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Upcoming ACS Webinars®

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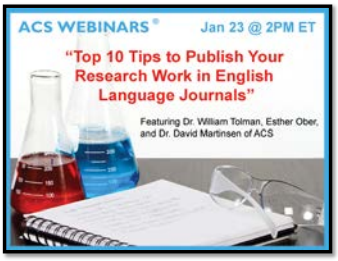
Thursday, January 16, 2014

"The Chemistry and Anatomy of the Hangover"

Dr. Alyson Mitchell,
Department of Viticulture and Enology at UC, Davis

Bill Courtney, Chemist/Chef/Owner of Cheese-ology Macaroni & Cheese



Thursday, January 23, 2014

"Top 10 Tips to Publish Your Research Work in English Language Journals"

Dr. William Tolman,
Editor-in-Chief, ACS Inorganic Chemistry Journal, ACS

Esther Ober, ACS Journals Editing Manager, ACS

Dr. David Martinsen, Publications Division, ACS

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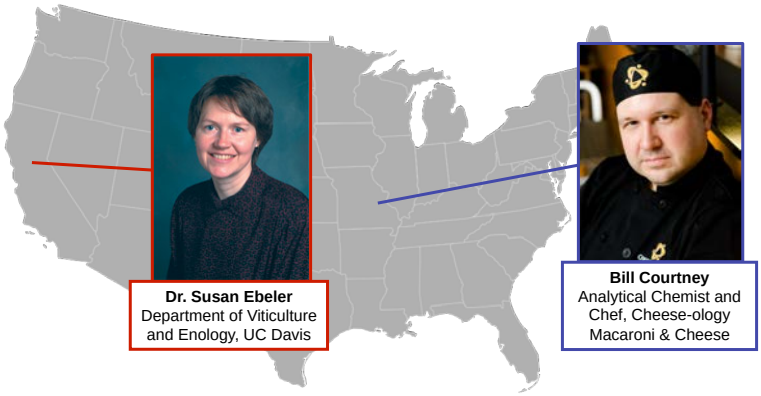
Wine Science: Designing Great Wines



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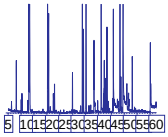
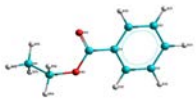
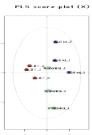
Wine Science: Designing Great Wines

Susan E. Ebeler
Department of Viticulture and Enology
University of California, Davis, CA

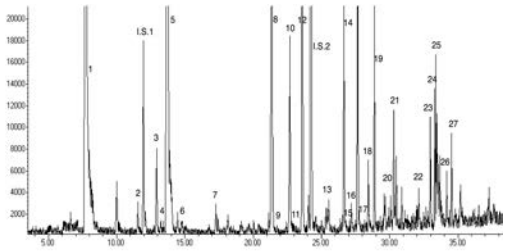






Wine Chemistry and Flavor is Complex

- **Hundreds of compounds in wine – impact taste, aroma, mouthfeel, color**
- **Volatiles contribute to wine aroma—measure by gas chromatography**



Volatiles in Cabernet Sauvignon grapes

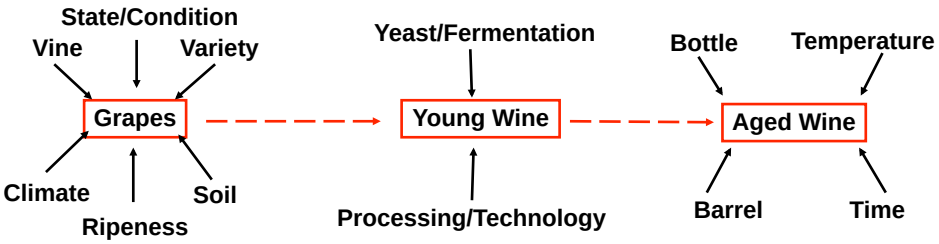
Canuti et al., J. Chrom. A, 2009, 1216: 3012-3022

