





Behind the Scenes of
"The Bitter, Twisted, Truth of
the Hop"



1. World Brewing Congress

Honolulu, Hawaii

August 2-6, 2008

2. American Chemical Society, Milwaukee Chapter

Milwaukee, WI

December 4, 2009

3. American Chemical Society National Meeting

Boston, Massachusetts

August 22-26, 2010

**The Bitter, Twisted Truth of
the Hop**

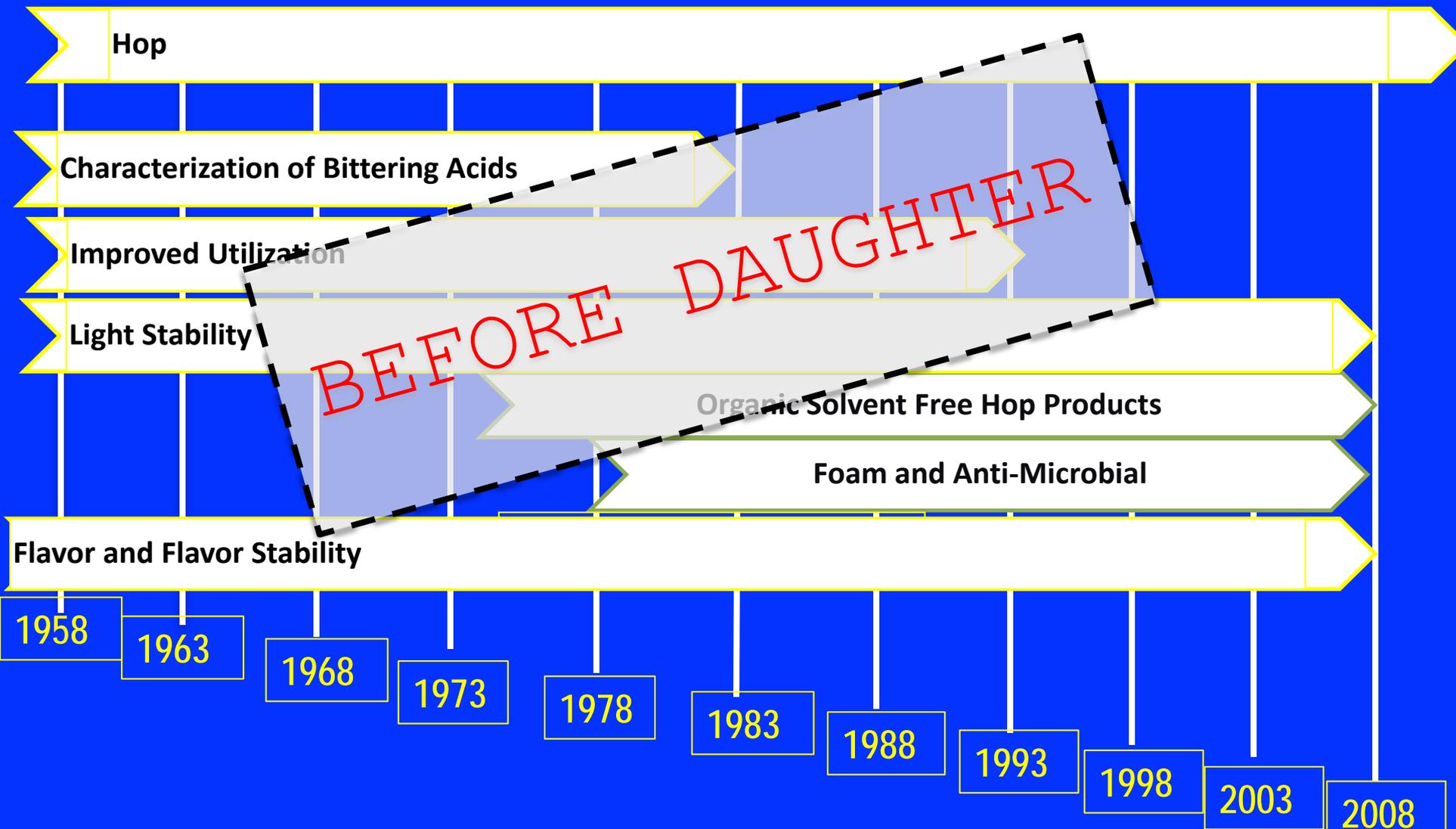
50 Years of Hop Chemistry

Patrick Ting, David Ryder

Miller Coors

Milwaukee, USA

Unfolding Hop Chemistry



Unfolding HOP Chemistry

(1958-2008)



