Master Brewers Association of the Americas

Dedicated to the technology of brewing.

MBAA Brewing Fundamentals Track
2014 Brewing Summit
Hop Quality

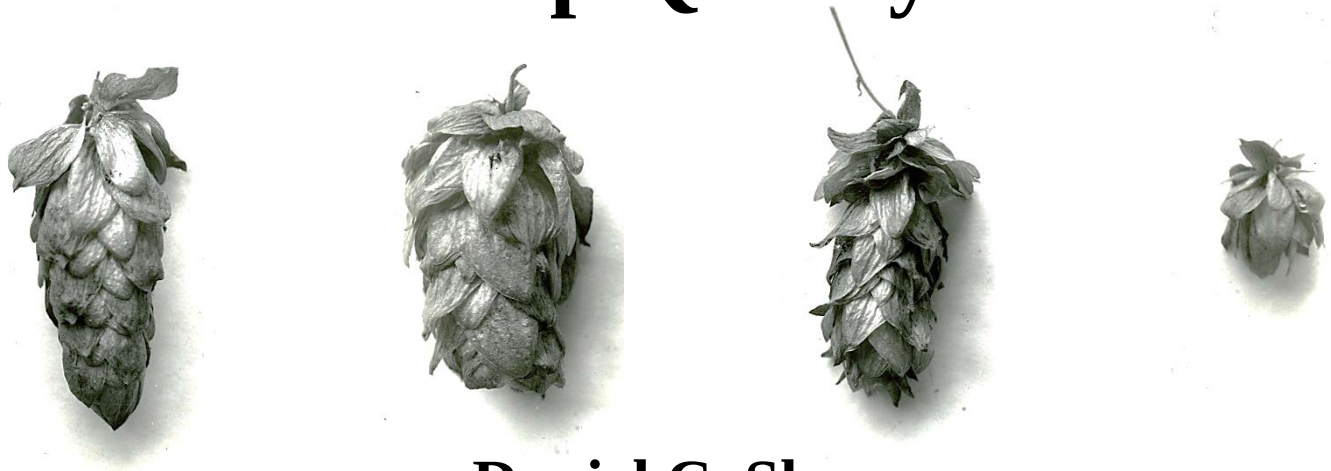

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Photo: Oregon Hops and Beer Archives

The Challenge of Hops

- Subjective definitions of “quality”
- Wide range of phenotypes.
- Susceptible to storage effects.
- **Agricultural product with inherent variation.**

Table 6: Deviations of α-acids in case of sampling every bale

Variety	Number of bales	Conductometric value EBC 7.5 (% w/w) min.	max.	∅	difference	Homogeneity
Hallertau Perle	48	7.5	8.2	7.91	0.7	good
Hallertau Perle	43	5.9	7.4	6.76	1.5	medium
Hallertau North. Brewer	17	6.8	9.8	8.44	3.0	bad

Forster, A. 2001.

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Forster, A. 2001.

What is hop quality?

Quality: *The standard as measured against other things of a similar kind; the degree of excellence of something.*

