Indiana Horticultural Congress & Trade Show
Indianapolis, January 23 - 25, 2006

Wine Quality: The Science of Funk

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A definition:

A variety of “interesting” odors in wine that - depending on their concentration - may smell offensive to some, appealing to others.
Wine Preferences

Kramer

Laube

Parker

Butzke
The Science of Funk

- Chemistry
- Sensory
- Causes
- Prevention/Management/Removal
Reduction
Oxidation
Volatile Acidity
Nailpolish
Brettanomyces
Buttery
Geranium
Lady Bug
Cork Taint
<table>
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Sulfur in Wine

**Reduced**
- electron-rich
- **H₂S**
  - hydrogen sulfide
- **S²⁻**
  - sulfides

**Neutral**
- elemental sulfur

**Oxidized**
- electron-poor
- **SO₂**
  - sulfur dioxide
- **SO₄²⁻**
  - sulfate
- **HSO₃⁻**
  - bisulfite
Reduction
3x Sulfides

- Hydrogen Sulfide \( \text{H}_2\text{S} \)
- Mercaptans
- Disulfides
# Reduction

## Sulfides

<table>
<thead>
<tr>
<th>Sulfide</th>
<th>Odor Descriptors</th>
<th>In Wine μg/L</th>
</tr>
</thead>
<tbody>
<tr>
<td>hydrogen sulfide</td>
<td>rotten egg, sewage-like</td>
<td>0.9-1.5</td>
</tr>
<tr>
<td>ethyl mercaptan</td>
<td>burnt match, sulfidy, earthy</td>
<td>1.1-1.8</td>
</tr>
<tr>
<td>methyl mercaptan</td>
<td>rotten cabbage, burnt rubber</td>
<td>1.5</td>
</tr>
<tr>
<td>diethyl sulfide</td>
<td>rubbery</td>
<td>0.9-1.3</td>
</tr>
<tr>
<td>dimethyl sulfide</td>
<td>canned corn, cooked cabbage, asparagus</td>
<td>17-25</td>
</tr>
<tr>
<td>diethyl disulfide</td>
<td>garlic, burnt rubber</td>
<td>3.6-4.3</td>
</tr>
<tr>
<td>dimethyl disulfide</td>
<td>vegetal, cabbage, onion-like at high levels</td>
<td>9.8-10.2</td>
</tr>
<tr>
<td>carbon disulfide</td>
<td>sweet, ethereal, slightly green, sulfidy</td>
<td>5</td>
</tr>
</tbody>
</table>
Reduction
Hydrogen Sulfide

Copper fining possible!

- Boiling Point: -51 °F
- State: it’s a gas!
Reduction
Mercaptans

H₂S + Alcohol = Mercaptan

H₅C₂(-SH)

Copper fining possible!
Reduction
Disulfides

Mercaptan + Mercaptan = Disulfide

\[ H_5C_2-S-S-C_2H_5 \]

Copper fining **NOT** possible!
Reduction Sulfides

Sensory Threshold

- $\text{H}_2\text{S}$: 1 µg/L
- Mercaptans: 1 µg/L
- Disulfides: 30 µg/L
Reduction

Sulfides

Causes
- Juice nitrogen imbalances
- Fungicide (sulfur) residues
- Excess sulfate

Remedies
- Prevention!
- Aeration
- Copper Sulfate
Aeration/Splashing

- $\text{H}_2\text{S} + \text{Air}$
- $\text{Mercaptans} + \text{Air} = \text{Disulfides} = \text{bad idea!}$

Why?

**In Barrel:**
- Disulfides

**Sensory Threshold**

**In Bottle:**
- Disulfides $\Rightarrow$ Mercaptans
- 30 $\mu$g/L
- 1 $\mu$g/L
H$_2$S Prevention

- Assess juice nitrogen status
- Add juice nutrients selectively
- Lower elemental sulfur residues
- Reduce solids in whites
- Add SO$_2$ at crush
- Inoculate early/reduce inoculum
- Use low H$_2$S-producing yeast strains
- Lower fermentation temperature
- Aerate fermenting must
H₂S Prevention

After fermentation

• Rack off lees *immediately* if smelly
• Don’t aerate wine with mercaptans
• Test bulk wine for disulfides

Removal

• Add copper sulfate solution (Bench test!)
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Oxidation

Chemistry

- Acetaldehyde

Sensory

- *Sherry*, nutty, bruised apple
- Sensory threshold: 100 mg/L
Oxidation
Acetaldehyde

Causes

- Yeast fermentation by-product
- Oxidation of ethanol (alcohol) via oxidized phenolics

Prevention/Removal

- Proper free $\text{SO}_2$
- Air exclusion: aging/bottling/storage
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Volatile Acidity “V.A.”

