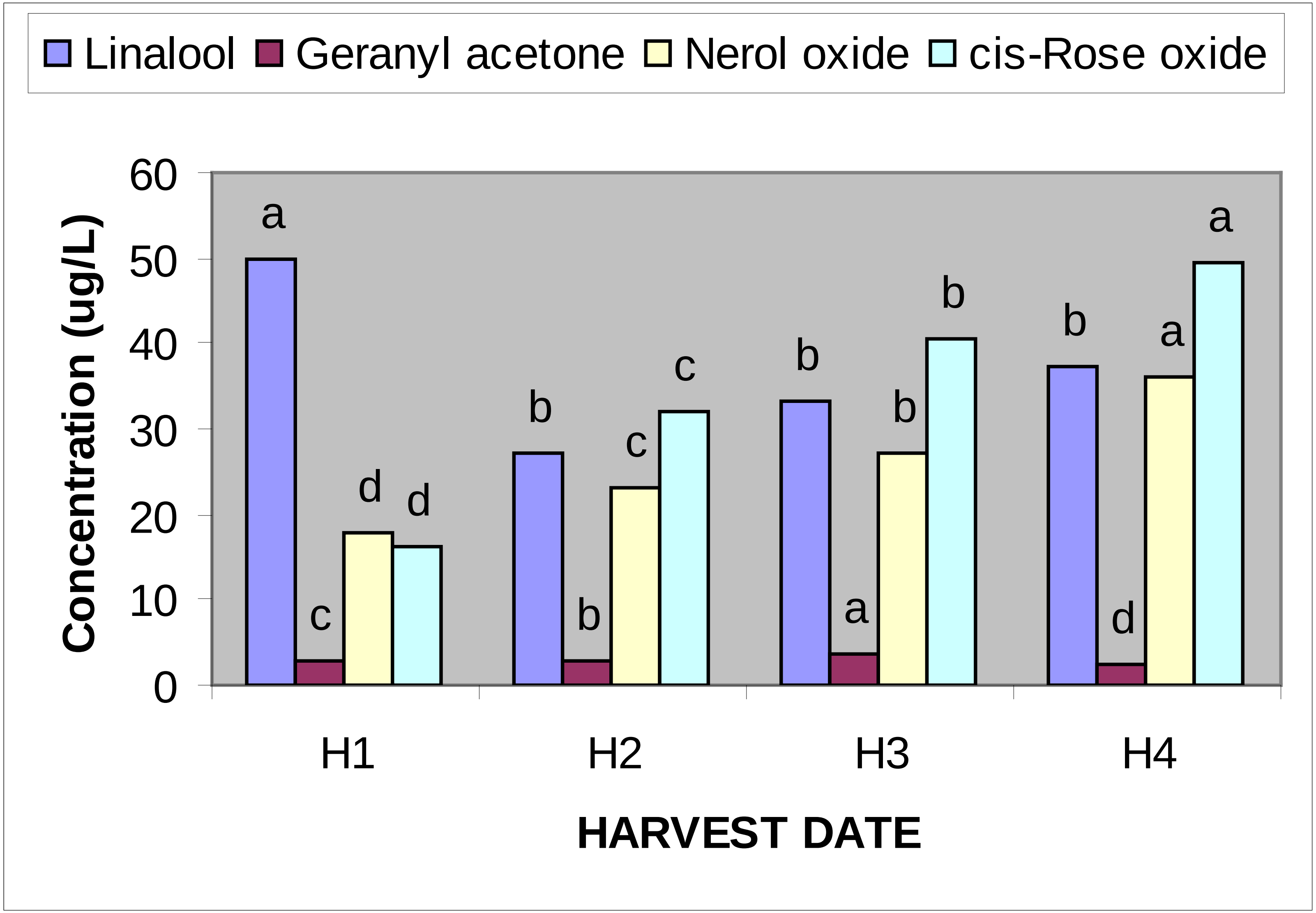
Processes

Desiccation Concentration Oxidation



Vidal-Harvest Date Effects

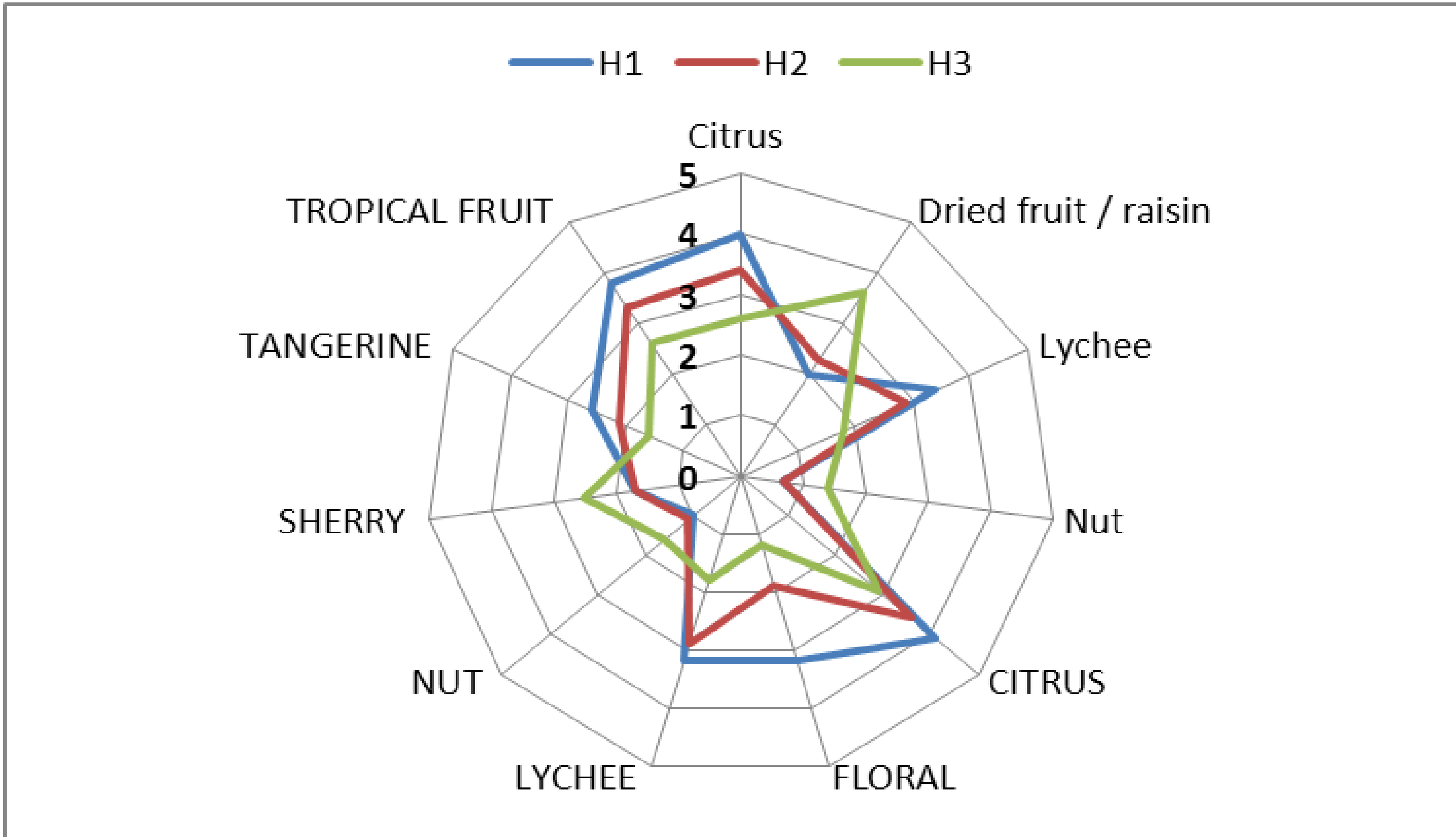
Most terpenes increase with later harvests



Bowen & Reynolds. 2015a. Food Research International .

