Yeast Selection for Wines made from Cold-Hardy Grapes

Katie Cook, Enologist, 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

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

Trebbiano, Ugni Blanc

Most widely planted grape in France and Italy!
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

Others...?
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:

  - Lag Phase
  - Exponential Phase
  - Deceleration Phase
  - Stationary Phase
“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 organisms from being established during the lag phase of Saccharomyces

- After 5% alcohol is reached, Saccharomyces will dominate the fermentation
# Effect of Four Strains of *Saccharomyces cerevisiae* and Native Yeasts on Selected Free Aroma Components of White Riesling Juice and Wines Immediately Following Fermentation

<table>
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<th>Compound</th>
<th>Juice</th>
<th>Prise de Mousse</th>
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<th>Fermiblanc</th>
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**TOTAL FREE COMPOUNDS**

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<th>monoterpenes</th>
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</table>
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:

  - Lag Phase
  - Exponential Phase
  - Deceleration Phase
  - Stationary Phase

<table>
<thead>
<tr>
<th>Time</th>
<th>Yeast Population</th>
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<tr>
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<td>Lag Phase</td>
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<tr>
<td></td>
<td>Stationary</td>
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</tbody>
</table>
Fermentation Kinetics - Native

- Lag Phase
- Exponential Phase
- Deceleration Phase
- Stationary Phase

Non-Saccharomyces Activity
Native Yeast Fermentation

- Next generation of yeast for inoculations are looking into the positive attributes of non-\textit{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
Fermentation Considerations

- Usually carried out in riper fruit that has more potential for complexity
- Typically carried out at ambient temperatures (68° - 72°F)
- 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 °Brix 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