Chemistry

- Acetic acid

Sensory

- Vinegar odor
- Spoilage threshold: 700 mg/L
- Legal limits: 1,400/1,200 mg/L

(27 CFR Part 4 Subpart C §4.21 a iv)
Volatile Acidity “V.A.”

Causes
- Yeast fermentation by-product
- Lactic acid bacteria
- Acetic acid bacteria

Prevention/Removal
- Clean fruit, SO$_2$ at crush, sanitation
- Avoid yeast stress
- Minimize fruit flies
- Reverse osmosis + ion exchange
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Nailpolish

Chemistry

- Alcohol + V.A. = Ethyl acetate

Sensory

- Nailpolish/remover odor
- Spoilage threshold: 150 mg/L

vs. Acetic acid: 700 mg/L
Nailpolish
Ethyl acetate

Causes:
- Yeast fermentation by-product
- Lactic acid bacteria
- Acetic acid bacteria

Prevention/Removal:
- Clean fruit, SO₂ at crush, sanitation
- Avoid yeast stress
- CANNOT be fully removed
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Brettanomyces

Sweaty saddle

Horse blanket

Band aid

Wet dog
Brettanomyces
Fr: Animale
Brettanomyces

Chemistry:
- Impact compound: 4-Ethylphenol

Sensory:
- Medicinal, band aid
- Threshold: 440 µg/L
Brettanomyces Yeast

En-wine-ronment:

- Residual Sugars (pentoses)
- Alcohol
- Vitamin *Thiamin* => low free SO$_2$
- Amino acids (including proline)
- Oxygen (air)

- Warm temperature (>50F)
- High pH => low molecular SO$_2$
- Low alcohol
Brettanomyces yeast + Grape/Oak components

Causes:

Prevention/Removal:

- Proper free SO₂ based on wine pH
- Sanitation, monitoring of 4-Ethylphenol
- Barrel maintenance
- Sterile filtration
- Reverse Osmosis?
Brettanomyces
Wet Dog Odor
Brettanomyces

Volatile Phenols

GRAPE Phenolic Acids

- 4-Ethylphenol
- 4-Ethylguaiacol
- 4-Vinylphenol
- 4-Vinylguaiacol
- 2-Phenylethanol
- Vanillin
- Tyrosol
- Ethylcinnamate
- Benzaldehyde

GRAPE Vinylphenols

Brett decarboxylase

GRAPE Glycosides

Brett reductase

H⁺

ΔT
Brettanomyces
Barrel maintenance
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Buttery

Chemistry

- Diacetyl

Sensory

- Buttery, nutty, movie popcorn
- Desirable in certain wine styles
- Funk threshold: 5 mg/L
Buttery Diacetyl

Causes:
- Malolactic bacteria (mainly)

Prevention/Removal:
- Suppress malolactic fermentation with SO$_2$
- Use different malolactic strain
- Wait after ML has “finished” before SO$_2$
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Geranium

Chemistry:

- 2-Ethoxy-hexa-3,5-diene

Sensory:

- Geranium leaves
- Threshold: 100 ng/L
Sorbic Acid

- Yeast growth inhibitor: 200 mg/L
- Legal limit: 300 mg/L
- Sensory threshold: 135 mg/L
- Some yeasts are resistant
- NO effect against bacteria
- Added as potassium salt (sorbate) (=> watch cold stability)
Geranium

**Cause**
- Sorbic acid + Malolactic bacteria

**Prevention**
- Avoid sorbate as preservative
- Use sorbate only with proper SO₂
- Add no earlier than day before bottling
- Always bubble test/sterile filter
- NO removal option from wine
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Lady Bug
Multicolored Asian Lady Beetle