Sensory Attributes-Riesling Harvest Date

Later harvest dates enhance dried fruit, nut, sherry aromas



Bowen et al. 2016. Food Research International.

Making Icewine

Pressing

- Must press while temp still optimum

– Low temp must be maintained to obtain juice with average min. of 35 Brix (min. 32 for indiv. batch)

– Vineyard for larger operations

- No crushing
- Must be a continuous process
- Press requirements:

1. Sufficient pressure
2. Clean juice
3. Robust !

Fermentation

- Not easy!
- High sugar leads to osmotic stress
- As juice soluble solids increase, -ve linear correlation with yeast growth & sugar consumption
- High inoculation levels, sometimes multiple re-inoculations

– K1-V1116, EC1118, R2*

- Some nutrient supplement beneficial, and yeast inoculation procedure important
- Preferred fermentation temp: 15-17 C
- Length: weeks (6-8) …

Challenges for the future

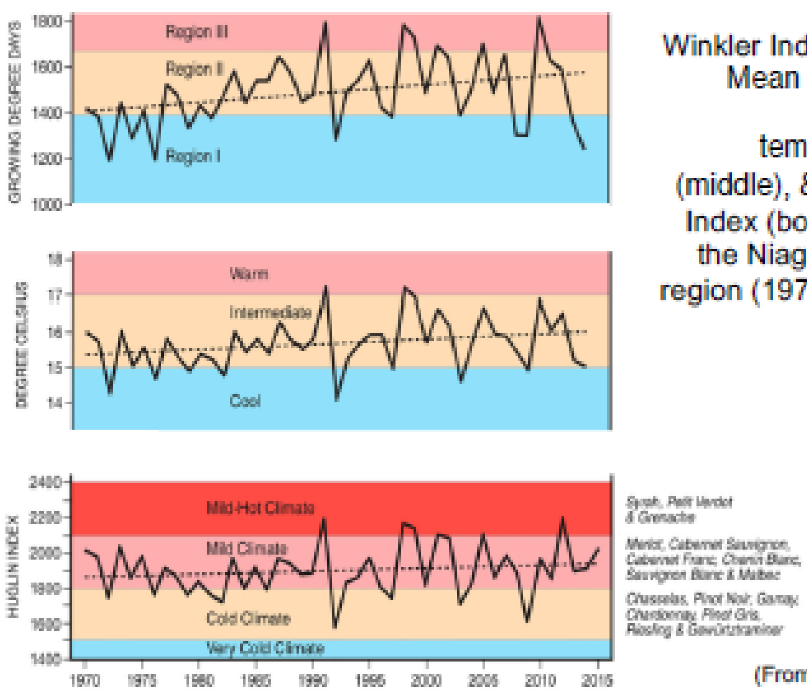
1. Counterfeit Icewine
2. Misleading labeling
3. Growing the markets for increased production
4. Climate change

Compounds of Greatest Importance- Vidal Icewines

Bowen & Reynolds. 2012. J. Agric. Food Chem. 60:2874-83.

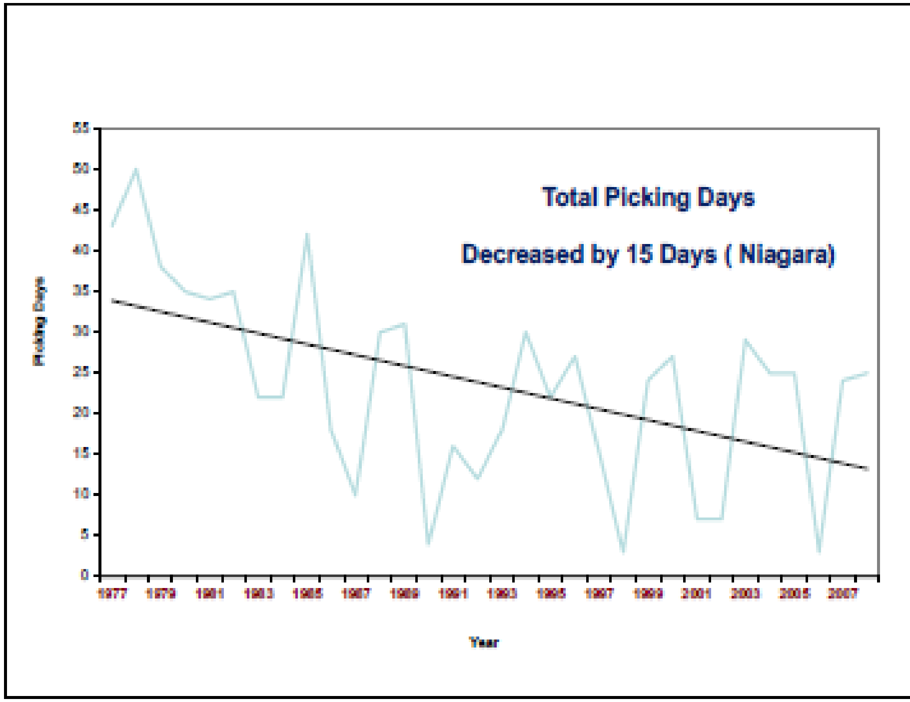
Compound	VIDAL				
	Concentration (ug/L)		Odor activity value		Significance
	Table wine	Icewine	Table wine	Icewine	
Ethyl isobutyrate	72.3±0.7	71.3±0.2	4.82	4.75	ns
Ethyl butyrate	162±3	78.6±0.1	8.09	3.93	***
Ethyl 2-methylbutyrate	14.2±0.8	27.4±0.5	0.79	1.52	**
Ethyl 3-methylbutyrate	25.3±0.3	29.9±0.5	8.43	9.97	**
Isoamyl acetate	205±9.2	173±1.5	6.83	5.77	*
Ethyl valerate	2.06±0.3	9.70±0.6	1.38	6.47	**
1-Heptanol	7.94±0.1	28.6±1.3	2.65	9.55	**
1-Octen-3-ol	6.97±0.1	188±4.9	6.97	188	***
Ethyl hexanoate	878±28	480±30	62.7	34.3	**
Linalool	12.8±0.1	46.9±2.1	0.51	1.88	**
cis Rose oxide	5.03±0.1	22.2±1.2	25.2	111	**
Phenethyl alcohol	15274±256	20140±6.7	1.09	1.44	**
Ethyl octanoate	2665±13	739±65	533	148	***
Decanal	13.7±0.5	0.95±0.2	6.84	0.48	***
p-Vinylguaicol	111±1.6	81.2±1.5	11.1	8.12	**
β-Damascenone	11.3±0.6	45.1±1.0	225	902	***