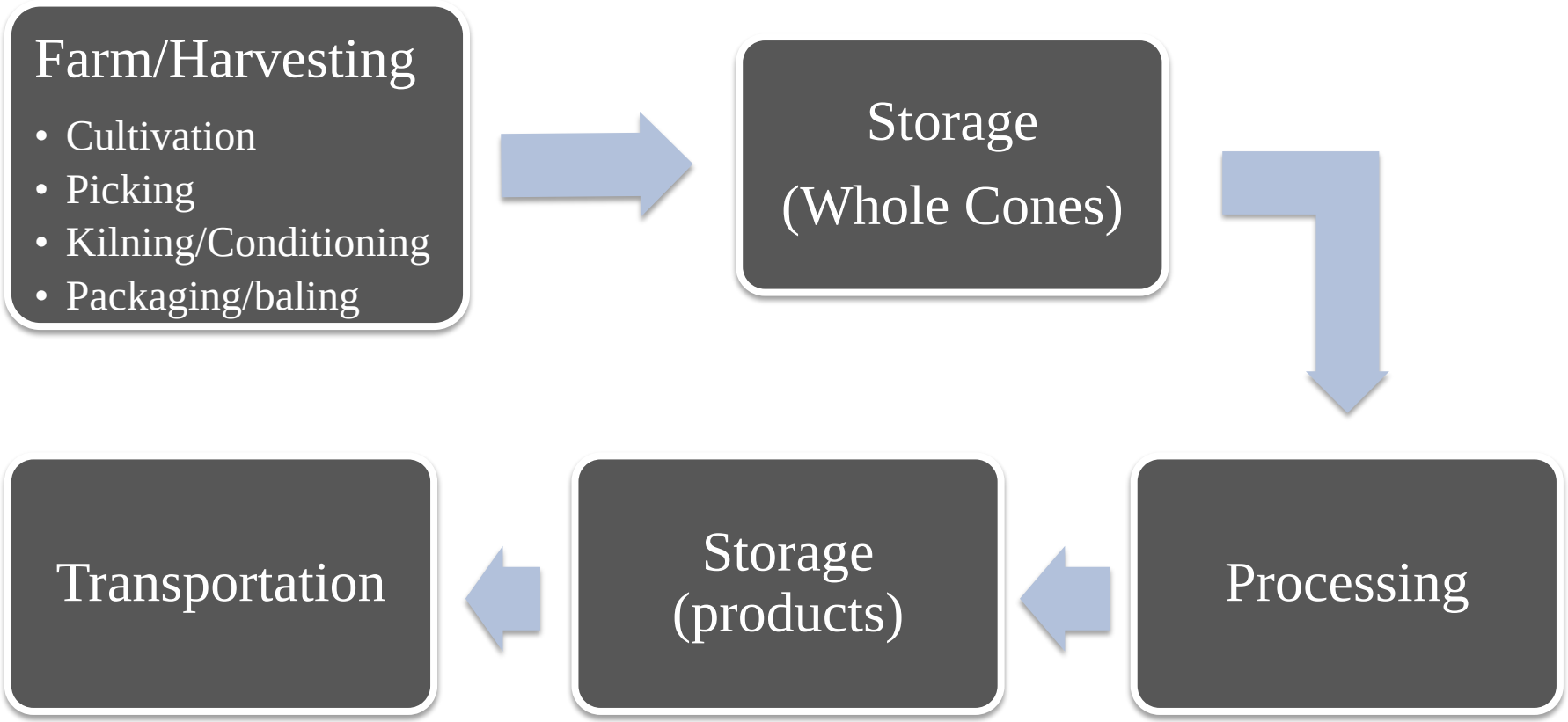
-Oxford English Dictionary

[Hop] Quality *is the indicator for the condition in which hop constituents are when being added to the beer/wort. i.e. the definition of quality indicates whether degradation took place from picking to dosage.* ***Quality*** *is the same as "degree of freshness."* ***Ageing components or indicators describe the reduction in quality.***

-Adrian Forster

Forster, A. 2001.

Supply Chain Determines Hop Quality



Adapted from: Forster, A. 2001.

Indicators & measurements of quality
Overview

- **Physical Indicators**
  - Visual
  - Texture
  - Aroma
- **Measurements**
  - Hop Storage Index (HSI)
  - Hop Acids
  - Aroma/Essential Oil
  - Moisture

Photo: Oregon Hops and Beer Archives

Physical Indicators of Quality: Visual

- **Color/brightness**
  - burning, browning, over drying
- **Seeds and stems**
- **Size**
  - Intact
- **Diseases/pest**
  - Mites, aphids, mildews

Photos: American Plant Pathologists Society

Physical Indicators of Quality: Texture

- **Moisture**
  - Over drying
- **Resinous/Sticky**
  - Compressibility of cones
- **Integrity**

Physical Indicators of Quality: Aroma

Attributes

- Consistency
- True-to-type
- Off-aromas
- Intensity

- **Examples**
  - Citrus
  - Piney
  - Cheesy
  - Sweaty
  - Skunky

Methods

- **Hand rub –** Limitations
- **Haas Method**
  - Blind code
  - Standardized Hop Grinding (e.g. 20g/10 s)
  - Warm in Jars (~120F)
  - Time sensitive (~2 hours)

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Measurements-Routine

- **Hop Acids**
  - **Concentration**
  - **Reduction**
  - HSI

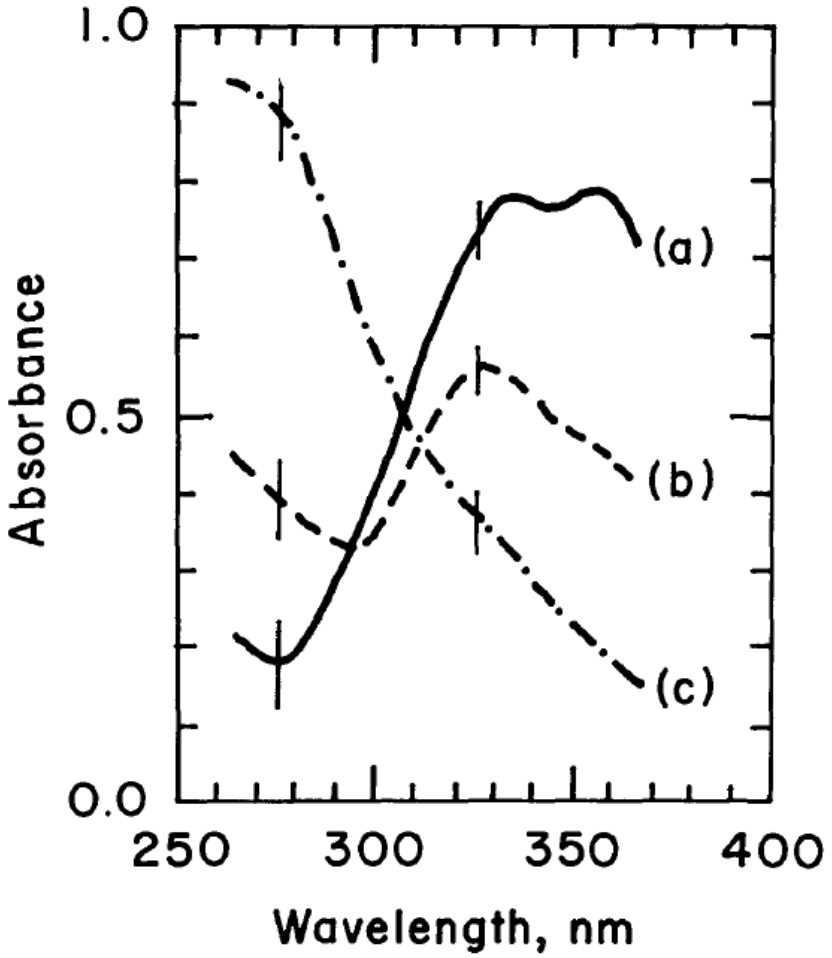
TABLE 1
Brews made with an identical amount of cone hops stored 18 months at different temperatures

