Yeast Selection for Wines made from Cold-Hardy Grapes

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NORTHERN GRAPES PROJECT

Viticulture, enology and marketing for cold-hardy grapes

UNIVERSITY OF MINNESOTA

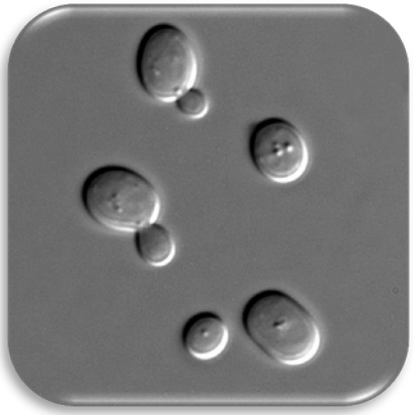
Yeast and Fermentation History

- Yeast from *Saccharomyces s.s.*have been used for thousands of years for the fermentation of food and beverages
- 1860 – discovery that yeast was responsible for the conversion of sugar to ethanol
- 1890 – Müller-Thurgau recommends inoculating wine with pure yeast strains

Yeast and Fermentation history

- 5400-5000 BC - First evidence of winemaking
- Wine Fermented in open jars, and sealed when fermentation was finished
  - Jars had to be broken to open
- Wine was considered as coming from God

Fermentation Yeast



- *Saccharomyces* – "sugar fungus"
  - In absence of oxygen, they transform sugar to ethanol and CO_2
- Evolved at the same time as fruits with competitive advantages:
  - produce large amounts of ethanol and tolerates it
  - Able to grow in both aerobic and anaerobic conditions

Saccharomyces sensu stricto species

- *S. cariocanus, S. mikatae, S. paradoxus, S. kudriavzevii*
  - Mostly found in natural environments; not associated with human activity
- ***Saccharomyces uvarum***
  - Has been isolated from wine and cider fermentations
- ***Saccharomyces bayanus***
  - Used in lager beer fermentation
- ***Saccharomyces cerevisiae***
  - Most commonly used species by humans
  - Wine, ale beer, sake, palm fermentation
  - Leavened bread

Saccharomyces cerevisiae

- Numerous strains of this species have been isolated from beverages and food, but only few have been found in nature
  - *S. cerevisiae* originated in natural environments, and was followed by human domestication
  - For wine yeasts, 95% of strains isolated around the world belong to the same genetic cluster

Suggests a unique origin of wine yeasts, followed by expansion of populations through human activities

Saccharomyces cerevisiae

Trebbiano, Ugni Blanc

Most widely planted grape in France and Italy!

Sug
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What do yeast contribute to wine?

- Ethanol
- Glycerol
- Higher Alcohols
- Esters
- Acetic Acid
- Lactic Acid

Indirect Aroma Contributions

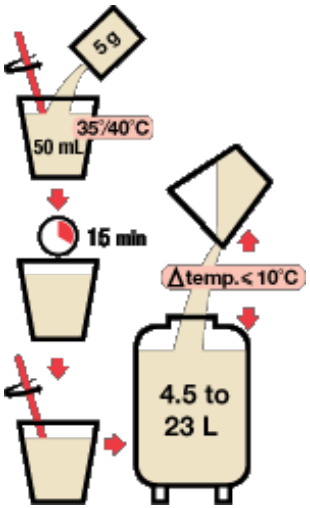
- Enhance varietal aroma freeing bound aromas
  - Monoterpenes
    - Floral aromas, muscat
  - Thiols
    - Lemongrass, grapefruit, passionfruit, guava

Contribution of Yeast Lees

- Yeast lees can *remove undesirable* compounds
  - Ochratoxin A, Diacetyl, fungicides
- Yeast lees can *increase undesired* compounds
  - Biogenic Amines, fatty acids, higher alcohols
- Yeast lees can *increase desirable* compounds
  - Mannoproteins, esters
- Yeast lees can *remove desirable* compounds
  - Esters, diacetyl, oak aroma

Choosing a Yeast

- All of these direct and indirect contributions by yeast need to be considered when choosing a yeast strain – or when choosing to NOT inoculate your wines!