Hops

Characterization of Bittering Acids

Improved Utilization

Light Stability

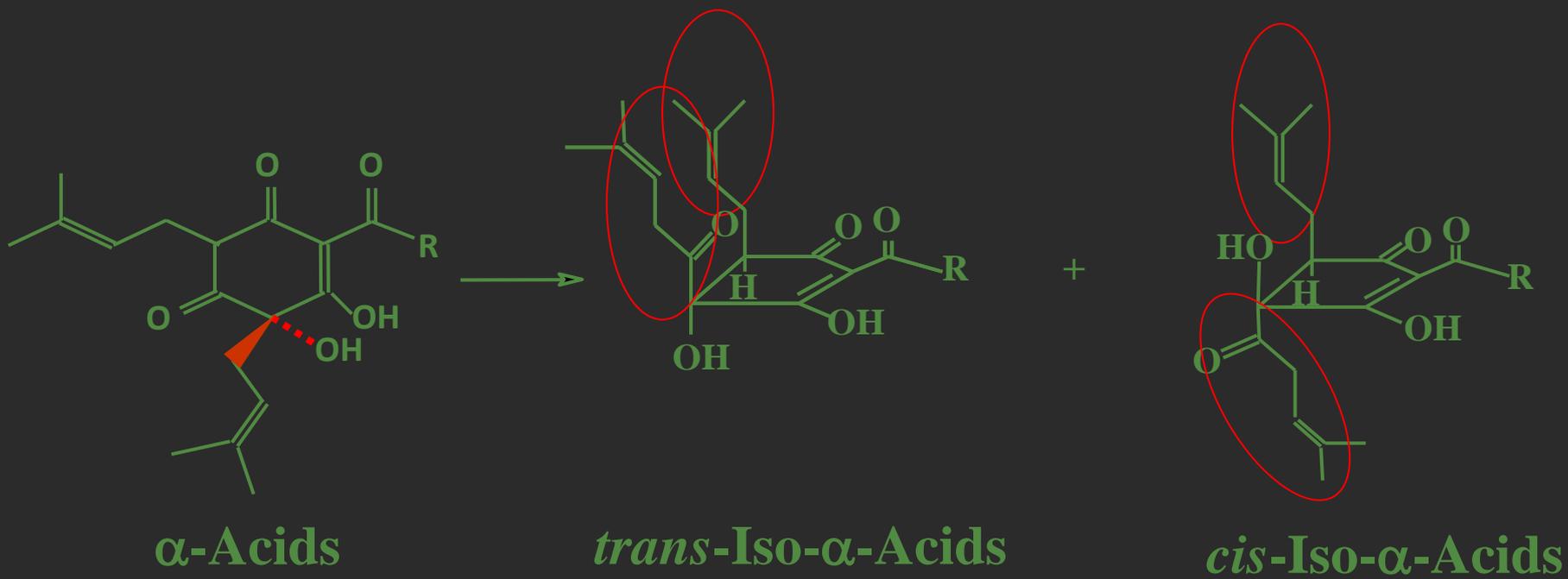
Organic Solvent Free Hop Products

Foam and Anti-Microbial

Flavor and Flavor Stability

1958 1963 1968 1973 1978 1983 1988 1993 1998 2003 2008

Established **D-configuration** of α -acids and **stereoisomers** of iso- α -acids. (Verzele, De Keukeleire)



Bitterness Intensity

Differences Between High and Low Isocohumulone
(Shellhammer et al. 2004)