‘Ladybug taint’
a new wine off-flavour

G. J. Pickering¹,², J.Y. Lin ², G. Soleas ⁵, A. Reynolds ¹²,³, R. Riesen ⁴, I. Brindle ³

¹ Cool Climate Oenology and Viticulture institute, ² Department of Biological Sciences, ³ Department of Chemistry, Brock University,
⁴ Lake Erie Ecosystem Research Center, Youngstown State University, Ohio, USA, ⁵ Quality Control Division, Liquor Control Board of Ontario, Ontario

How to distinguish MALB (*Harmonia axyridis*)
(Photos courtesy of Ker and Brewster, 2003)
Lady Bug

Chemistry:

- (Isopropyl)-Methoxypyrrazine

Sensory:

- Asparagus, bell pepper, earthy, herbaceous, peanut
- Threshold: 10-15 ng/L
Lady Bug
*Methoxypyrazine*

**Cause:**
- MALB haemolymph

**Prevention/Removal:**
- Remove beetles before crushing, pressing, fermenting
- **NO** removal option from wine
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Cork Taint

Chemistry:

- 2,4,6-

Sensory:

- Musty, moldy, earthy
- Threshold: < 5 ng/L
Cork Taint
TCA
Cork Taint

TCA

Chlorination  Methylation

Lignin  Phenol  Chlorophenol  Chloroanisole

Methylation  Chlorination

Lignin  Phenol  Anisole  Chloroanisole

Methylation

Penta/Tetra-Chlorophenol  Chloroanisole
Keep out!

Winery
Barrel room
Warehouse
Tasting room
Restrooms
Everywhere else

TCA
Reverse Osmosis

Potential Removal

- Alcohol
- Volatile Acidity (+ Ion Exchange)
- Brett (4-Ethylphenol/guaiacol) ?
- Oxidation (Aldehydes) ?
- Reduction (Sulfides) ?
Reverse Osmosis

No absolute cut-off!

Pore Size (nm) Distribution

Pore Size (nm)

smallest

largest
Reverse Osmosis

Aroma Removal

Molecular Weights:

- Ethyldecadienoate 196
- Oak Lactone 156
- Vanillin 152
- 4-Ethylphenol 122
- 2-Phenylethanol 122
- Methoxypyrazine 110
- Ethylacetate 88
- Diacetyl 86
- Molecular SO₂ 64
- Acetic acid 60
- Ethanol 46
- CO₂ 44
- Water 18
Indiana Horticultural Congress & Trade Show
Indianapolis, January 23 - 25, 2006

Tomorrow:
Winery Safety: A Crush Course

Dr. Christian E. BUTZKE
Associate Professor of Enology
Department of Food Science

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The Purdue Wine Grape Team is a partnership between the Indiana Wine Grape Council and Purdue University to serve the state’s winegrowers and help grape, the Indiana wine grape industry, enter world class competitiveness. The 5-member task force is available at any time to trouble shoot emerging issues in your vineyard and winery.

**SERVICES**

**WINE MAKING**
- Winery Establishment and Design
- Fermentation Techniques and Issues
- Off Odor and Haze Rectification
- Delivering Decisions/dumping preparation
- Winery Sanitation
- Equipment/Supplies Purchase Advice

**WINE GROWING**
- Vineyard Establishment and Design
- Vineyard Management
- Pest Identification
- Pest Management
- New Varietal Evaluation
- Equipment/Supplies Purchase Advice

**WINE QUALITY**
- Winery Quality Control
- Winery Staff Training
- Indy International Wine Competition
- Wine Education and Appreciation
- Wine Microbiology
- Product Development

**WINE ANALYSIS**
- Wine Aroma Evaluation
- Free and Total SO₂
- pH and Preferable Acidity
- Volatile Acidity
- Alcohol
- Lab Proficiency Testing Coordination

**WINE MARKETING**
- Media Contacts
- Event Coordination
- Testing Room Setup
- Direct Sales Advice
- Shipping Compliance
- Publication Development

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**Purdue Wine Grape Task Force**