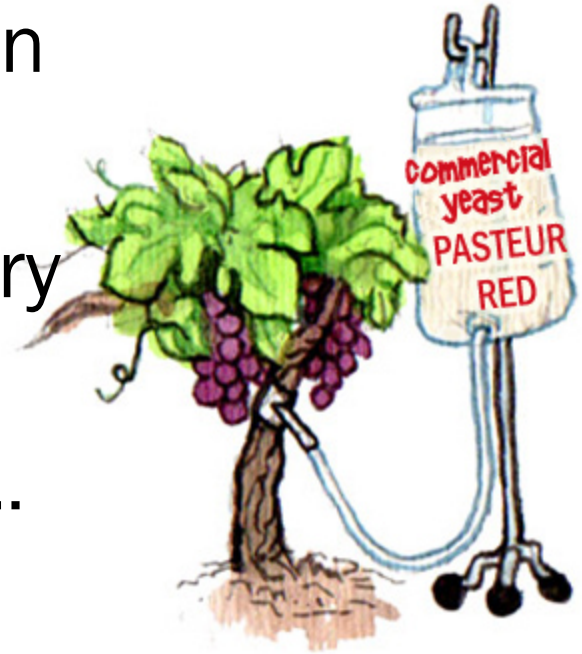


Advantages of cultivated yeast

- Faster start to fermentation
  - Exclusion of defects due to delayed start
- Greater yield of ethanol
- Lower production of volatile acidity and other off-aromas
- Full exhaustion of fermentiscible sugars
  - Limits bacterial growth; Better control of wine flavor
  - Increases wine stability

Advantages of cultivated Yeast

- Better control of fixed acidity through malic acid consumption or production
- Optimal production of secondary metabolites
  - Higher alcohols, esters, glycerol…
- Optimizing interaction with Malolactic bacteria