Wine Chemistry and Flavor is Complex

- Hundreds of compounds in wine – impact taste, aroma, mouthfeel, color
- Volatiles contribute to wine aroma
- **Multiple compounds interacting together influence wine aroma and flavor**
- **Information processed in brain (context, memory, etc. influence perception)**

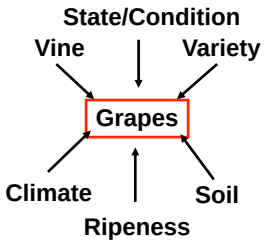
Wine Chemistry and Flavor

- **Designing Great Wines: What impacts wine flavor?**



Adapted from Schreier, CRC Crit Rev Food Sci Nutr, 12(1): 59-111 (1979)

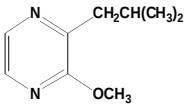
Wine Chemistry and Flavor



Adapted from Schreier, CRC Crit Rev Food Sci Nutr, 12(1): 59-111 (1979)

Grape Genetics

- Variety
- Aroma compounds produced in berry, not translocated from vine (e.g., methoxypyrazines, terpenes)



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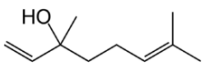
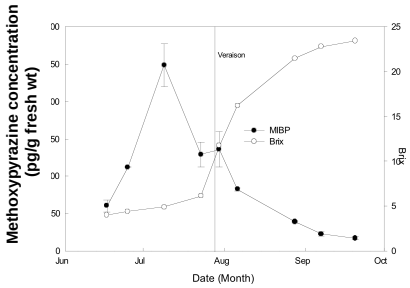
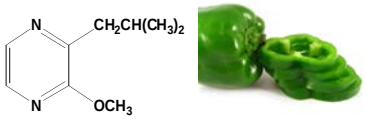


www.totnescancerhealthcentre.com/?p=494

Koch et al., 2010, Phytochemistry, 71: 2190-2198
Gholami et al. 1995, Austr. J. Grape Wine Res. 1: 19-24

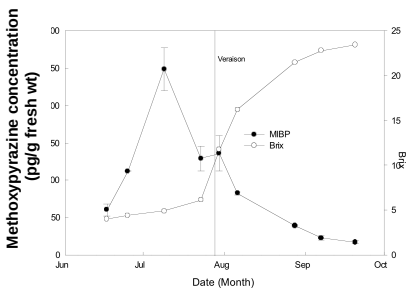
Grape Maturity

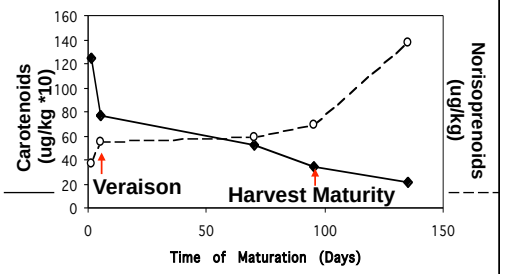


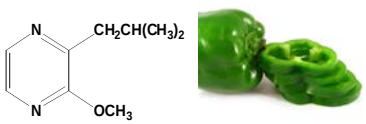


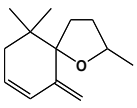
Koch et al., 2012, Physiologia Plantarum 145: 275-285
Razungles & Bayonove, J. Intern. Sci. Vigne et Vin, 1996

Grape Maturity









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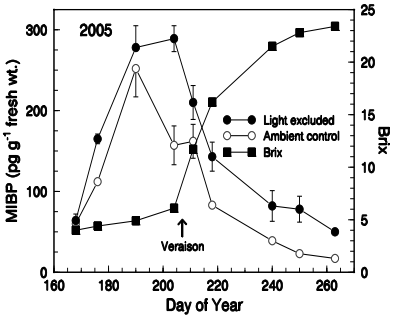
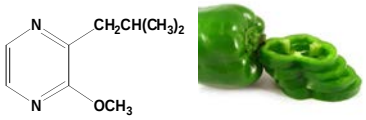
Koch et al., 2012, Physiologia Plantarum 145: 275-285
Razungles & Bayonove, J. Intern. Sci. Vigne et Vin, 1996