Tetrahydro
iso

Hexahydroi
so

Iso

r-Iso



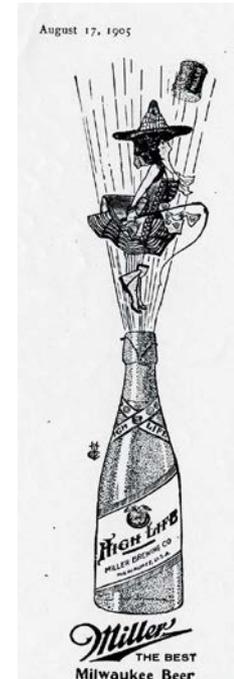
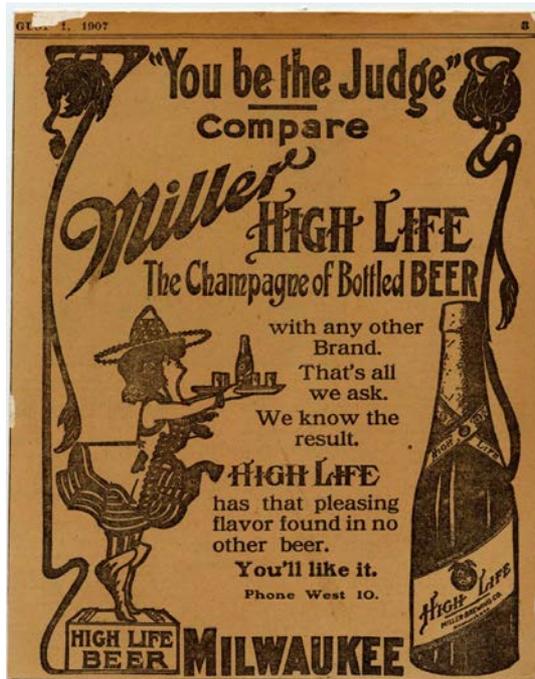
Advantages of Tetrahydroiso- α -acids



- Tetrahydroiso- α -acids and Hexahydro- β -acids are the most antimicrobial of hops acids, but at **two different pH values**. (Miller Brewing 1987 and 1995)
- Tetrahydroiso- α -acids show more effective antimicrobial action than iso- α -acids during the acid washing of yeast. (Miller Brewing 2001)

Unique Beer, Unique Need and Unique Opportunity

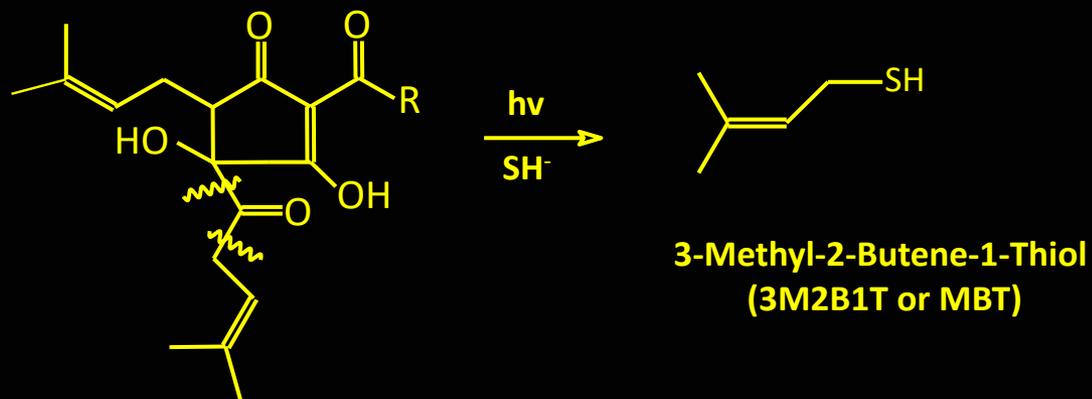
- Established in 1855
- 1903 Miller High Life
- "The Champagne of Bottle Beer"





The sun-struck or "skunky flavor"

(3M2B1T)