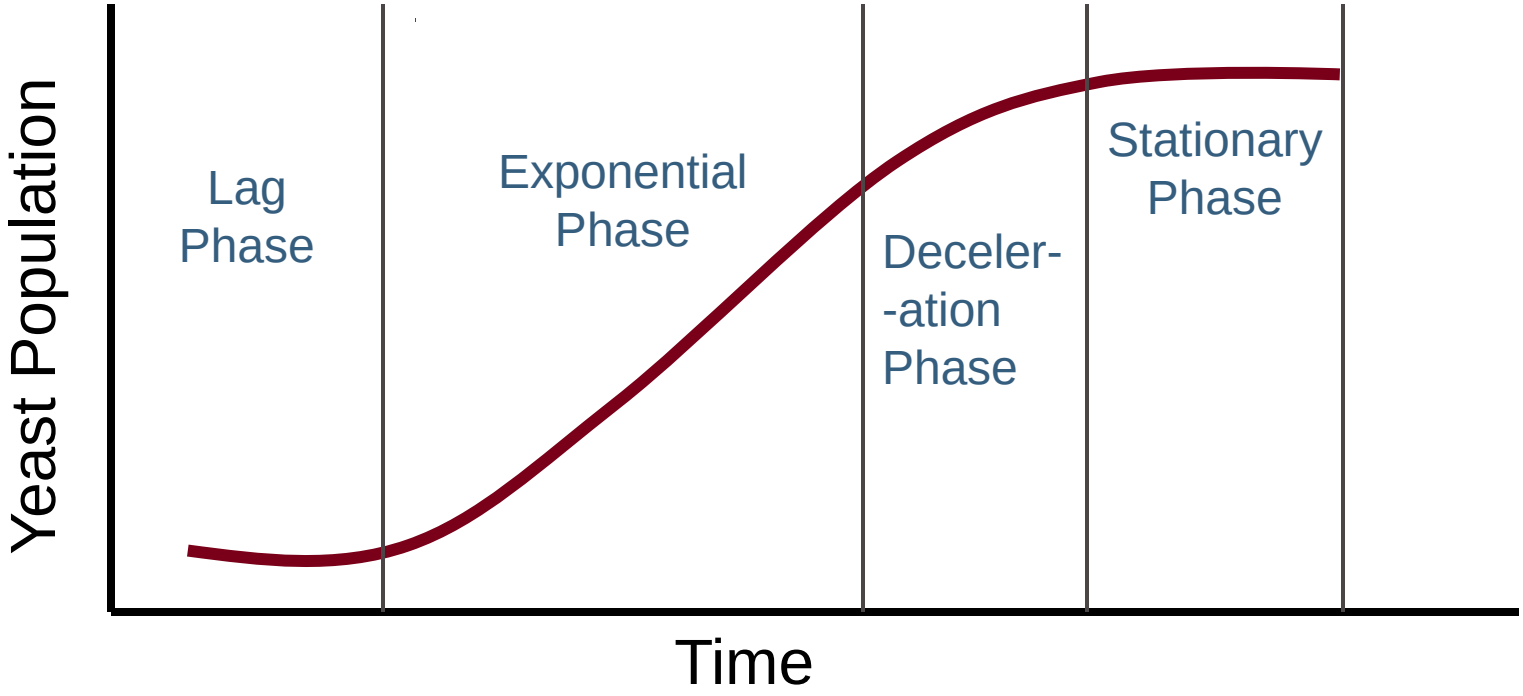


Advantages of cultivated Yeast

- Selection of yeast strains has made wine safer:
  - Able to ferment and stabilize wine with lower levels of SO2
  - Detoxification of wines from Heavy metals originating from vineyard treatments
  - Low production of ethyl carbamate and biogenic amines

Fermentation Kinetics

- Four phases of yeast growth:



“Spontaneous” Fermentations

- Natural fermentation is carried out by yeast present on grapes and winery equipment
- Indigenous yeast populations present in grape must represent many different genera of yeast
- *Saccharomyces cerevisiae* is absent or rarely present on grapes, but is associated with the winery environment

Non-*Saccharomyces* yeast in wine

- *Brettanomyces/Dekkera*
- *Candida*
- *Cryptococcus*
- *Debaryomyces*
- *Hanseniaspora/Kloeckera*
- *Kluyveromyces*
- *Metschnikowia*
- *Pichia*
- *Rhodotorula*
- *Saccharomyces*
- *Saccharomycodes*
- *Schizosaccharomyces*
- *Torulaspora*
- *Zygosaccharomyces*

Natural Fermentations: The Good

- Non-*Saccharomyces* yeasts, being the most abundant, start fermentation relatively quickly
  - Can have favorable aromatic and gustatory impact
  - Prevent unfavorable organisims from being established during the lag phase of *Saccharomyces*
- After 5% alcohol is reached, *Saccharomyces* will dominate the fermentation

Zoecklin, et al., 1996

Effect of Four Strains of *Saccharomyces cerevisiae* and Native Yeasts on Selected Free Aroma Components of White Riesling Juice and Wines Immediately Following Fermentation

Compound ug/L		Yeasts				
	Juice	Prise de Mousse	D47	Fermiblanc	VL1	Native
linalool	32	23	40	38	43	34
nerol	11	<1	1	2	1	<1
geraniol	22	2	2	2	3	4
α-terpineol	8	32	35	24	37	50
hotrienol oxide	nd	33	39	60	40	44
t-pyran linalool oxide	4	21	18	40	24	26
benzyl alcohol	8	5	6	7	9	1
2-phenylethanol	33	88	101	122	107	139
TOTAL FREE COMPOUNDS						
monoterpenes	77	112	135	166	148	133
aromatic alcohols	41	93	107	129	116	140