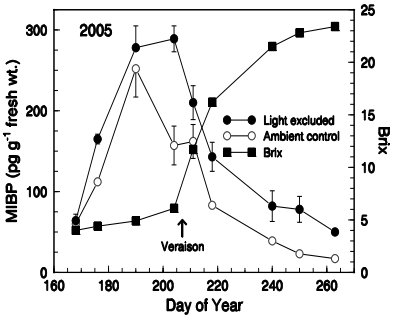
Light

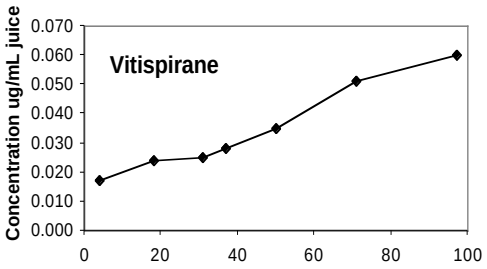


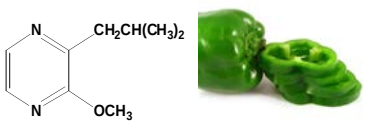


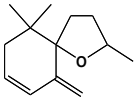
Koch et al., 2012, Physiologia Plantarum 145: 275-285
Stevens et al., 2008, ACS Symposium Series #988

Light









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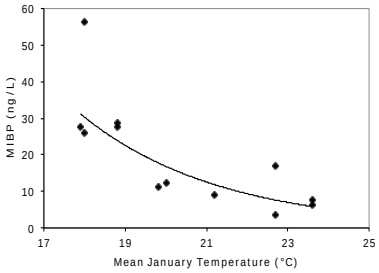
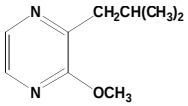
Koch et al., 2012, Physiologia Plantarum 145: 275-285
Stevens et al., 2008, ACS Symposium Series #988

Climate/Temperature

MIBP in Cabernet from Australia and New Zealand

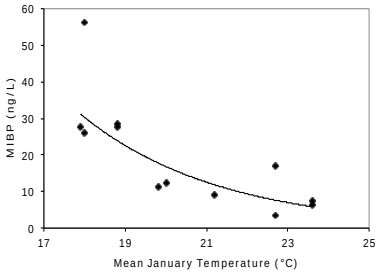


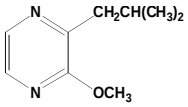


Allen et al., JAFC, 42: 1734-1738, 1994

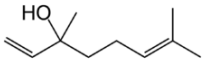
Climate/Temperature

MIBP in Cabernet from Australia and New Zealand





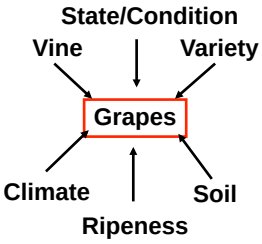
- **Terpenes**
  - **Opposite effects relative to pyrazines**
  - **↑ warm climate (South Africa)**
  - **↓ cool climate (New Zealand)**



Allen et al., JAFC, 42: 1734-1738, 1994

Marais et al. S. Afr. J. Enol. Vitic 13:71-77, 1992

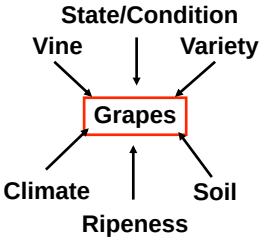
Viticulture Effects on Chemistry and Flavor



- **Other…**
  - Vintage
  - Water stress/Irrigation
  - Soil and nutrition
  - Canopy management
  - Pest and disease pressures
  - ~18% of genes influenced by environment (Dal Santo et al. 2013, Genome Biology, 14:R54)

Adapted from Schreier, CRC Crit Rev Food Sci Nutr, 12(1): 59-111 (1979)
Robinson et al., Am. J. Enol. Vitic. (available on-line Dec 2013)

Viticulture Effects on Chemistry and Flavor



Phenotype = genotype + environment + (interaction of genetics x environment)

Focus of much current research is to identify the genotype + environment interaction and understand how that affects phenotype.
We know very little about this…..