Old Instrumentation



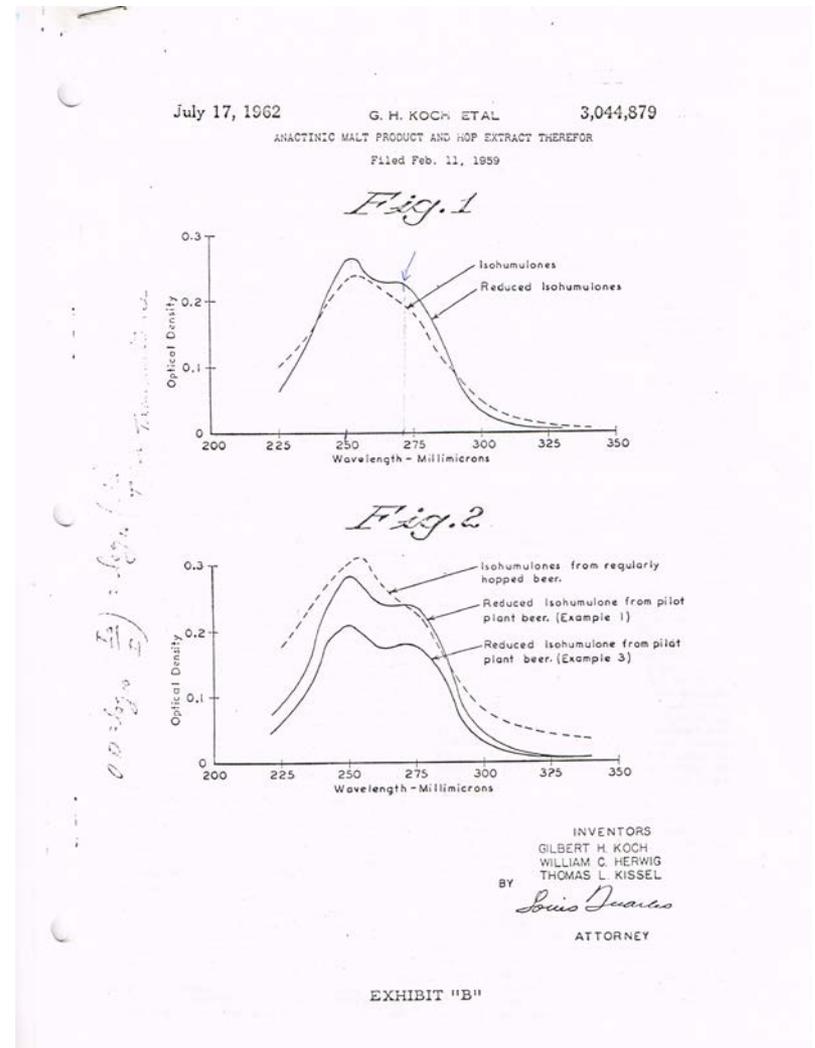
Countercurrent Distribution

Quantitation of rho-Iso- α -acids by IIV

$$\text{Rho-iso} = a_1 X_{254} + b_1 Y_{270} + c_1 Z_{350}$$

$$\beta\text{-Acids} = a_2 X_{254} + b_2 Y_{270} + c_2 Z_{350}$$

$$\text{Background} = a_3 X_{254} + b_3 Y_{270} + c_3 Z_{350}$$



Before Hop Ting...

- **1970** Miller Brewing Company rank #7 place - Acquired by Philip Morris
- **1975** rank #4 place - Miller Time - A Reward for Hard Work
- **1977** created a light beer category - Miller Lite



“You can’t connect the dots looking forward. You can only connect them **looking backward**. So you have to trust that the dots will somehow connect in your future.” – **Steve Jobs**



- **B.S.** in Chemistry
- **M.S.** in GC pack column and self-coated stainless steel capillary column
- **Ph. D.** in Ketene Chemistry - organic synthesis
- **Post-doctoral research** in “Biological Oxidation Reactions using HPLC and EPR