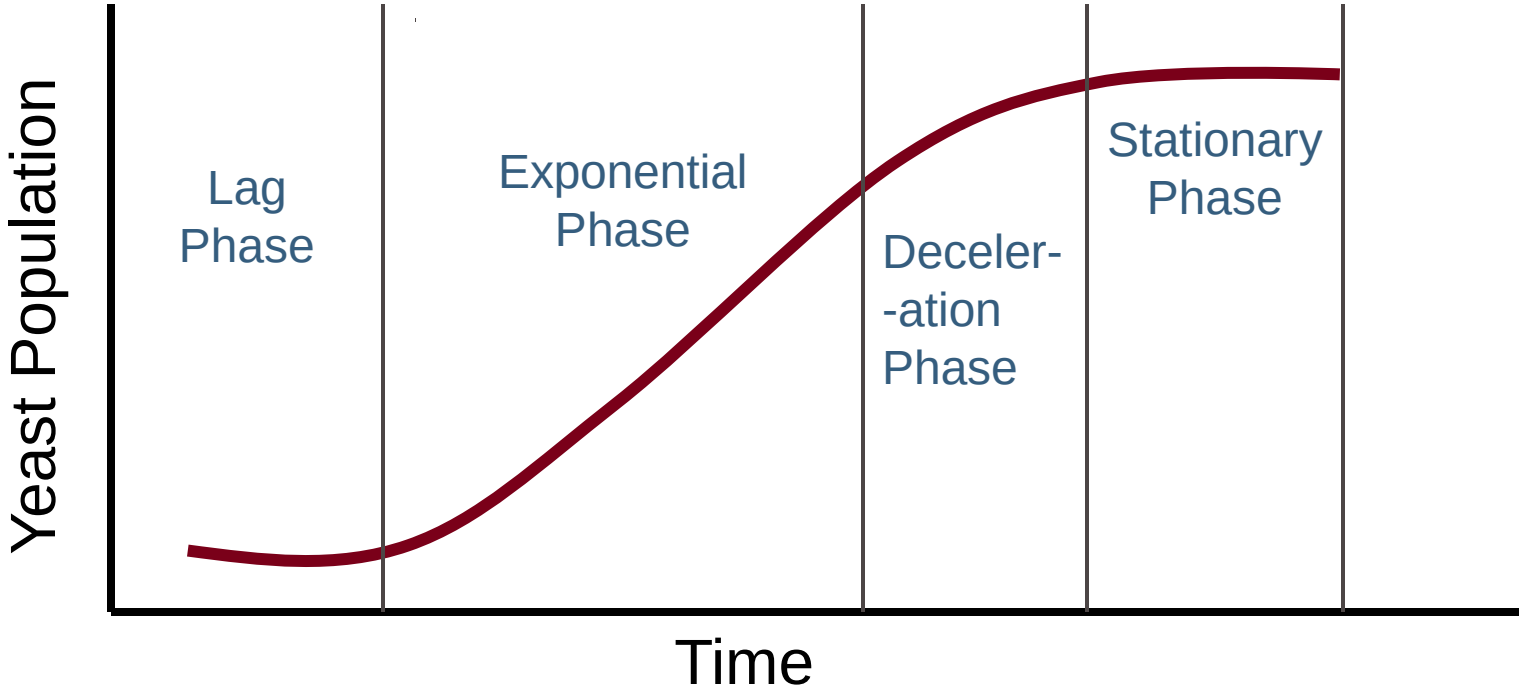



Natural Fermentations: The Bad

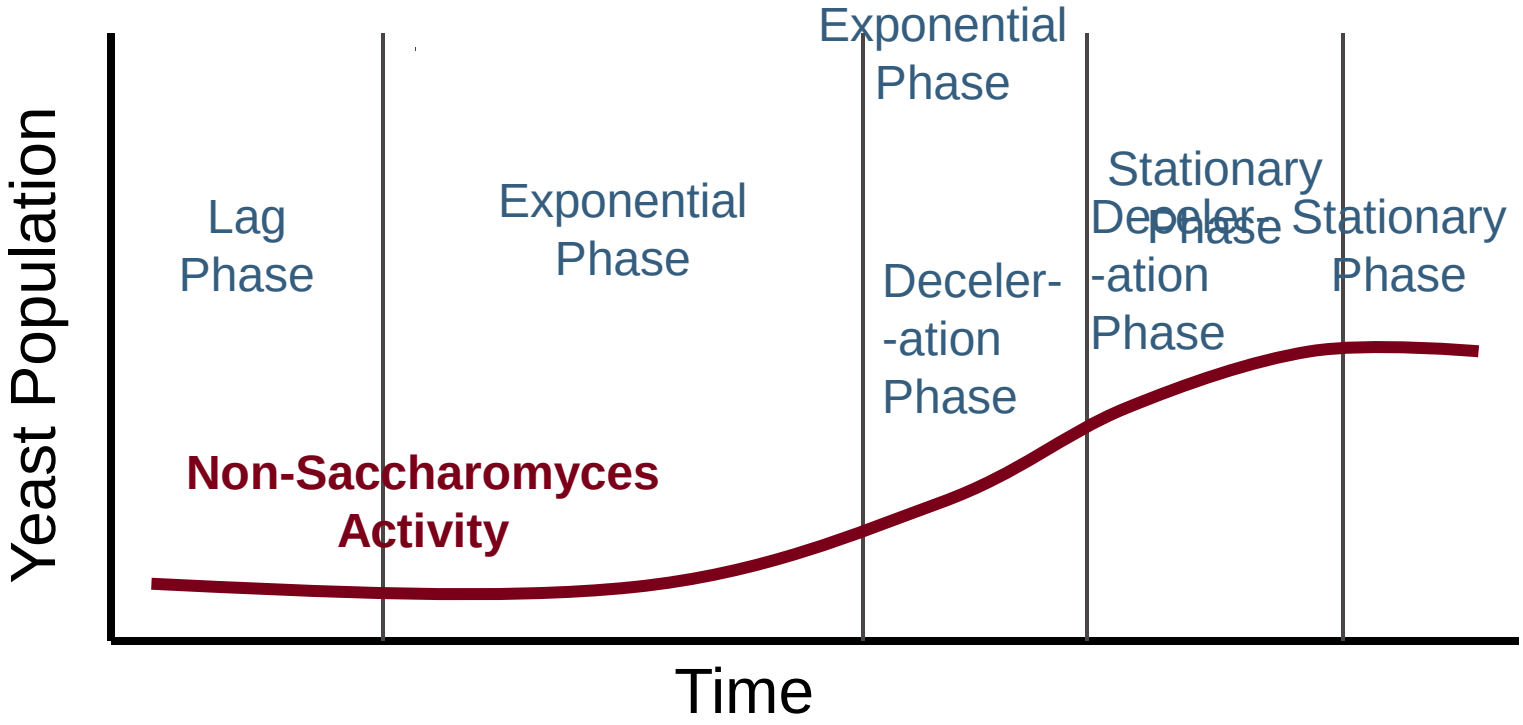
- Stuck and/or sluggish fermentations
  - Initial population of *S. cerevisiae* yeast may be low
  - Presence of killer yeast strains
  - Depletion of certain vitamins and other nutrients
- Off-aromas
  - Some yeast are higher producers of ethyl acetate and higher alcohols
  - Volatile phenols
  - Volatile Acidity (acetic acid)
  - Volatile Thiols (mercaptans)
- MLF can also start spontaneously or be inhibited

Fermentation Kinetics

- Four phases of yeast growth:



Fermentation Kinetics - Native



Native Yeast Fermentation

- Next generation of yeast for inoculations are looking into the positive attributes of non-*Saccharomyces* yeasts
  - Sequential inoculations
  - De-acidification
  - Mannoprotein and glycerol production

Choosing a Yeast

- The following questions need to be answered for each fermentation lot before selecting as yeast:
  - What style of wine would I like to produce?
  - What does my harvest chemistry look like?
  - What are my cellar limitations?
  - What post-fermentation treatments will I employ?