STORAGE TEMPERATURE	ALPHA ACIDS IN HOPS	ISO-ALPHA ACIDS IN BEER	BEER IBUs
-20F	3.22%	19.8 ppm	13.5
25°F	2.91%	18.1 ppm	12.0
45°F	1.71%	14.4 ppm	13.5
70°F	0.41%	2.9 ppm	11.0

Peacock, 1998

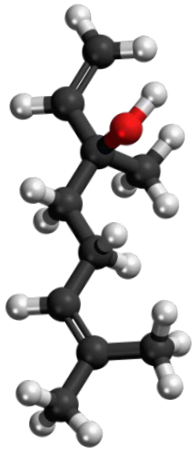
Measurements-Routine

- **Hop Acids**
  - Concentration
  - Reduction
  - **HSI**

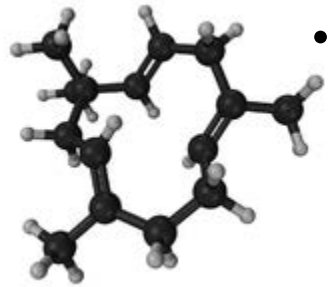


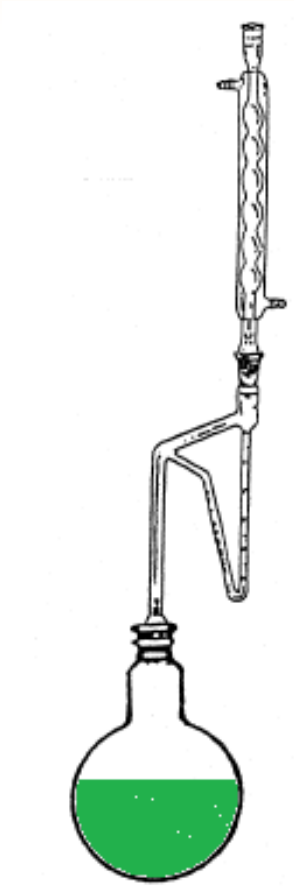
Nickerson, 1977

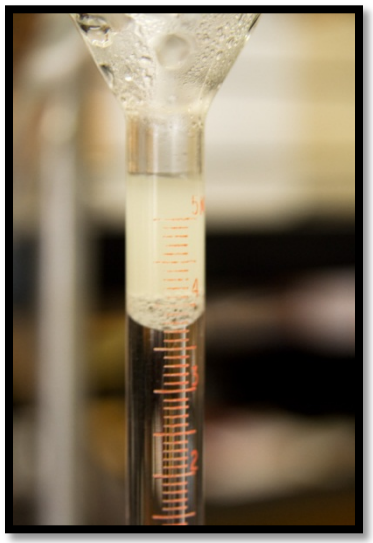
Measurements - Advanced



- **Essential Oil and Aroma**
  - Primary source of hop aroma
  - Varietal Dependent
  - Essential Oil = ml/100g hops
    - **<u>Linalool</u>**
    - Myrcene
    - Humulene/Caryophyllene
    - **<u>Humulene Epoxides</u>**
    - Isovaleric Acid
    - Sulfur Compounds
    - Hundreds more!