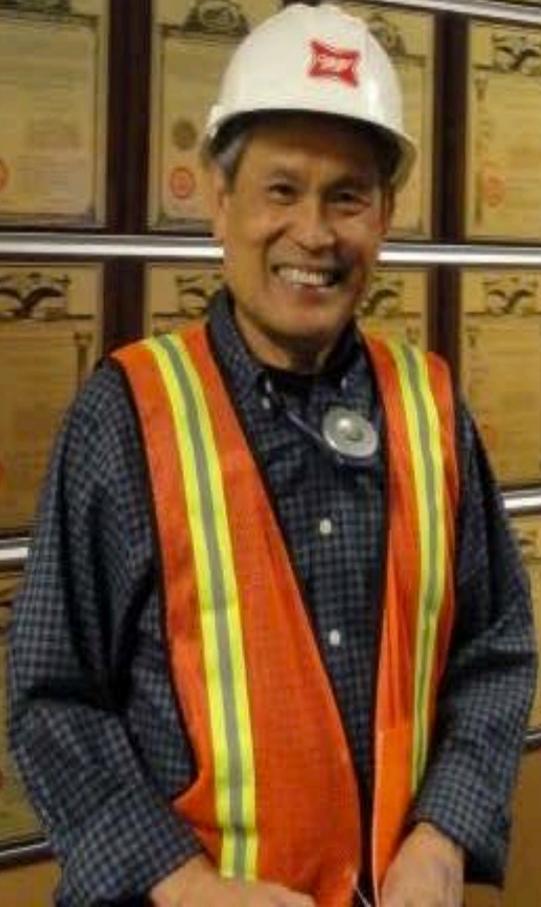


Quality Miller time

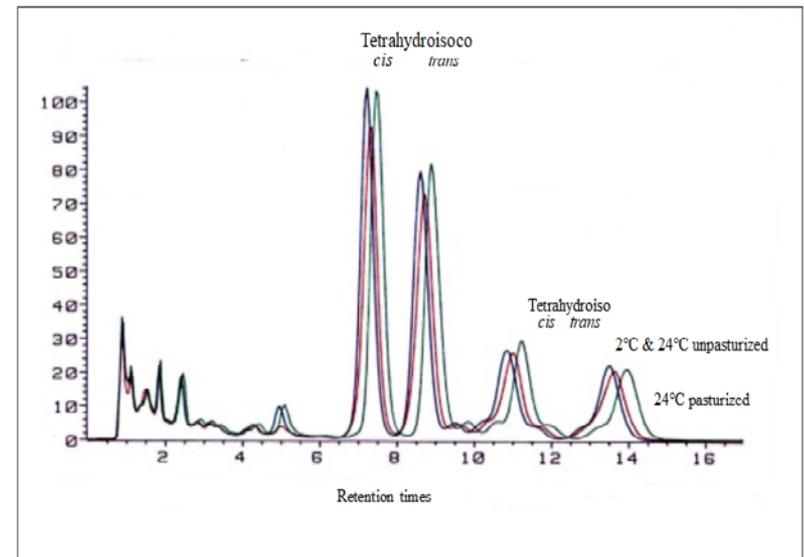
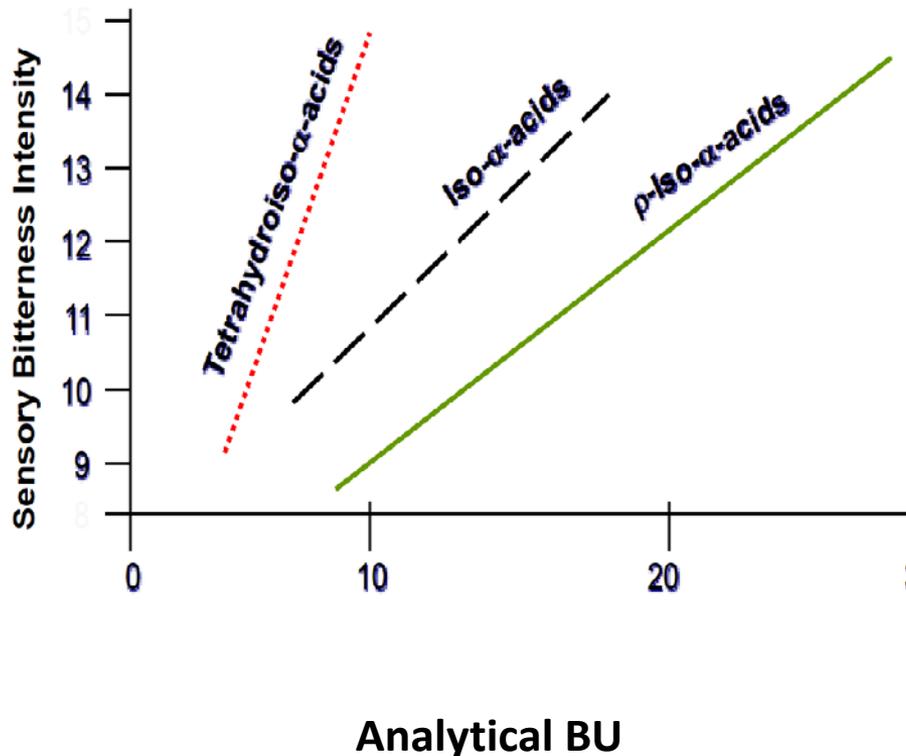
Brookfield resident Patrick Ting shows his daughter Linda, 13, what he does at work each day as a principal research chemist for Miller Brewing Company. The Tings were participating in Take Our Daughters to Work Day.'