Adapted from Schreier, CRC Crit Rev Food Sci Nutr, 12(1): 59-111 (1979)

Audience Question

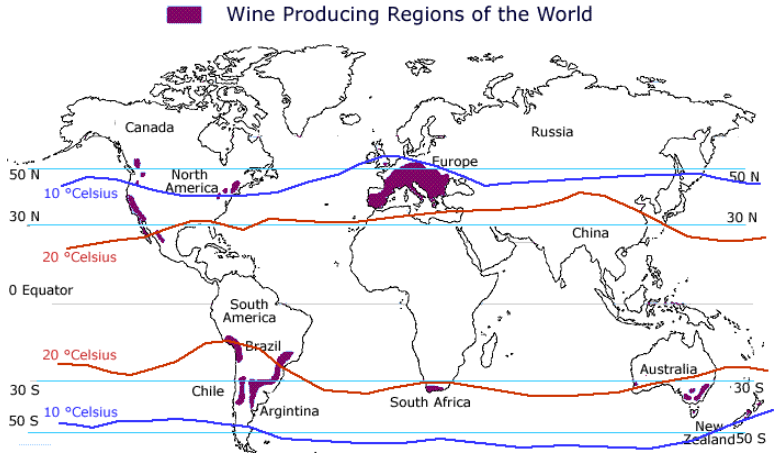
- **World-wide, where are most of the winegrapes grown?**

(A) **Equally all over the world**

(B) **Between 30°-50° latitude in north and south hemispheres**

(C) **In California**

(D) **In France**



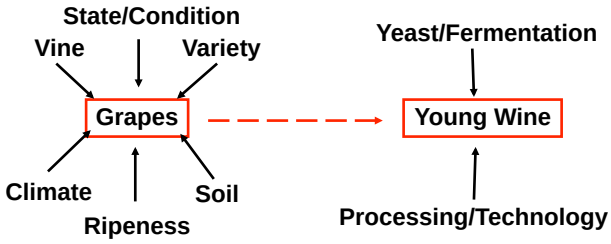
B. Between 30°-50° latitude in north and south hemispheres

(~10-20°C (50-68°F); sunlight/growing season; minimum temperature/winter kill effects; water availability/irrigation)

Implications for Global Climate Change?

www.thirtyfifty.co.uk

Wine Chemistry and Flavor



Adapted from Schreier, CRC Crit Rev Food Sci Nutr, 12(1): 59-111 (1979)

Changes in Flavor during Fermentation

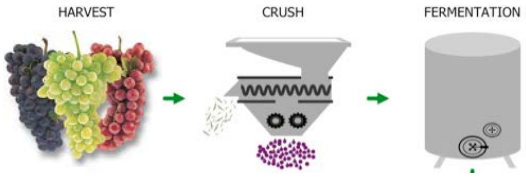
- Compounds extracted from grapes
- New compounds formed
- Chemical reactions/hydrolysis

Changes in Flavor during Fermentation

- **Compounds extracted from grapes**

e.g., methoxypyrazines, norisoprenoids, terpenes

influenced by temperature, skin contact, mixing, etc.