Yeast as a tool

- While selecting proper yeast can help you achieve a desired wine style, it is just a small part of the winemaking process
- Quality primary material (grapes/fruit) will have biggest impact on final wine

Technological Maturity

- Most cold-hardy grapes are harvested according to their technological maturity
  - Limitations in climate
    - Early frost, short growing season
  - Genetic constraints of cold-hardy cultivars
    - High brix/high TA/high pH; foxy characteristics
  - Poor understanding of phenolic development and its contribution to cold-climate wines

Choosing a Yeast

- Grape variety and ripeness should also be considered when thinking about wine style
  - Aromatic vs. neutral variety
  - Full-ripeness vs. underripe
  - Age of vineyard, soil type, climate…
- Overcropped vines or shaded fruit with poor phenolic and/or technologic ripeness will rarely make a high-end wine

Wine Style

- Often wine style is determined more by the quality of the fruit rather than the desire of the winemaker
- Poor quality fruit needs to be treated differently than high quality fruit
  - Short maceration time, cooler fermentation temperatures, less extractive techniques
  - Underdeveloped fruit aromas in the grape mean that aromatic yeasts should be used

Desired Style: light and Fruity

Fermentation Considerations

- Young vines, poor phenolic ripeness, high-vigor sites
- Cold-Fermentation guards fruity aromas
- Fruity flavors are derived from esters
- Fermentation should be rapid, with minimal production of thiols (except in Sauv. Blanc)

Yeast Considerations

- May want a yeast that is a high glycerol producer
- Yeast need to have good cold tolerance
- Look for a high-ester producing yeast
- Yeast should be a low thiol/DMS producer and a strong fermentor

Desired Style: Barrel fermented

Fermentation Considerations

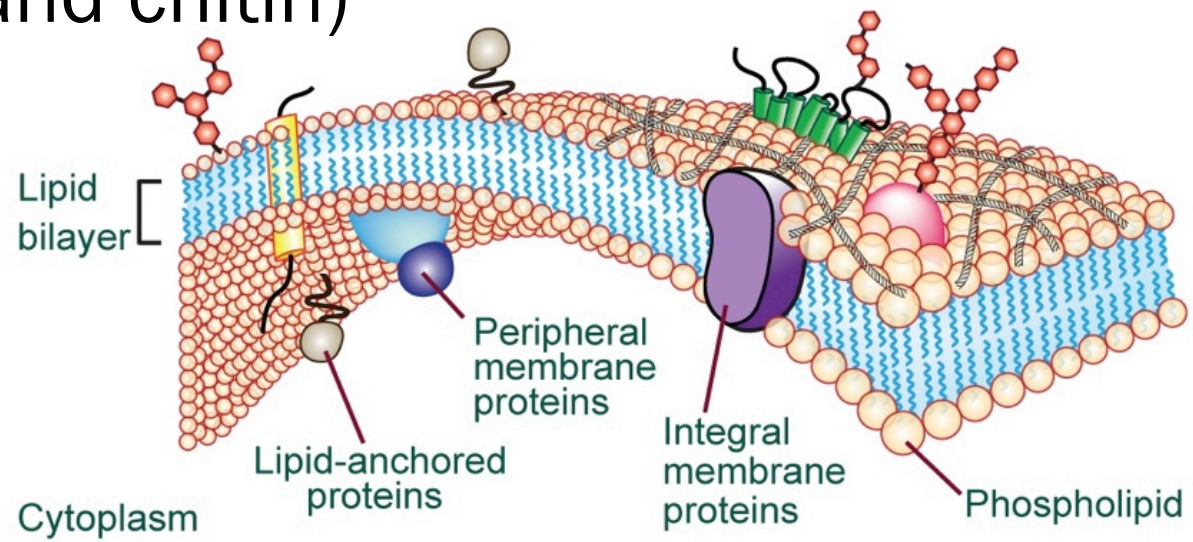
- Usually carried out in riper fruit that has more potential for complexity
- Typically carried out at ambient temperatures (68º - 72ºF)
- Barrel fermented wines typically spend time on lees to gain some opulence