Climate Change Implications



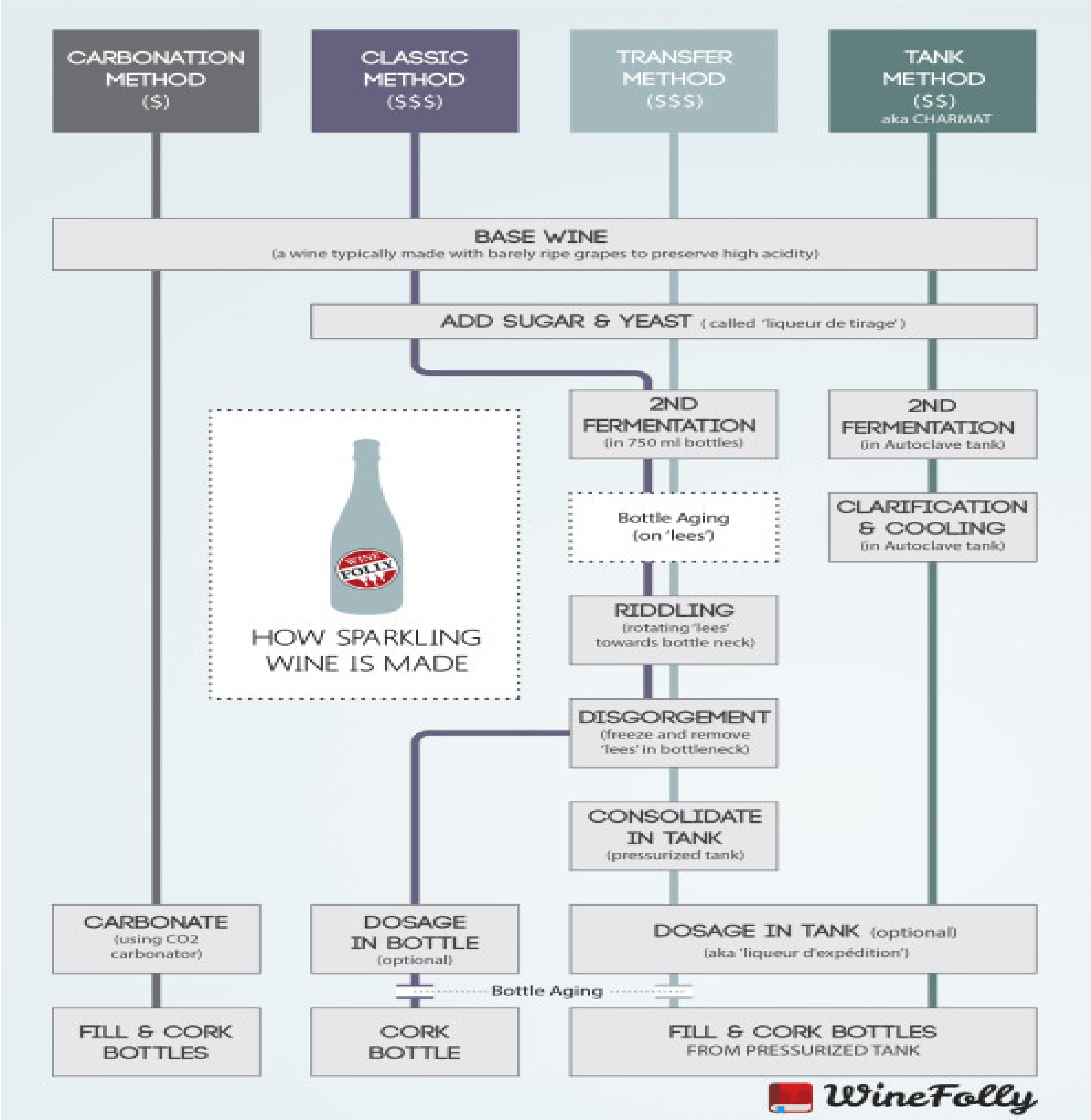
Winkler Index (top), Mean Growing Season temperature (middle), & Huglin Index (bottom) for the Niagara wine region (1970–2015)

(From Shaw, 2017)



Sparkling wines

- **Transfer method – very popular in Australia**
- **Charmat/Cuve closed – Prosecco, Italy**
- **Traditional method– Champagne, France & Franciacorta, Italy**



Viticulture impacts

- Grape variety: Chardonnay, Pinot noir
- Clones: i.e. California clones - higher acidity at harvest in California compared to Champagne clones
- Vineyard site differences in base wines
- Yield, vine spacing, row orientation, training system, canopy management, soil & climate differences, maturity level, disease

Production Impacts on Flavor

- Press fraction
- Nutrient levels
- Yeast
- Stainless steel/oak barrel/ concrete egg
- Oxygen
- MLF
- Phenolics
- Blending/Single vineyard
- Tirage mixture/yeast
- Barrel ferment/base wine aging/reserve wine/*dosage* aging
- Acid levels (aging)
- Screwcap – Oxygen ingress
- Bottle color
- Sugar levels in *dosage (pH/TA?)*
- Closure
- Bottle aging
- Bottle variation
- CO2
- Glass/serving environment/temp

Important Flavor Compounds in Sparkling Wines

<u>Aliphatics</u>

- Ethyl butanoate
- Ethyl hexanoate
- Ethyl octanoate
- Ethyl decanoate
- Ethyl lactate
- Ethyl succinate
- Propanol
- Hexanol
- Dodecanol
- 2,3 Butanediol
- 2-Phenyl ethanol

<u>Terpenes & norisoprenoids</u>

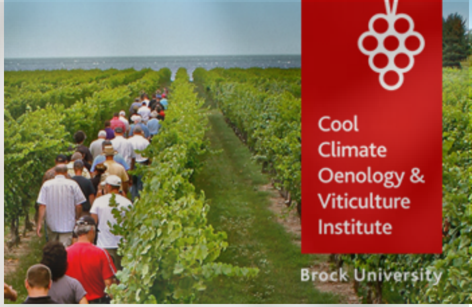
- Geraniol
- α-Terpineol
- Citronellol
- Farnesol
- Nerolidol
- TDN
- Vitisparine
- ß-Damascenone
- Sotolon

Appassimento and passito

Appassimento Winemaking

Changing Climate→ Adaptation of innovative strategies

- Appassimento wine
  - Grapes are picked at regular harvest time and **dried** to target sugar levels in a protected environment
    - Concentrates flavors and aromas, increases ethanol content
  - Winemakers are employing this method in Ontario
  - Method as a tool that may mitigate production risk and to overcome climatic barriers to obtaining fully ripe grapes
    - Seasonal variations, extreme weather
    - Impact is on fruit maturity
- Can we further develop flavors in our grapes for use in high end wines despite cool, wet, less optimal weather conditions?
  - Enological short term strategies to mitigate climate change impacts



How to dry the grapes?