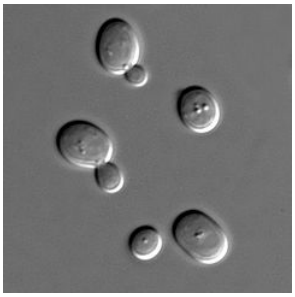
From H. Hopfer, 2013

Changes in Flavor during Fermentation

- **Compounds extracted from grapes**
- **New compounds formed**

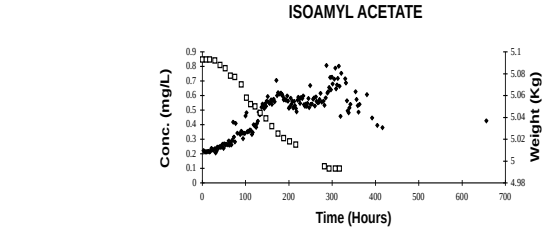
Yeast (*Saccharomyces cerevisiae*) metabolism

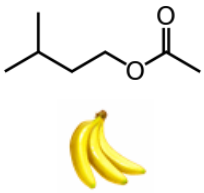
– **alcohols (ethanol), esters**

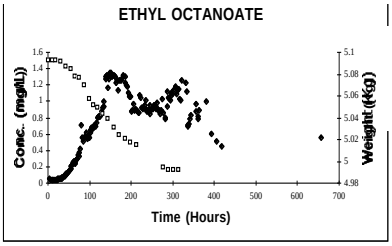


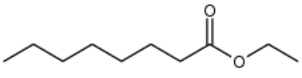
en.wikipedia.org/wiki/Saccharomyces_cerevisiae

Fermentation









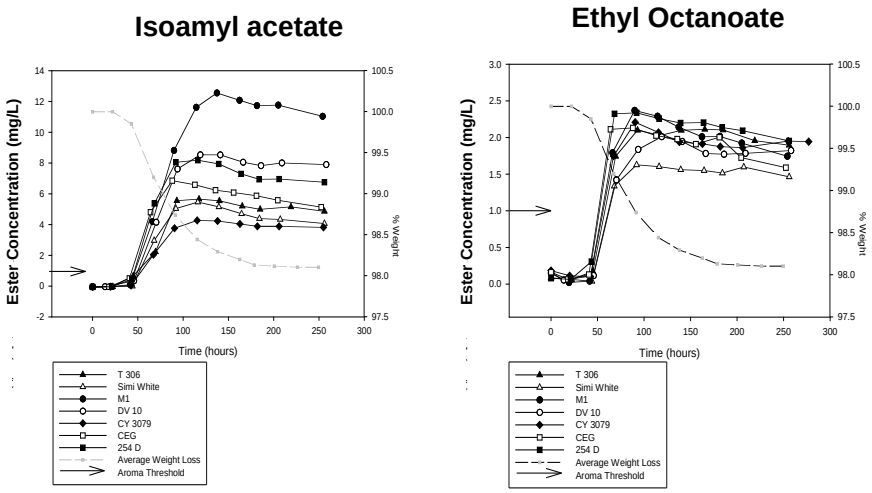
Vianna & Ebeler, 2001 J. Agric. Food Chem., 49(2): 589-595

Fermentation

Composition influenced by:

- **Yeast Strain**
- **Nutrition (Sugar, Nitrogen, Vitamins)**
- **Temperature**
- **Grape Variety?**

Yeast Strain



Miller et al., AJEV, 58(4): 470-483, 2007

Yeast Strain

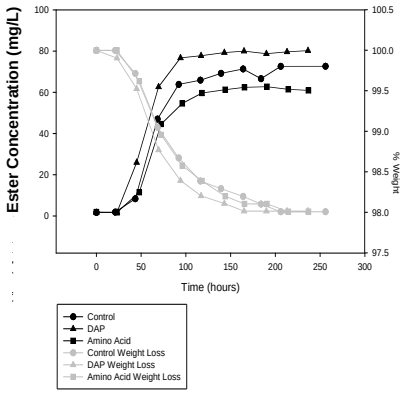
- **However, these chemical differences may not translate to sensory effects, particularly over storage time**

