Virginia

Major varieties:
- Chardonnay
- Cabernet Sauvignon
- Cabernet Franc
- Merlot

Other varieties:
- Mourvedre
- Sauvignon Blanc
- Riesling
- Viognier
- Norton
- Petit Manseng
- Tannat
- Petit Verdot
OUTLINE OF WINE PRODUCTION

WHITE WINES
- Grapes
- Destemming and crushing
- Maceration
- Pressing
- Fermentation

RED WINES
- Grapes
- Destemming and crushing
- Fermentation and maceration
- Pressing (rosé - early, red - late)

MAIN SPECIES INVOLVED
- *Vitis vinifera*
- *Saccharomyces cerevisiae*
- *Oenococcus oeni*

Malolactic fermentation (if desired)
- Clarification
- Maturation
- Fining / stabilisation
- Filtration
- Bottling

Source: Pretorius and Hoj (2005)
Profitability

Fruit quality
Sugar, colour, acid & flavour, *aroma*

Proteins & Metabolites

Environment
climate
land & water
pests & diseases

GENES

Management
irrigation
pruning
fertilisers & sprays

Yield

Flowering & fruitfulness

Source: Pretorius and Høj (2005)
Presentation Goals

• Defining the goals of aroma / flavor management and research
• Aroma / flavor as quality attributes
• Management of aroma and flavor in grapes and wines
• Eye towards the future
Wine Quality

HARMONY
FINESSE
COMPLEXITY
BALANCE
COLOR QUALITY

PERSONALITY OF THE GRAPE
VARIETAL CHARACTER

CLEANLINESS
ABSENCE OF UNPLEASANT AROMAS AND FLAVORS
Source: Francis et al. (2005)
Volatile Compounds in Wine

- directly from the grape
- from non-volatile grape precursors
- yeast and bacterial metabolism
- oak wood extraction
- chemical reactions upon storage
Vineyard Management

- Heat
- Light
- Soil
- Soil moisture

Steadman (1992)
Free and Bound Aroma/Flavor

Free Grape-Derived Volatiles

Sugar-bound Components

Odorless/Flavorless Nonvolatile Glycosides

Maturity Processing Aging

Virginia Tech Wine/Enology-Grape Chemistry Group
Glycoside Structure
Bound Aroma/Flavor Components

R
HOCH₃
O
O
O⁻

α-L-arabinofuranosyl

HO
O

CH₃

O

O⁻

α-L-rhamnopyranosyl

HOCH₂
O

O⁻

β-apiofuranosyl

D-glucose

R
CH₂
O
O

O

Aglycones

Aliphatic residues
Monoterpenes
Sesquiterpenes
Norisoprenoids
Phenols / Anthocyanins

source: M. Naeker and V.M. Cabalda-Crane
Wine Flavor Intensity

Strongly correlates with Grape Glycosides, but not always with Sugar
Vineyard Parameters

Impacting Glycosides and Free Volatiles

- Crop load
- Light interception
- Heat
- Soil
- Soil moisture
- Maturity
Chardonnay Crop Load
Total Glycosides vs. Brix

Degrees Brix

Total Glycosides umol/g fw x 10

4.4 TPA
7.5 TPA
8.4 TPA

Source: Zoecklein, 1998
Changes in Total Glycoside Concentration for Chardonnay Grapes

Source: Zoecklein, 1998
Geneva Double Curtain (GDC)

- Divided canopy
- Shoots trained down
Smart-Dyson (SD)

- Shoots trained up and down
Vertical Shoot Positioned (VSP)

- Common system in Virginia
- Shoots trained up
2002 Berry Total Glycosides and Phenol-Free Glycosides