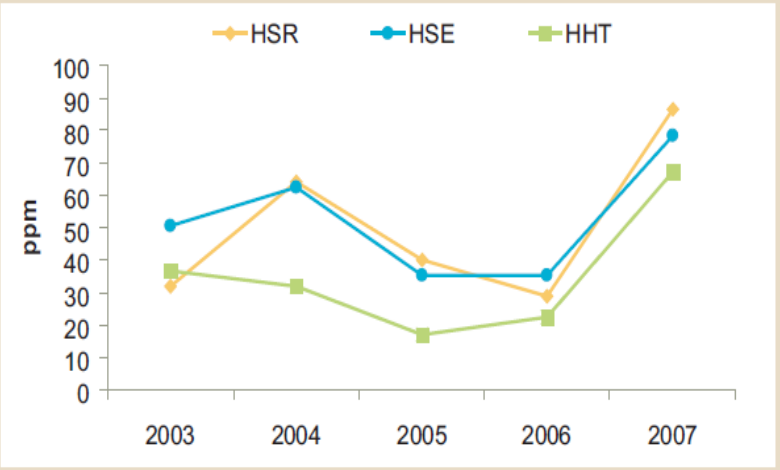






Factors affecting quality

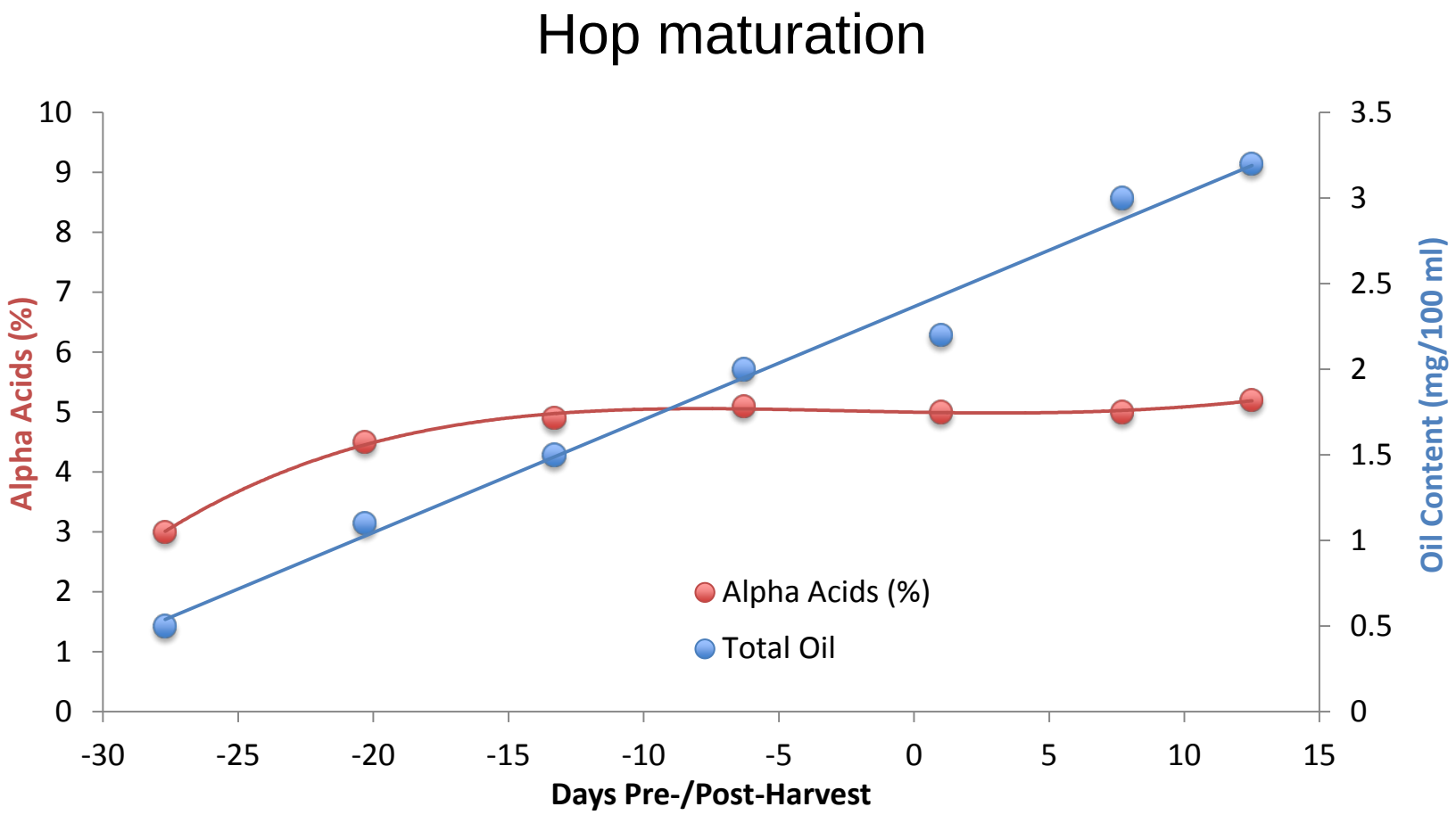
- **Farming practices**
  - Diseases/Pests
  - Seasonal Variation
  - Harvesting/Handling



Effects of Seasonal Variation on Hop Aroma in Beer		
Hop Addition 3g α-acids per hl	2006 Harvest	2007 Harvest
α-acids content in pellets	3.7%	4.2%
Linalool Content (pellets):	28.8 ppm	86.4 ppm
Pellet addition:	81.1g/hl	71.4hl
Linalool content (beer)	23.3 ppm	61.7 ppm

Adapted from Mitter and Steiner, 2009

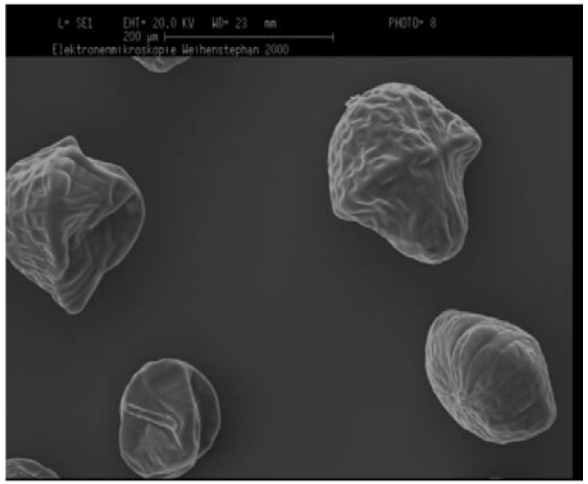
Factors Affecting Quality: Harvest Timing

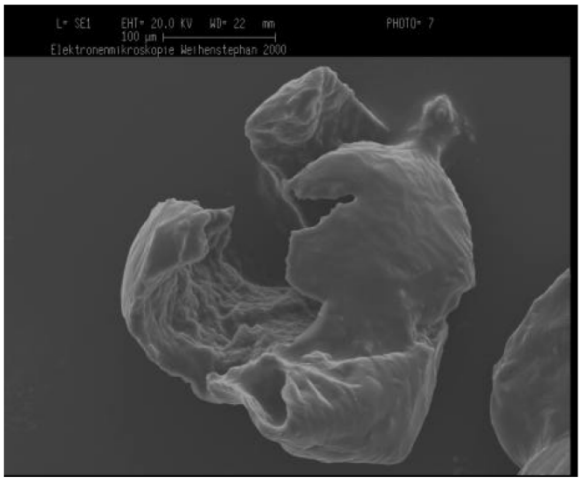


Adapted from: Murphey, J.; Probasco, G.

Factors affecting quality
Baling

- **Baling**
  - Purpose: Increase density and stability
  - Density
  - Size





Forster, A. 2001.