Cabernet franc: Five drying regimes compared

On-vine

Barn

Drying chamber

Kiln

Greenhouse

On-Vine vs. Barn Drying: Temperature and Relative Humidity

- **Long Duration Treatment (2+ months)**
- **Exposure to climate risks**
- **Rain, fog, dew, wind, freeze-thaw, wildlife**
- **Highly variable temperature (below freezing) and humidity (above 90% RH)**

- **Barn - Mid to long term duration (1-2 months)**
- **Protected from rain, wildlife but impacted by external climatic conditions**
- **Temp and humidity correlated to external climate conditions ($r = 0.836$)**
- **Not as variable as on-vine, Humidity 50-90% RH, Temp mainly above 0°C**

Other Drying Techniques

Greenhouse- Mid Duration Treatment (3-8 weeks)

- Protected from external climate (rain)
- Year to year variability in humidity (can approach 95% RH)
- internal conditions controlled with heat/air circulation, 15-20°C

Kiln - Short duration (days)

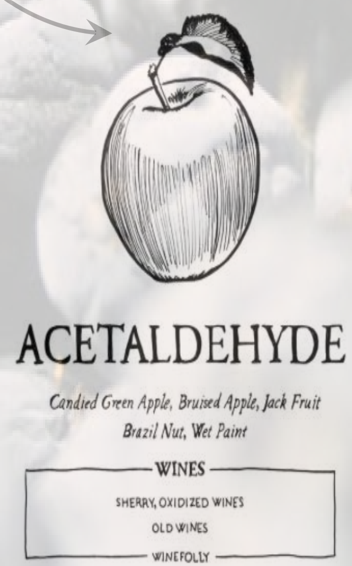
- Protected from rain, wildlife
- Not correlated to external climate conditions
- High air flow
- temperature control, we targeted 30°C, 40-70% RH

Drying Chamber - Longest duration (3 months)

- Protected from rain, wildlife
- No external climate influence, temp and humidity controlled
- Temperature 5-10°C, 80-90% RH

Challenges of Appassimento Winemaking

- Undesirable compounds may accumulate as a consequence of drying (Bellicontro et al., 2016)
  - Can negatively impact the final wine when present at elevated concentrations
- Also form during high sugar fermentations



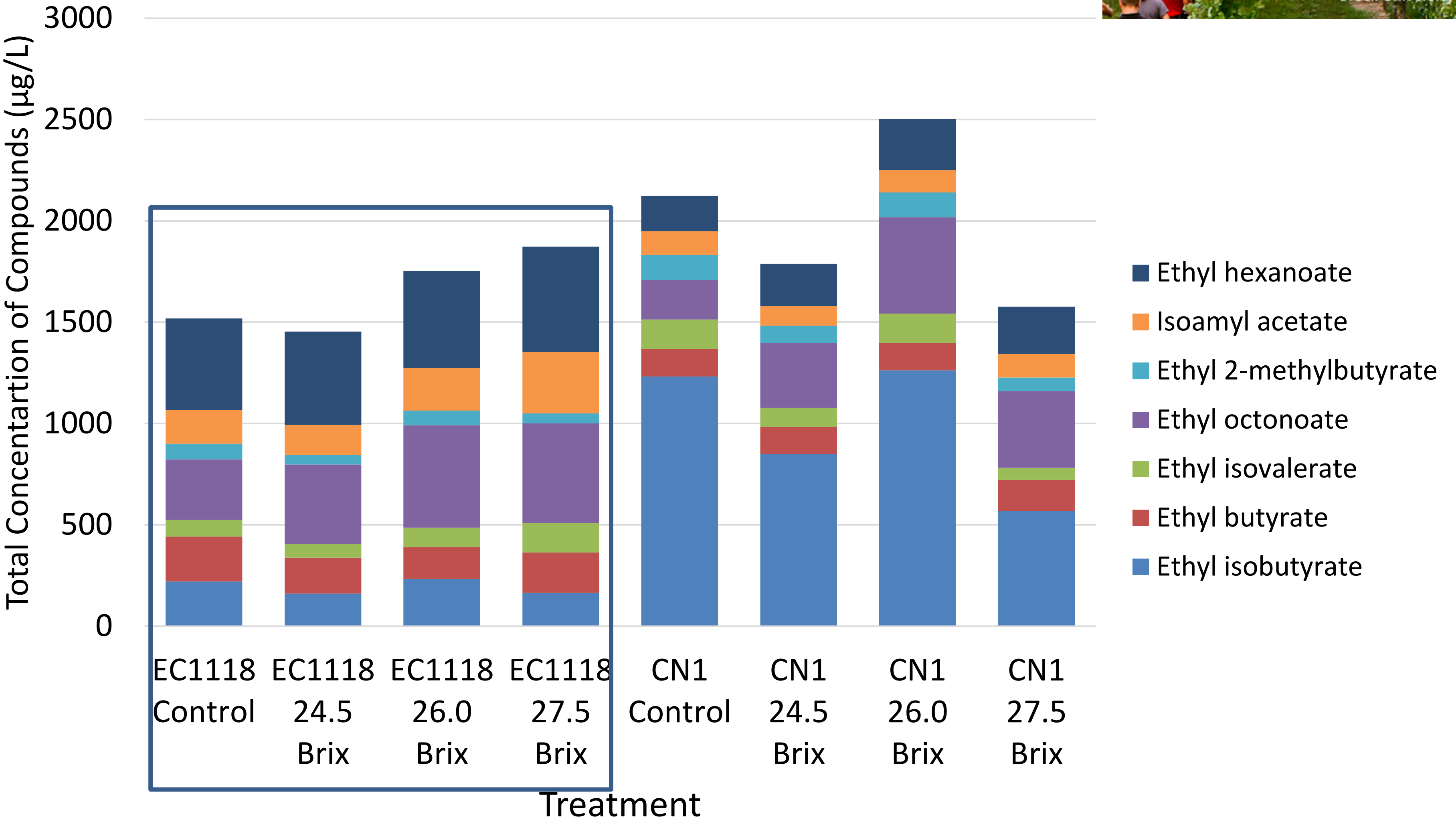
www.cee-portal.ac
www.winefolly.com

Chemical composition of Cabernet franc control (23°Brix) and appassimento (28°Brix) wine.