Achievements In Excellence



1986 - MGD (Miller Genuine Draft) a brewing breakthrough of cold-filtered non-pasteurized packaging beer - new category

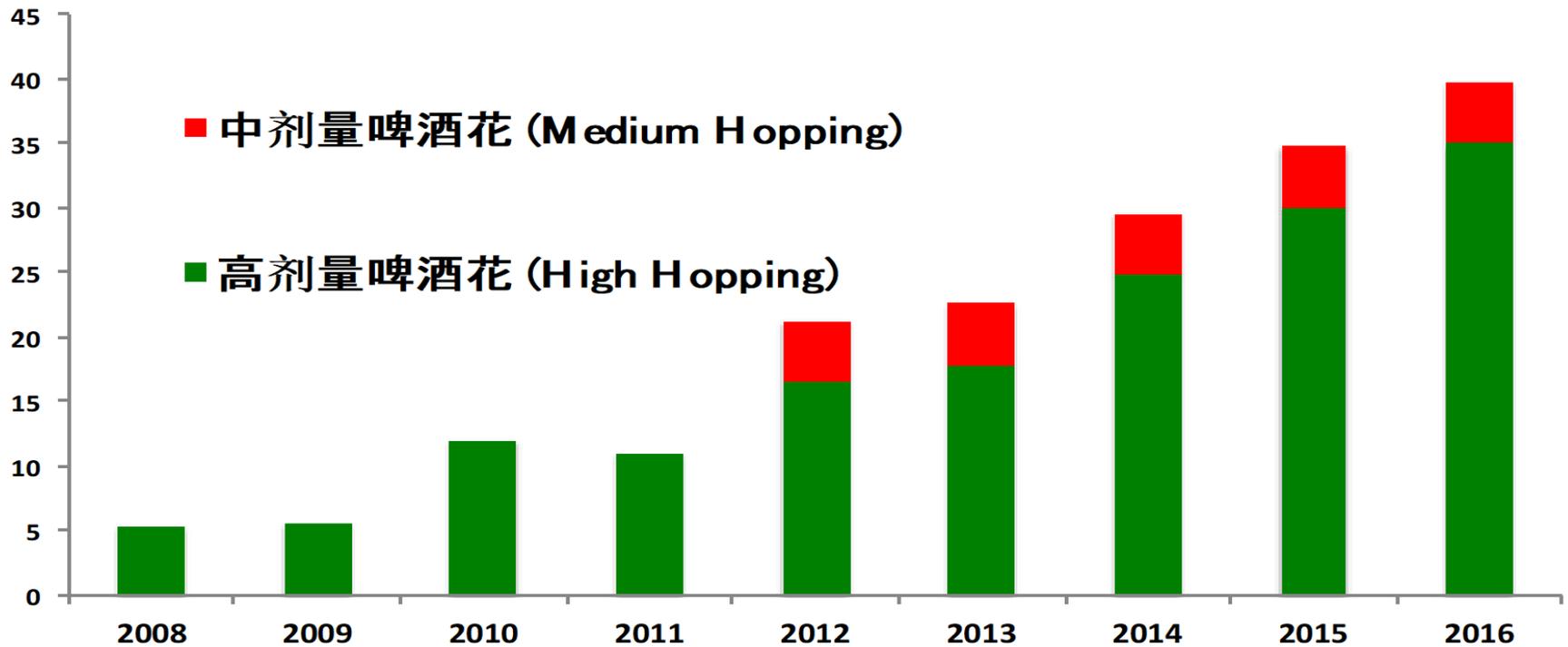


Annual Miller Hop Tours



HOP OF THE MONTH
CITRA

Trend of Hoppy Beer Consumption



Copy from 60th Annual America Hop Convention 2016, CA

2012 retired from MillerCoors



Barley Wine

高大师精酿 出品

Mad Ting is named after the world famous hop chemist Dr. Luping Ting, the founder of Citra hops.

猛丁 MadTing



Hoppy Family Time



In conclusion, my son told me:
*"Hop scientists never retire, they
turn bitter."*