Factors:
Baling

Table 3: Relationship between hop packaging and crushed lupulin glands

Type of bale	Dimension cm	Bulk weight kg/m^3	Degree of crushed lupulin glands % relative
Farmers' bales	80 x 120	85	< 1 %
40 kg rectangular bales	60 x 60 x 120	93	< 1 %
60 kg rectangular bales	60 x 60 x 120	139	< 1 to 3 %
80 kg rectangular bales	60 x 60 x 120	185	> 20 %
US bales	76 x 52 x 150	155	> 10 %

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Factors affecting quality
Storage

- **Temperature**
- **Time**
- **Oxygen**
- **Light**
- **Moisture**
  - Cones: 10-12%
  - Pellets: 9%
  - FIRE DANGER! > 12%

Photo: Oregon Hops and Beer Archives

Factors:
Storage Temperature

Figure 13: Ageing indicator "Hop Storage Index" of fresh, cold and normal stored hops and pellets made from these hops

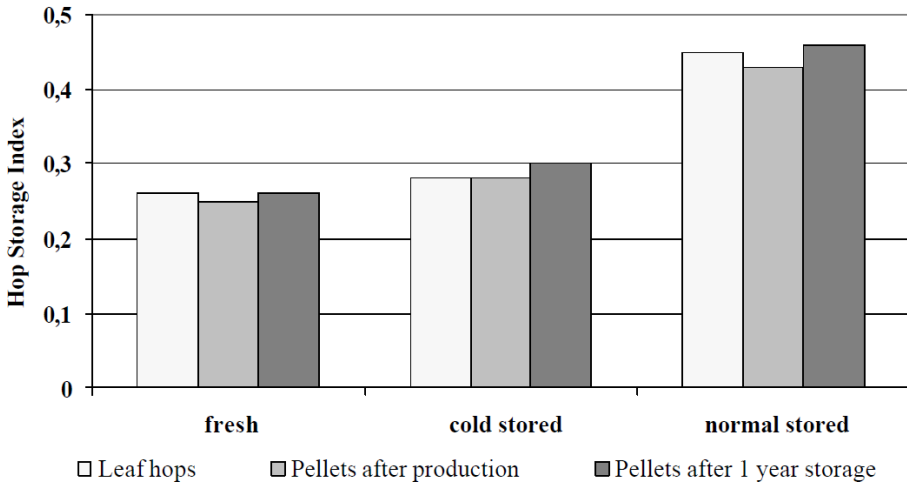
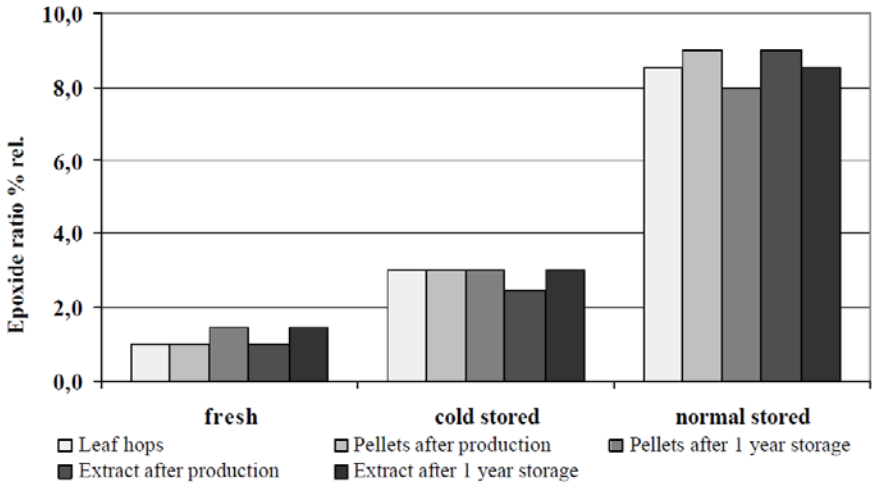


Figure 14: Ageing indicator "Epoxide fraction" of fresh, cold and normal stored hops, pellets and extract made from these hops



Forster, A. 2001.

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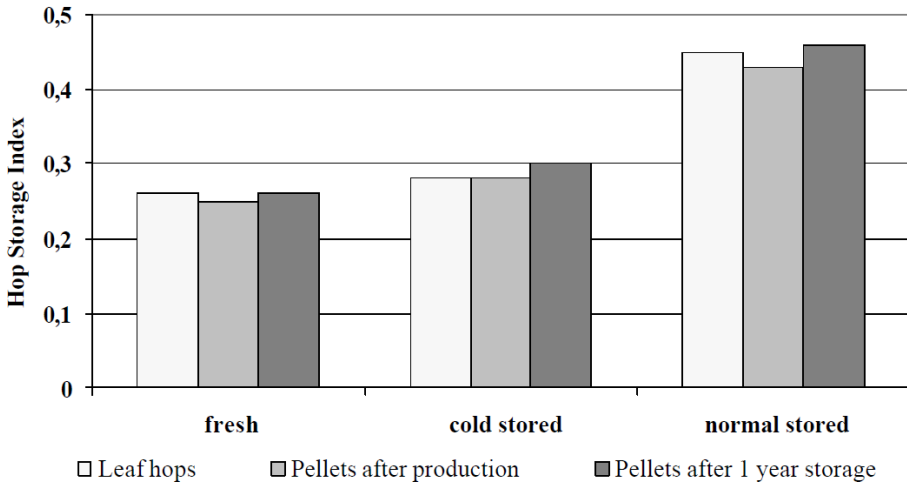