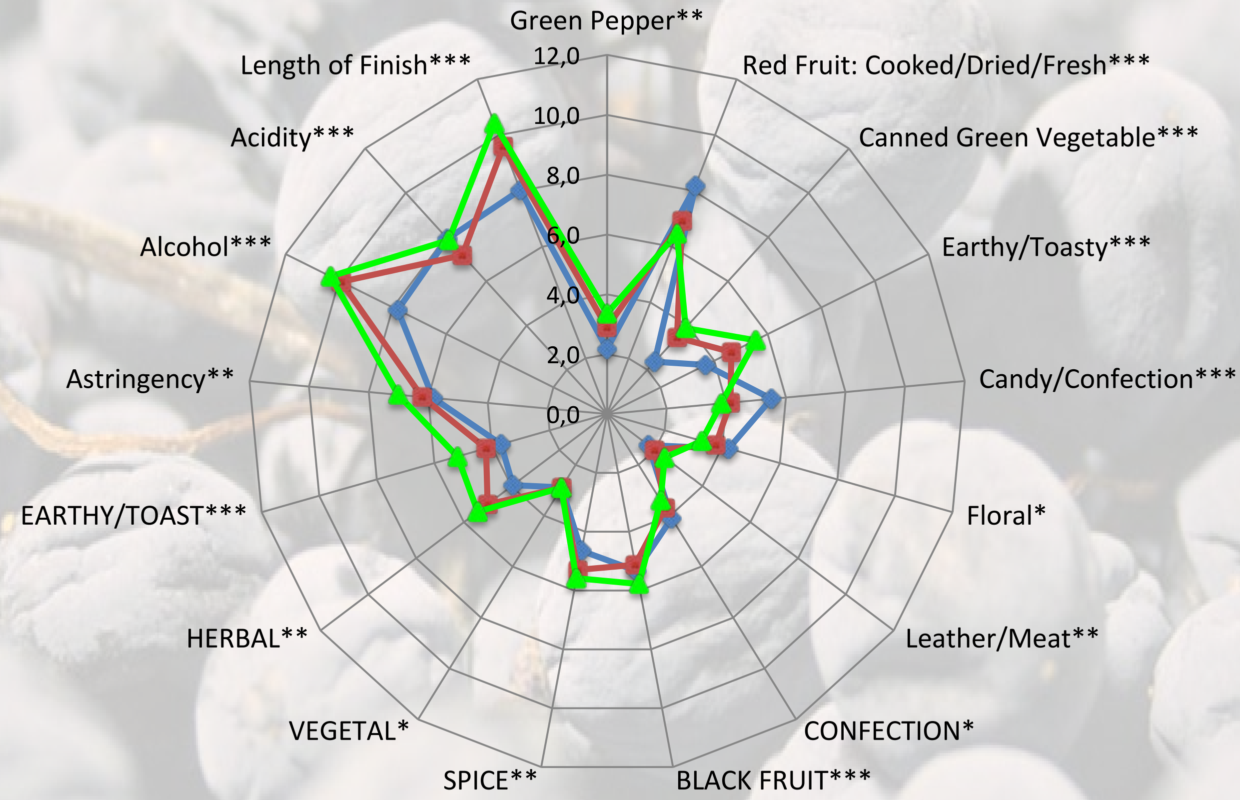
Parameter	23.0°Brix	28.0°Brix
Reducing sugar (g/L)	<0.07	<0.07
pH	3.78 ±0.09	3.74 ±0.00
Primary amino nitrogen (mg N/L)	<6	<6
Ammonia nitrogen (mg N/L)	28 ±3^{b}	40 ±2^{a}
Titratable acidity (g/L)	6.4 ±0.3	6.8 ±0.2
Malic acid (g/L)	1.6±0.4	1.9 ±0.1
Lactic acid (g/L)	0.45±0.42^{a}	<0.03^{b}
Glycerol (g/L)	8.5 ±0.4^{b}	11.2 ±0.1^{a}
Acetic acid (g/L)	0.30 ±0.02^{b}	0.36 ±0.02^{a}
Ethanol (% v/v)	13.0 ±0.3^{b}	15.3 ±0.7^{a}
Acetaldehyde (mg/L)	56 ±7^{b}	88 ±7^{a}
Ethyl acetate (mg/L)	36 ±3	37 ±13

Lowercase letters within the same parameter indicate differences between treatments (Fisher's Protected LSD$_{0.05}$)

Volatile aroma compound analysis.
All Treatments, EC1118 *S. cerevisiae* vs. CN1 *S. bayanus*



Sensory Impacts of Appassimento



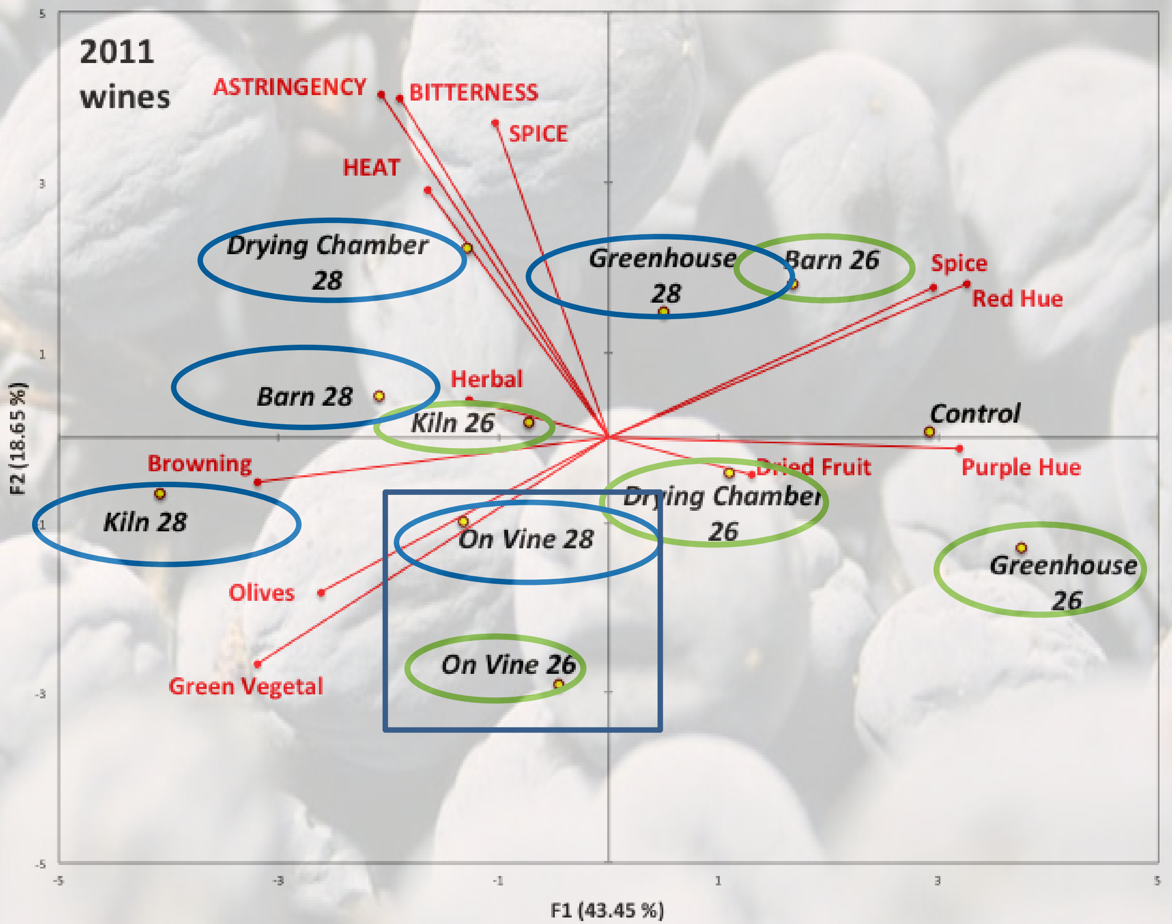
Note: Flavor in CAPS, aroma in lower case