Kunkee and Vilas, 1994; Thorngate, 1999

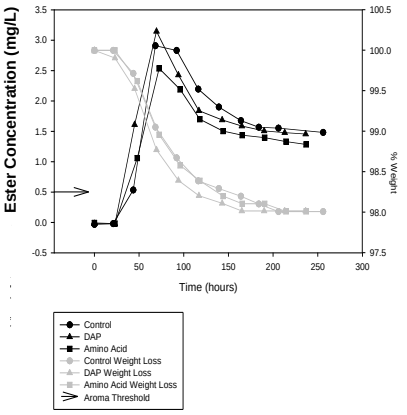
Nutrition

- **Nitrogen** Diammonium Phosphate (DAP) or Amino Acids (AA) added to ~500mg N/L; Strain 254D; Chardonnay N sufficent (~300mg N/L) must as control

Isoamyl acetate



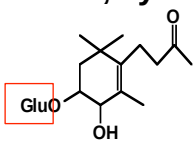
Ethyl Octanoate



Miller et al., AJEV, 58(4): 470-483, 2007

Changes in Flavor during Fermentation

- Compounds extracted from grapes
- New compounds formed
- **Chemical reactions/hydrolysis**
  - Many compounds exist in grapes as nonvolatile precursors (glycosides, cysteine/glutathione conjugates)



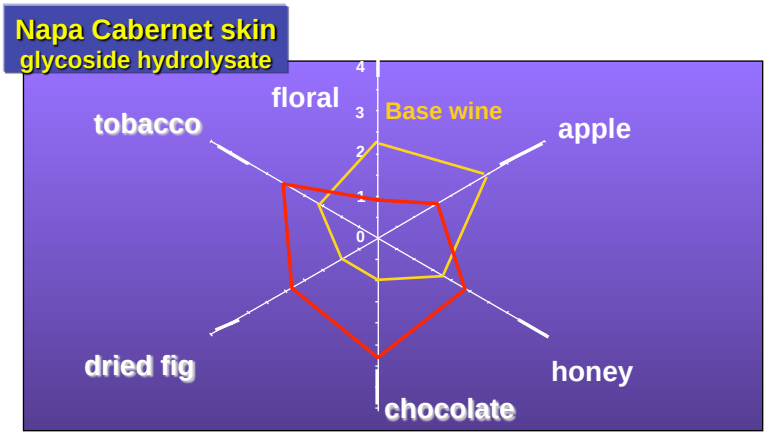
Proposed TDN Glycoside Precursor

Roscher & Winterhalter, J. Agric. Food Chem., 1993

Changes in Flavor during Fermentation

- **Enzyme/Acid hydrolysis**

  Releases 'free' aglycone during fermentation



Francis et al., ACS Symposium Series #714, 1999
(slide courtesy of Dr. Ann Noble)

Audience Question

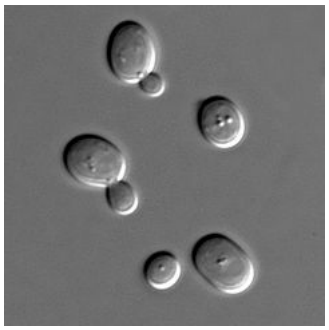
- **Which food fermentations do NOT involve *Saccharomyces cerevisiae*?**

(A) Beer

(B) Bread

(C) Sour Cream

(D) Olives



en.wikipedia.org/wiki/Saccharomyces_cerevisiae

Audience Question

- **Which food fermentation do NOT involve *Saccharomyces cerevisiae*?**

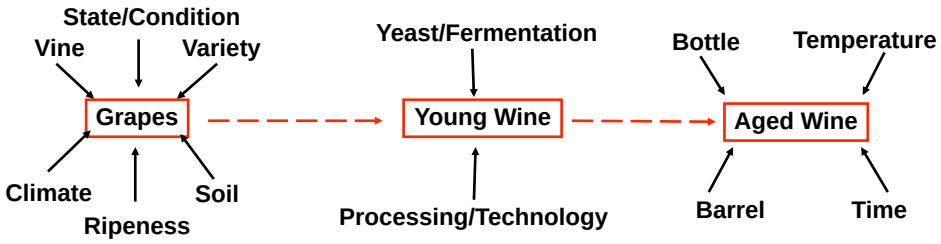
(A) **Beer**

(B) **Bread**

(C) **Sour Cream-malolactic fermentation/lactic acid bacteria**

(D) **Olives—typically a lactic acid fermentation, but also may include yeast (Hurtado et al. 2012, Food Microbiology, 31: 1-8)**