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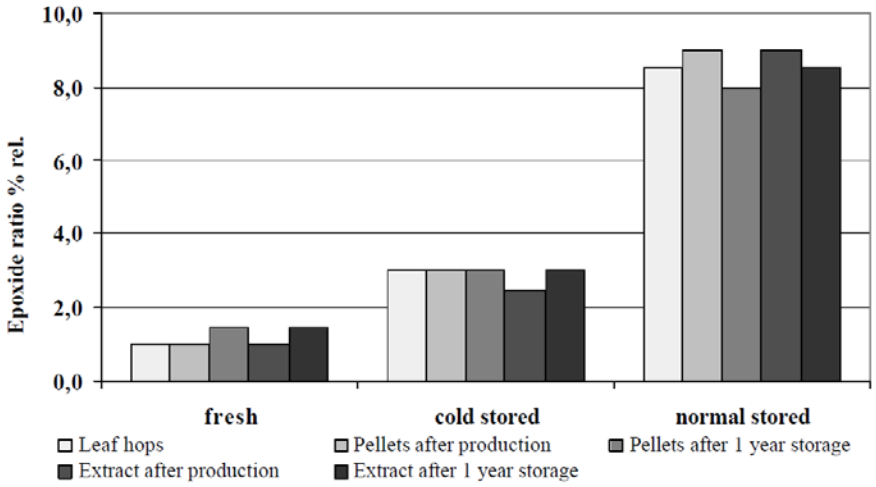


- Cold storage does not increase HSI or Epoxide fraction after 1 year
- Considerable loss in quality over 7 months at ambient conditions
- Quality of CO2 extracts dependent on raw hop quality

Forster, A. 2001.

Factors:
Storage

- **Cold Storage and Packaging**
  - Foil lining
  - Inert
  - Cold
  - Time

Table 11: Recommended temperatures for storing hops and hop products

	1 year	3 years	5 years
Whole hops	0 °C	<< 0 °C *)	? *)
Pellets	< 15 °C	< 5 °C	0
CO_2-extract	< 20 °C	< 10 °C	< 5 °C

Forster, A. 2001.

Factors:
Storage and Aroma

Moderate aging may increase aroma

Changes in hop oil/hoppiness during aging (6 month ambient).

- Category 1: Good storability
- Category 2: Poor storability
- Category 3: Improved by age
- Category 4: No helping it…

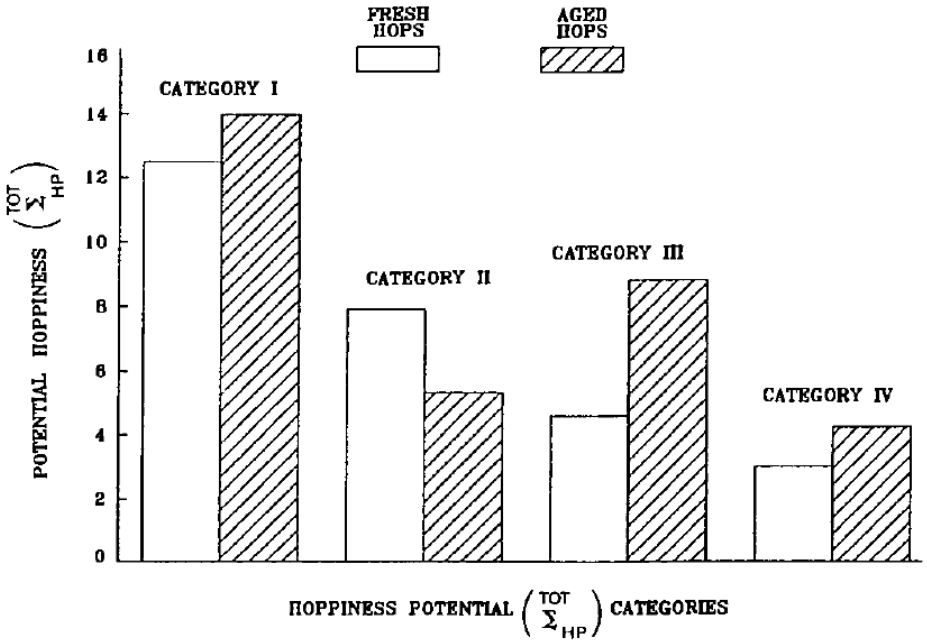
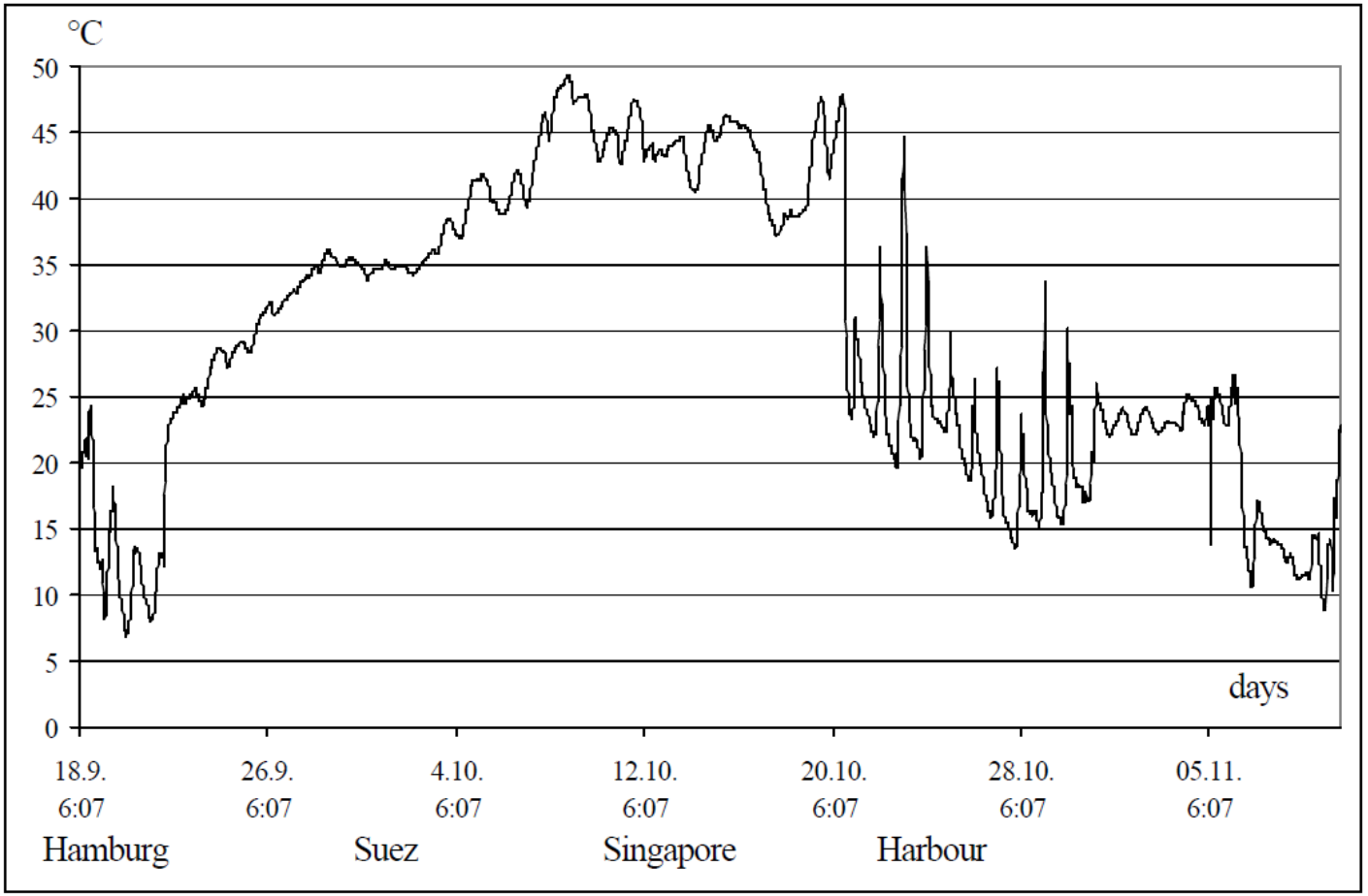