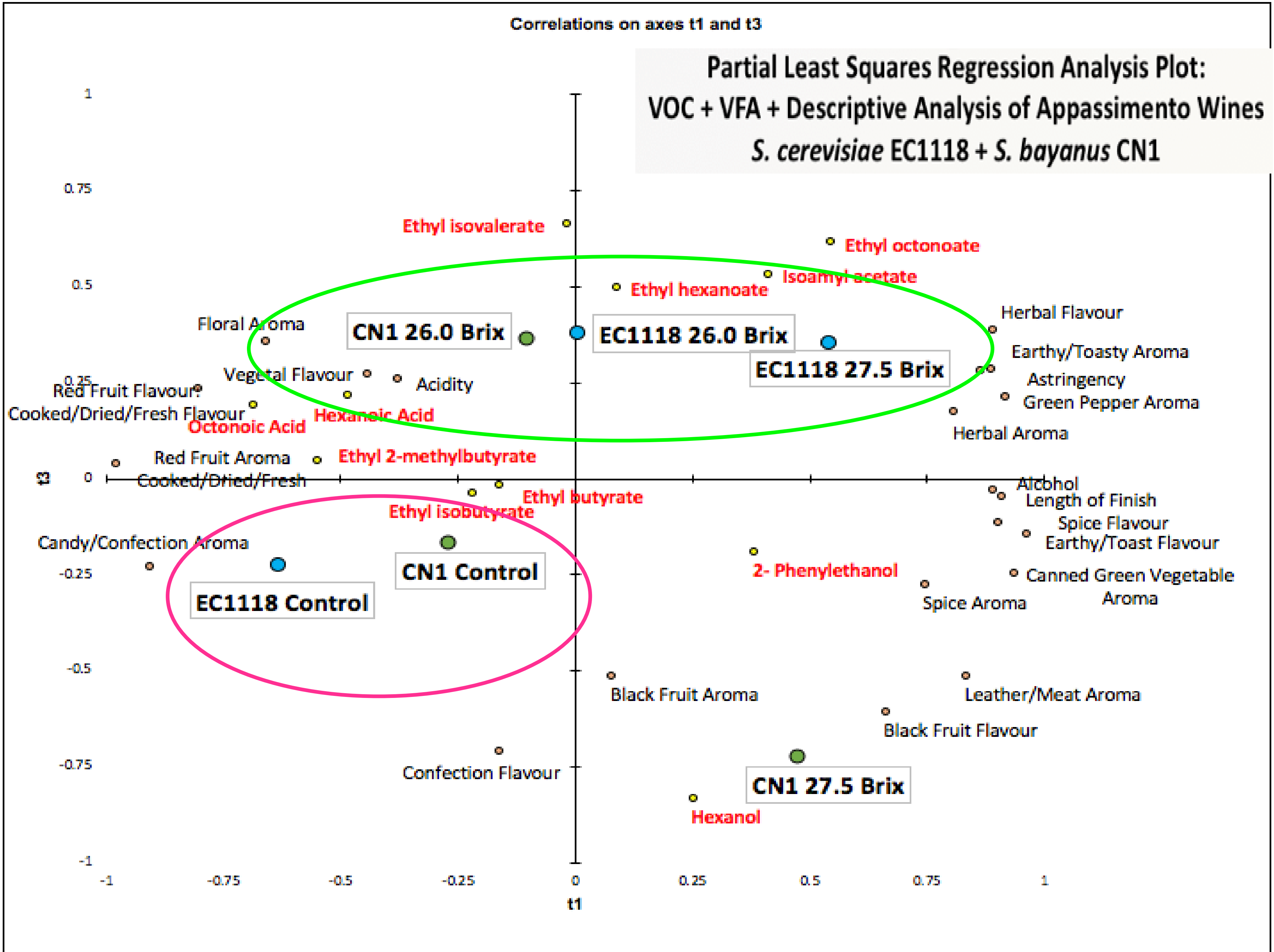
*= $p<0.05$
**= $p<0.01$
***= $p<0.001$

Descriptive Analysis of Wines, 2011
(G. Pickering Laboratory)

Descriptive Analysis:

- **Trained panel**
- **4-6 months after bottling**
- **Principal Component Analyses for descriptors that were <u>significantly different</u> between wines (p(F)<0.05).**
- **Labels in CAPITAL letters indicate flavor descriptors, those in lower case are aroma and colour descriptors.**





Correlations on axes t1 and t3
Partial Least Squares Regression Analysis Plot:
VOC + VFA + Descriptive Analysis of Appassimento Wines
S. cerevisiae EC1118 + S. bayanus CN1
Ethyl isovalerate
Ethyl octonoate
Isoamyl acetate
Ethyl hexanoate
Herbal Flavour
Floral Aroma
CN1 26.0 Brix
EC1118 26.0 Brix
Earthy/Toasty Aroma
EC1118 27.5 Brix
Astringency
Vegetal Flavour
Acidity
Red Fruit Flavour
Green Pepper Aroma
Cooked/Dried/Fresh Flavour
Hexanoic Acid
Octonoic Acid
Herbal Aroma
Red Fruit Aroma
Ethyl 2-methylbutyrate
Cooked/Dried/Fresh
Alcohol
Length of Finish
Ethyl butyrate
Ethyl isobutyrate
Spice Flavour
Earthy/Toast Flavour
Candy/Confection Aroma
CN1 Control
2- Phenylethanol
Canned Green Vegetable Aroma
EC1118 Control
Spice Aroma
Black Fruit Aroma
Leather/Meat Aroma
Black Fruit Flavour
Confection Flavour
CN1 27.5 Brix
Hexanol
t3
t1

Ontario Producers

Pillitteri Reserva Famiglia $69.95 CAN

Colaneri Coraggiogo Amaroso $64.95 CAN

Foreign Affair Winery Cab Franc $110 CAN

Kew Heritage $39.95 CAN

Reif Estate Winery The Magician $39.95 CAN

Burning Kiln Kiln Hanger $49.95 CAN

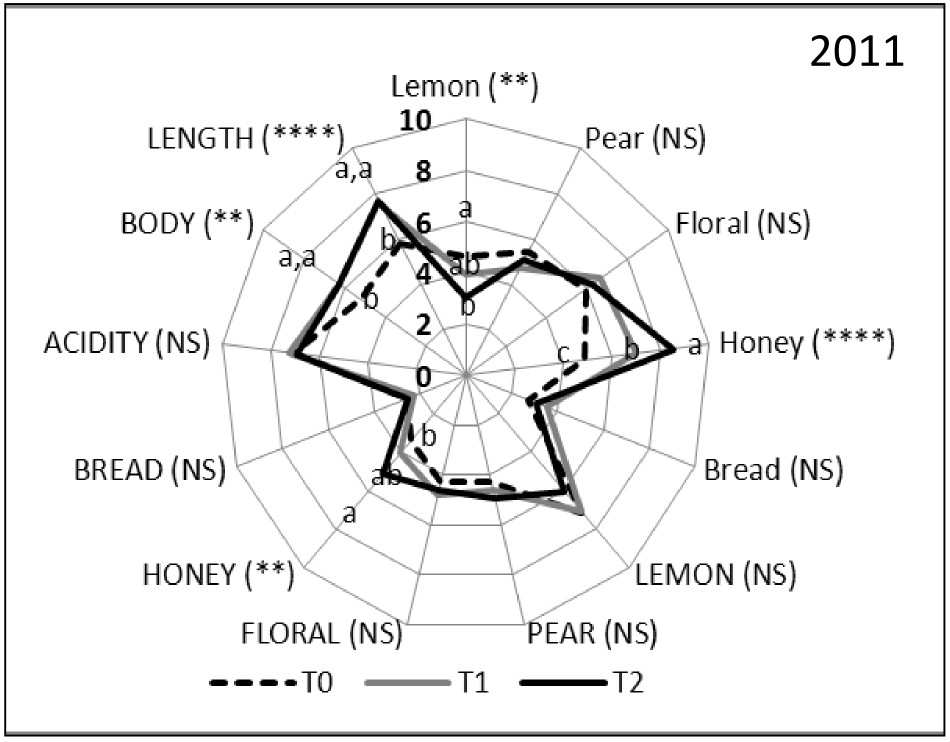
Big Head Wines Bigger Red Select 49.95 CAN