Yeast Considerations

- Neutral yeast selections should be used
- temperature tolerance in yeast not very important
- Look for high mannoprotein yeast

Limitations on yeast

- Yeast cell membrane - lipid bilayer
  - The fluidity of the Lipid bilayer is weakened by alcohol, temperature, sugar concentration…
- Polysaccharides provide strength to the cell wall (glucan and chitin)



Harvest Chemistry and yeast

- High sugar musts mean a greater osmotic pressure on yeasts at the start of fermentation, as well as higher alcohol at the end of fermentation
  - If a dry wine is desired, the yeast need to tolerate the potential alcohol of the final wine
- Yeast are also sensitive to nutrition
  - If nitrogen levels cannot be measured in the must, a yeast with low nutrient needs should be chosen

Desired Style: Dessert Wine

- Dessert wines usually start with a high-sugar must
  - Yeast should have high osmotolerance
  - Alcohol tolerance is important if winemaker desires a certain alcohol level
  - Low VA producers
  - Low H2S producers

Desired Style: Fortified Wine

- Because alcohol is used to stop the fermentation, yeast should be a weak fermenter with a low alcohol tolerance

Cultivar Considerations

- Most yeast catalogs give yeast recommendations based on how well they work with certain grape cultivars
- Generally a large sensory study is carried out to determine the organoleptic impact that the yeast has on the wine
- Only a very small % of the world's cultivars are represented on these charts

Cultivar Considerations

- When working with a grape cultivar not listed on yeast charts, key words listed in the description can help guide your selection:
  - Monoterpenes
  - Esters
  - Thiols
  - Neutral
  - Spicy
  - Aromatic
  - Extraction
  - Mouthfeel

Cultivar Consideration - NGP

In 2012, a multi-state trial of wine yeasts with cold-hardy cultivars will help give insight as to how certain yeast might benefit wines made from cold-hardy grapes

- Marquette
  - looking to enhance varietal character (spiciness and dark fruits) as well as mouthfeel and extraction
- Frontenac Gris
  - Looking at the effect of thiol-producing yeast on wine made from FG
- La Crescent
  - Aromatic yeast strains, as well as monoterpene production
- Frontenac
  - Enhancing fruit character with ester-producing yeast

Other Factors to Consider

- Cellar Limitations
  - Wineries without cooling systems need to be wary of yeast that are fast fermenters, as fermentation may finish quickly and get very hot
  - Inability to measure Nitrogen in the must should lead to selection of yeast that have low nutrition requirements
  - H2S production can become a problem in large tanks where the reduction potential is high; choose yeasts that have lower H2S production

Other factors to Consider

- Malic Acid reduction by malo-ethanolic Fermentation
  - *Schizosaccharomyces pombe*
  - Certain *Saccharomyces* strains will partially degrade Malic acid
  - Genetically modified Yeast with malic degrading properties

Other Factors to Consider

- Efficiency of Fermentation
  - Selected yeast strains typically yield higher alcohol than their “wild” counterparts
    - On average 16.8 g/L sugar for 1% alcohol
  - In some instances, yeast with lower fermentation efficiency may be desired
    - Warmer climates where ºBrix is high
    - Using a yeast that uses more sugar to make 1% alcohol may result in a lower-alcohol wine

Conclusions

- Understand exactly what a yeast can contribute to your wine, as well as their limitations
  - This will help to navigate the key phrases that yeast companies use when writing descriptors of their yeast
  - Also will make you more able to ask technical questions of sales representatives

Conclusions

- Know that yeast will not be a fix-all for your wine, but can be an important tool for steering your wine toward a certain style
- Plan yeast selections knowing the limitations of your winery
- Brix, temperature, and yeast nutrients along with clean, healthy fruit will have the largest impact on the outcome of your wine