Fig. 14. The categorization of hop variety type by total hoppiness potential, or sigma, in both fresh and aged hops.

Foster, R. T.; Nickerson, G. B. **1985**.

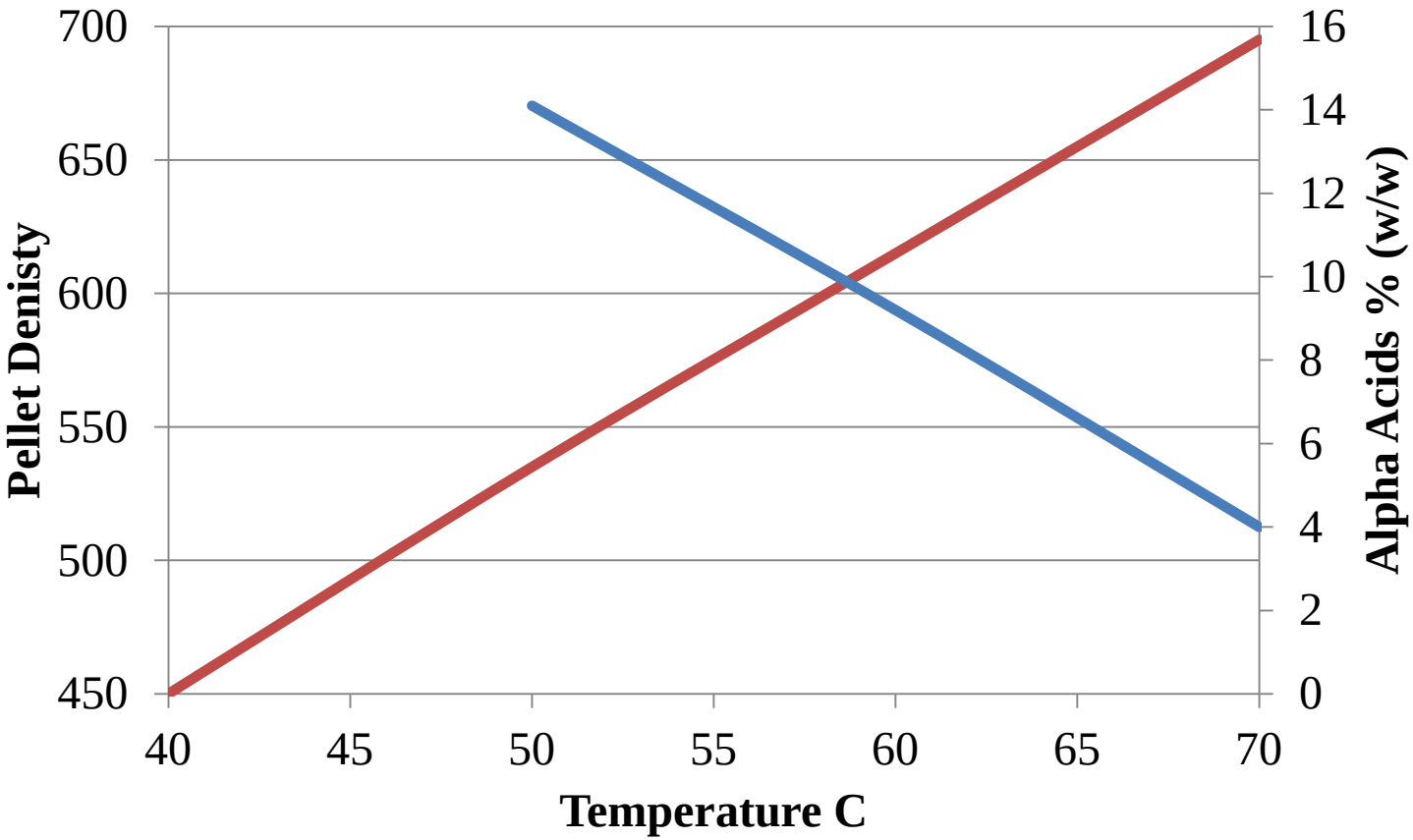
Factors:
Transportation

Figure 10: Temperature graph in a container shipped to Far East – „disastrous“



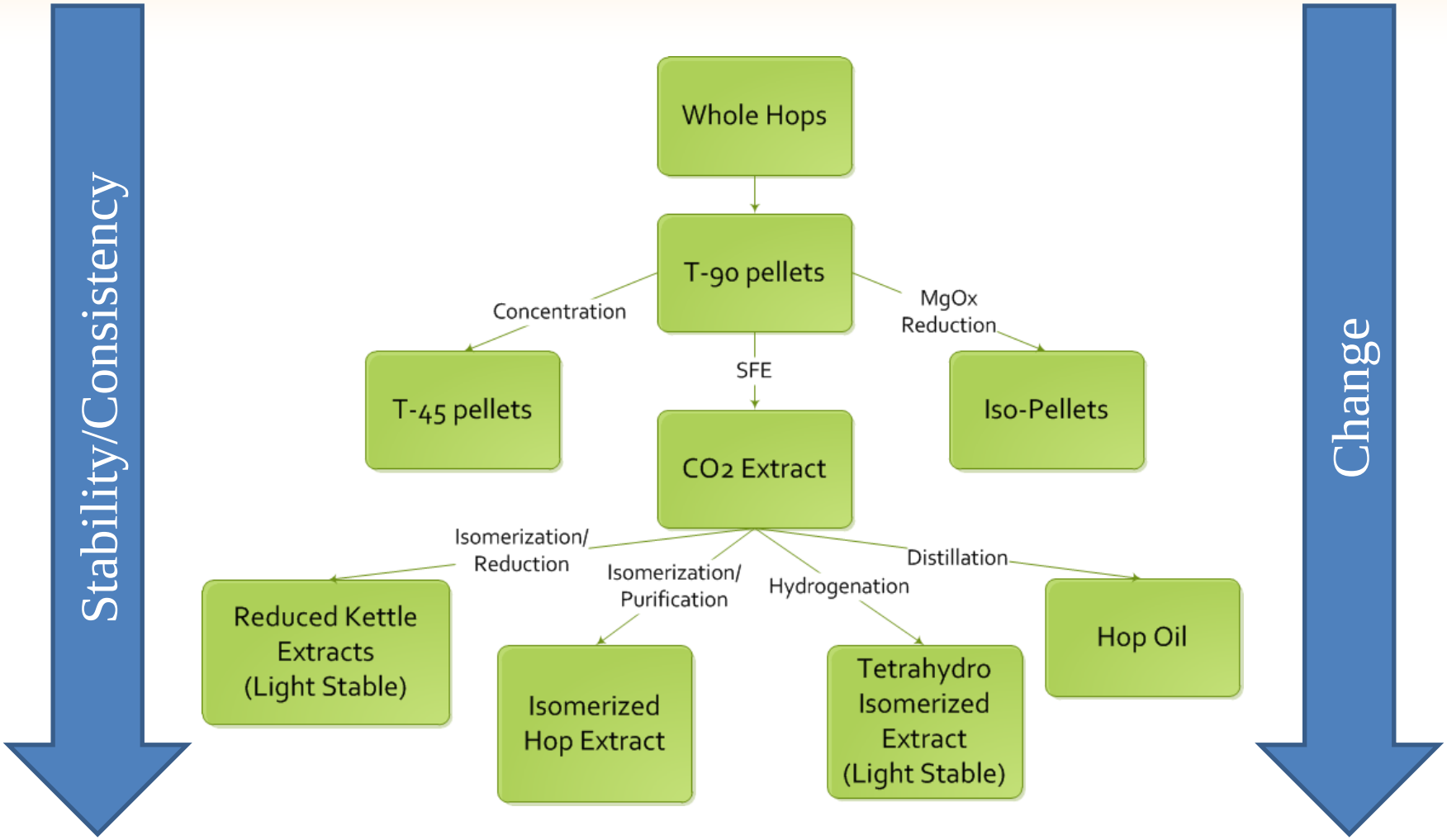
Forster, A. 2001.

Factors:
Pelletizing



Adapted from EBC Manual of Good Practice, 1997

Hop Processing



Adapted from Hop Union, LLC

The Challenge of Hops

- Subjective definitions of “quality”
  - Define your style and needs
    - Hops, Pellets, extracts, etc.
- Susceptible to storage effects.
  - Minimize oxygen, temperature, and light.
- Agricultural product with inherent variation.
  - **Actively select your hops.**
  - **Communication your needs.**

Thank You!

References

1. Benitez, J. L., Forster, A., De Keukeleire, D., Moir, M., Sharpe, F. R., Verhagen, L. C., et al. *EBC-Manual of good practice: Hops and Hop Products*. Hans Carl-Verlag, Nürnberg. 1997.
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6. Nickerson, G. B.; Likens, S. T. *J Am Soc Brew Chem* 1979, *37*, 36–24.
7. Peacock, V. Fundamentals of hop chemistry. MBAA TW 35 (1) :4–8 1998.