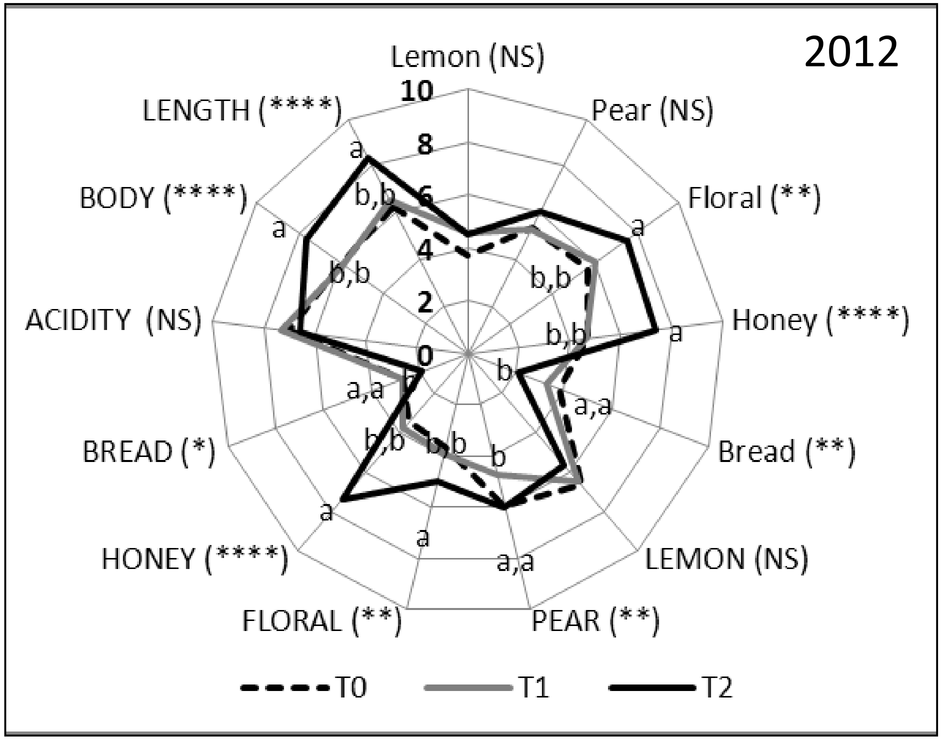
Impact of Harvest Date and Passito on Wine Aroma Compounds

- Pinot gris, Riesling, Cabernet franc, Cabernet Sauvignon—two crop loads, three harvest dates, two seasons
- Very little crop level effects
- Delayed harvest overcame effects of crop reduction for almost volatile components.
- Pinot gris and Riesling benefitted with increases in varietal aromas e.g. monoterpenes (linalool, geraniol, citronellol) and increases in esters, aldehydes, alcohols, and norisoprenoids.
- Reduced concentrations with delayed harvest for volatile acids and grassy-green odor compounds (e.g. 1-hexanol, hexyl acetate) in wines were also evident.
- Increases in ethanol were related to increased berry and must sugars, but higher alcohols did not necessarily increase with harvest date.

Sensory Analysis- Pinot gris

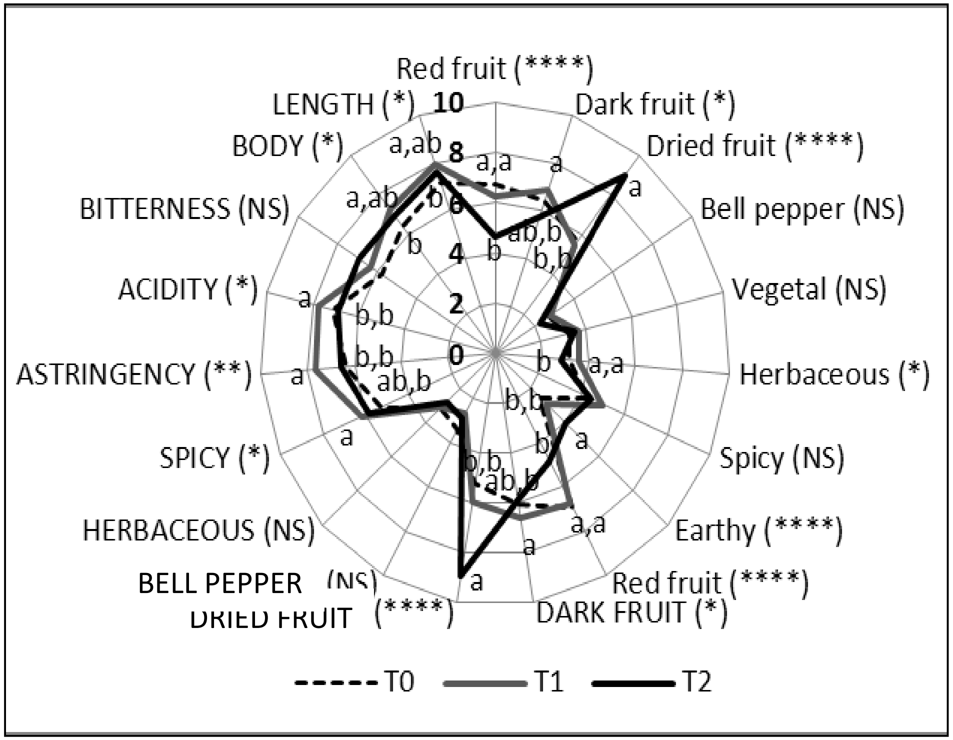
Latest harvest wines enhanced in terms of floral & honey aromas and flavor, body, length