Percent difference relative to VSP
Wine Volatile Organic Compound Analysis
Different letters denote significant difference (p ≤ 0.05) of treatment means.
<table>
<thead>
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<th>Targets for Improvement</th>
<th>Focus of Research</th>
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<td><strong>Grape Quality</strong></td>
<td>Improved color development</td>
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<td>Improving quality factors</td>
<td>➢ Ripening-related processes and signals</td>
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<td>Improved sugar accumulation and transport</td>
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<td>➢ Phloem loading and unloading</td>
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<td>➢ Improved production of glycosidically-bound aroma/flavor precursors</td>
</tr>
<tr>
<td></td>
<td>➢ Improved engustment, the liberation of free volatiles</td>
</tr>
</tbody>
</table>

Source: In part, Pretorius and Høj (2005)
Volatile compounds in grape juice

Saccharomyces cerevisiae

Fermentation

Oenococcus oeni

Which of these are the impact aroma and flavour compounds?

Volatile compounds in wine

Source: Swiegers et al. (2005)
Yeast Fermentation

Source: Swiegers et al. (2005)
**Targets for Improvement**

**Improving fermentation performance**
- Improved resilience and stress tolerance
- Improved efficiency of sugar utilisation
- Improved efficiency of nitrogen assimilation
- Improved ethanol tolerance
- Increased tolerance to antimicrobial compounds
- Reduced foam formation

**Focus of Research**
- Stress response, sterol, glycogen and trehalose
- Hexose transporters, hexose kinases
- Improved utilisation of less efficient N sources
- Sterol formation, membrane ATPase activity
- Resistance to killer toxins, sulfur dioxide, agrichemicals, heavy metals
- Cell-surface proteins

Source: Pretorius and Høj (2005)
Effect of Fermentation on the Relative Concentration of Wine Volatiles

Source: Adapted from Simpson and Miller (1984)
Effect of Capture and Return on Chardonnay Wines, Control vs Treatment

Source: Zoecklein et al. 2001

* Significance of t-test at $p \leq 0.05$. 

The diagram shows the effect of capture and return on Chardonnay wines, comparing control and treatment groups. The chart includes various flavor profiles such as Cut Grass, Citrus, Honey, Butterscotch, Butter, Banana, Grape, Pear, Cherry, Apple, Floral/fruity, and Nail Polish Remover. The significance level for the t-test is indicated by an asterisk (*).
Post-Bottling Heat Treatment:
Total Glycosides and Phenol-Free Glycosides of Heat Treated Cabernet Sauvignon

Source: Mansfield and Zoecklein, 2003
### Targets for Improvement

**Improving wine sensory attributes**

- ✔ Enhanced liberation of grape volatiles
- ✔ Enhanced production and retention of desirable volatile esters
- ✔ Optimised fusel oil production
- ➢ Enhanced glycerol production
- ➢ Bioadjustment of wine acidity
- ➢ Optimisation of phenolics
- ➢ Reduced sulfite and sulfide production
- ➢ Release of volatile thiols

### Focus of Research

- ➢ Glycosidases, glucanases, arabinofuranosidases
- ➢ Esterases, alcohol acetyl transferases
- ➢ Amino acid metabolism
- ➢ Glycerol metabolism
- ➢ Maloethanolic and malolactic fermentation, lactic acid production
- ➢ Phenolic acid metabolism
- ➢ Sulfur metabolism, hydrogen sulfide formation
- ➢ Lyases

Source: in part, Pretorius and Høj (2005)
Management of vineyards and wineries to market specifications

Source: Swiegers et al. (2005)
### Targets for Improvement

**Improving wine wholesomeness**

- Increased production of resveratrol
- Reduced formation of ethyl carbamate
- Reduced formation of biogenic amines
- Decreased levels of alcohol
- Decreased levels of pesticides / fungicides

### Focus of Research

- Stilbene synthesis and β-glucosidases
- Amino acid metabolism, urea formation
- Bacteriolytic enzymes, bacteriocins
- Carbon flux, glycerol metabolism and glucose oxidation

Source: Adapted, in part, from Pretorius and Høj (2005)