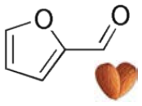
Wine Chemistry and Flavor

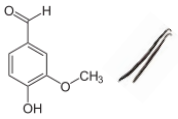


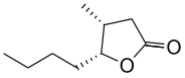
Adapted from Schreier, CRC Crit Rev Food Sci Nutr, 12(1): 59-111 (1979)

Oak Flavor

- **Volatiles (influence aroma)**
  - **Carbohydrate derived: Furfural, 5-methyl furfural**
  - **Lignin derived: Guaiacol, 4-methyl guiacol, 4-ethyl guaicol, 4-vinyl phenol, 4-ethyl phenol, eugenol, isoeugenol, vanillin, syringol**
  - **Lipid derived: *cis*-β-methyl-γ-octalactone, trans β-methyl-γ-octalactone (oak lactones)**



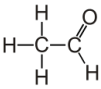




See also
http://acswebinars.org/barrels-of-chemistry

Aging Reactions

- **Oxidation**
  - **e.g., ethanol oxidized to acetaldehyde, acetic acid**
- **Hydrolysis and rearrangements**
  - **e.g., glycoside hydrolysis, terpene rearrangement**
- **Off-flavors**
  - **e.g., cork taint (haloanisoles), geosmin, 1-octen-3-one, acetic acid/ethyl acetate (uncontrolled oxidation)**



1,1,6-trimethyl-1,2-dihydronaphthalen (TDN)



Aging Reactions

- Dependent on
  - Temperature
  - Time
  - Closure type
  - Storage/Packaging container

Justgrapesandfood.wordpress.com

See also http://acswebinars.org/ebeler

news.ucdavis.edu

Hopfer et al., 2012, J. Agric. Food Chem. 60: 10743-10754
Hopfer et al., 2013, J. Agric. Food Chem. 61: 3320-3334
Robinson et al., 2010, Am J. Enol. Vitic. 61: 337-347

Linking Composition to Sensory Properties

Flavor perception

- Multiple sensory inputs
  taste, aroma, color, mouthfeel, etc
- Receptors activated
- Brain processes information

.

See also http://acswebinars.org/ebeler and http://acswebinars.org/noble-grapes

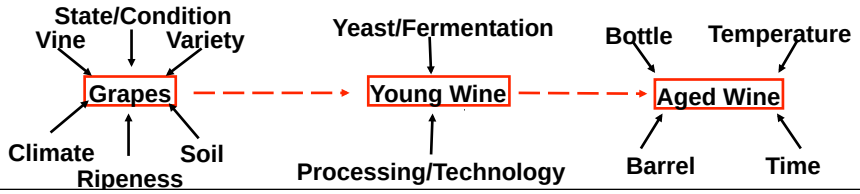
Linking Composition to Sensory Properties

- Flavor perception is integrative
- Perceptual interactions—additive, masking/suppression, enhancing effects—Difficult to predict
- Physical/chemical interactions with matrix influence volatility and release
- Perception is influenced by context, training/experience, genetics, etc.

See also http://acswebinars.org/ebeler and http://acswebinars.org/noble-grapes

Summary: Designing Great Wines

- Wine chemistry and flavor is complex
- Great wine begins in the vineyard—but effects of vineyard practices depend on compounds and variables studied
- During fermentation, flavors are extracted from grape and new flavors are formed (by yeast and via chemical reactions)
- Aging reactions further alter composition
- Flavor = interaction between consumer and product



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- **M.S. in Viticulture and Enology**
- **PhD in Various Disciplines (Agricultural Chemistry, Food Science, Microbiology, Plant Biology, Horticulture, Genetics, Engineering, etc…..)**
- **Certificate in Winemaking for Distance Learners**
  http://extension.ucdavis.edu/unit/winemaking/certificate/winemaking/
- **University Extension 1- and 2-Day Shortcourses**
  http://extension.ucdavis.edu/index.asp