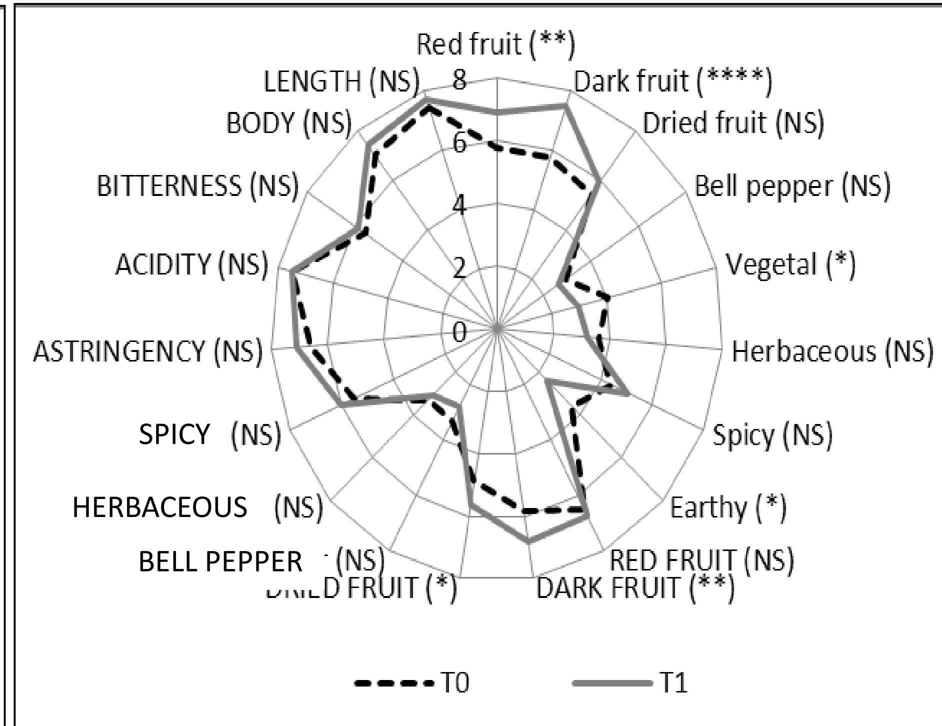




Sensory Analysis- Cabernet franc

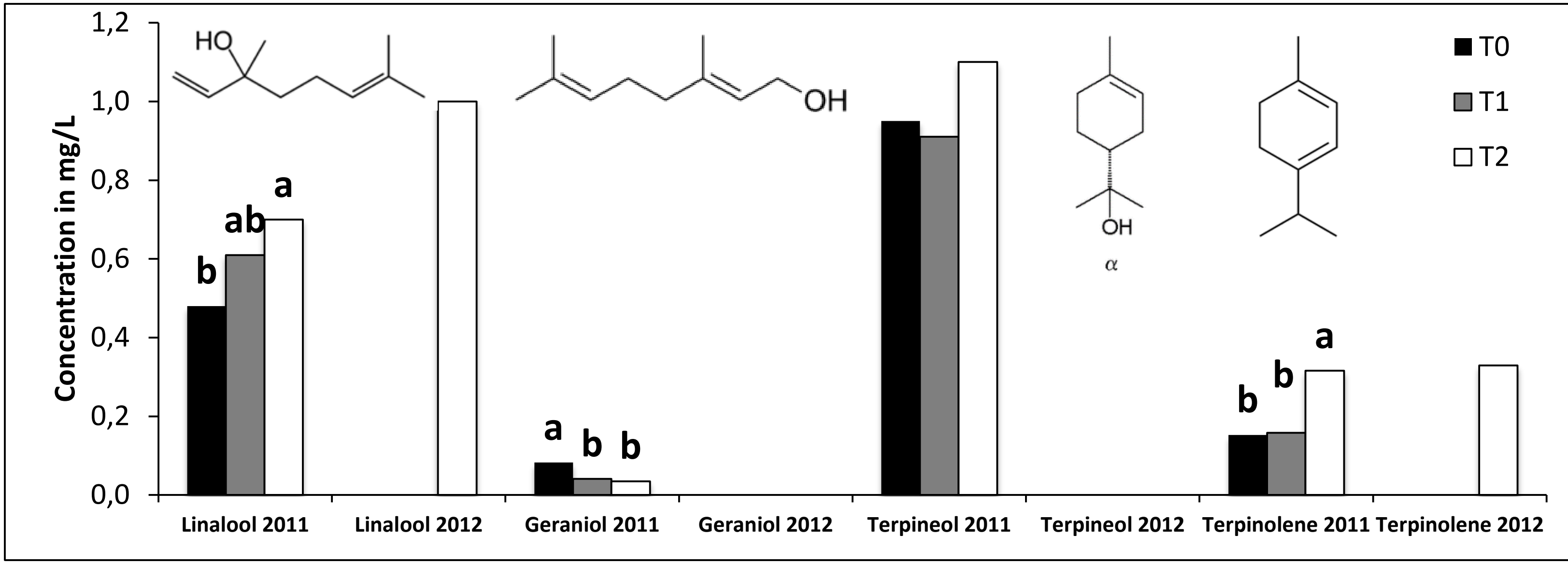
Extended harvest wines enhanced in terms of dark fruit, dried fruit, body, length plus reduced vegetal, astringency

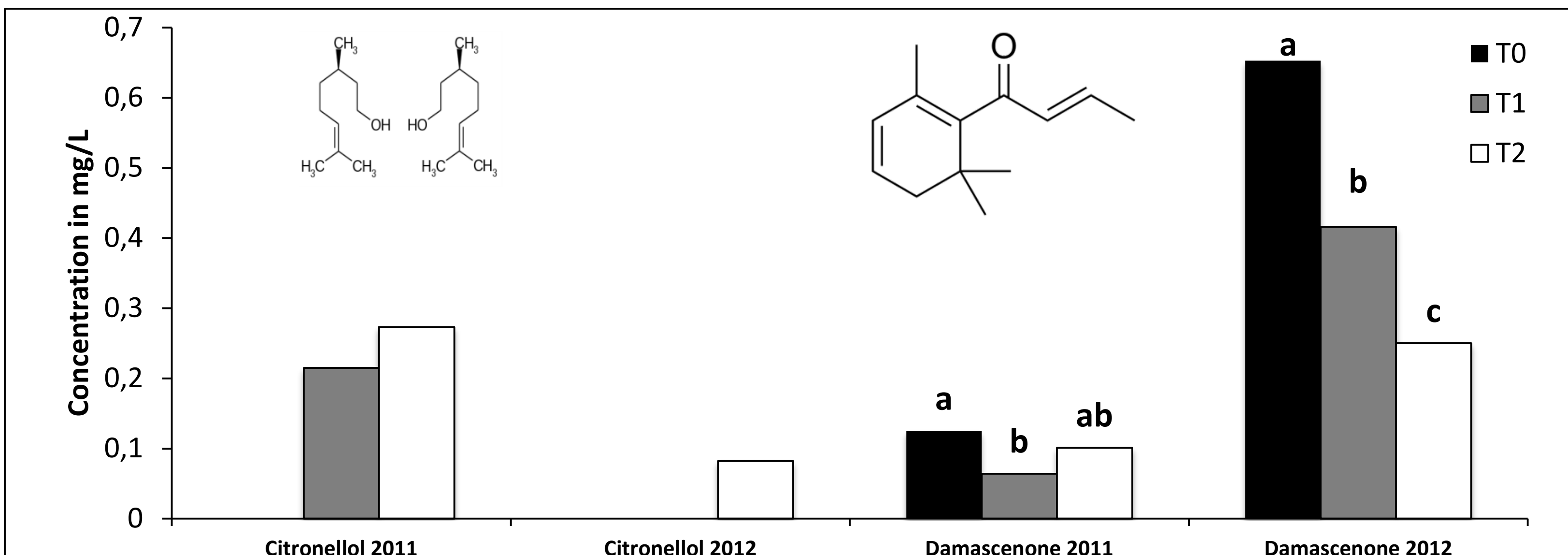




Riesling-Terpenes, Norisoprenoids

Increased linalool (floral), terpineol (oil), terpinolene, citronellol; reduced damascenone





Acknowledgements

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- Belinda Kemp—information on sparkling wines
- Gary Pickering—information on icewine