References/Information Sources

- **Principles and Practices of Winemaking, Boulton et al., Chapman & Hall, 1996 (ISBN 0-412-06411-1)**
- **Chemistry of Wine Flavor, Waterhouse & Ebeler, American Chemical Society, 1998 (ISBN 0-8412-3592-9)**
- **Polaskova et al., *Chemical Society Reviews*, 2008, 37: 2478-2489, DOI: 10.1039/b714455p**
- **Ebeler and Thorngate, *J. Agric. Food Chem*., 2009, 57: 8090-8108, DOI: 10.1021/jf9000555**
- **Robinson et al., *Am. J. Enol. Vitic*., 2013, Available on-line, DOI: 10.1016/j.foodchem.2013.11.052**
- ***Journal of Agricultural and Food Chemistry***
- ***American Journal of Enology and Viticulture***

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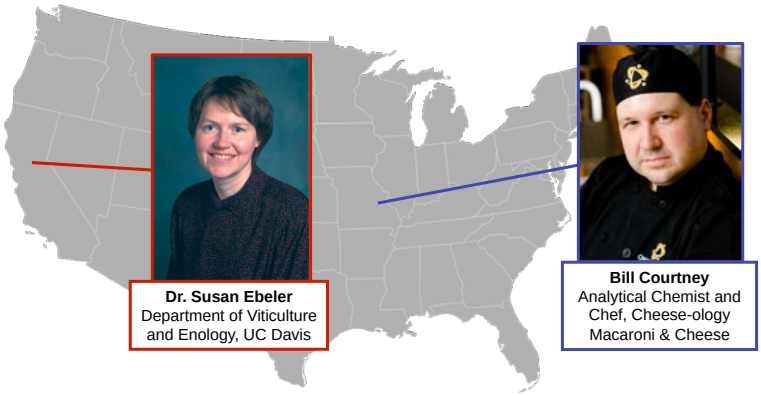

Dr. Susan Ebeler
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Bill Courtney
Analytical Chemist and Chef, Cheese-ology Macaroni & Cheese

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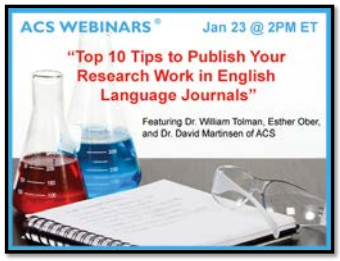

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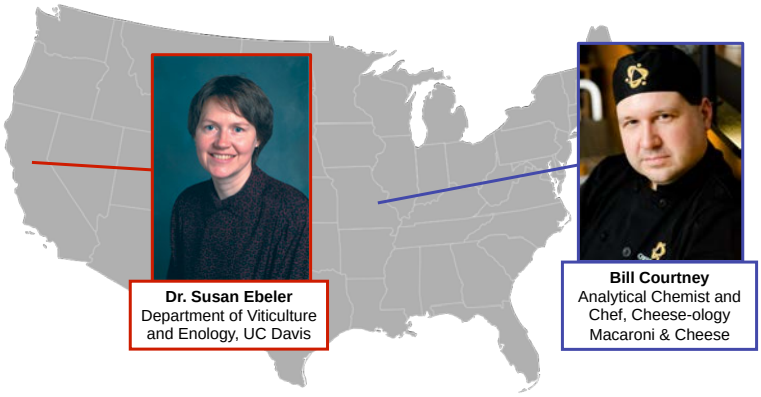

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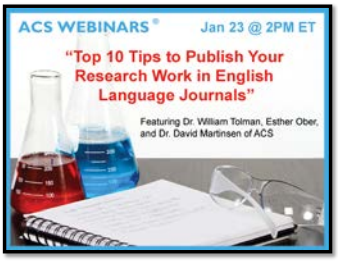

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