THE MALTSTER'S KILN: A CURE FOR YOUR ALES

The best way learn about Malt is to start a conversation about it. . . .

Presented by Andrea Stanley

The Conversation

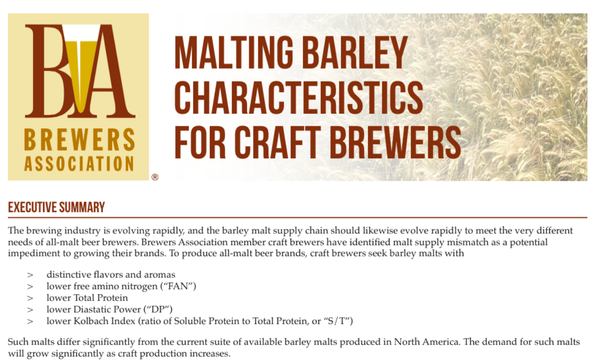
2013 Kiln Air Temperature, Bed Depth and Air Volume Flow Rate Effects on the Quality and Production of Hops

HOP QUALITY GROUP
OILS OVER ALPHA EST. 2010

2014 Craft Malt Sensory Workshop
Same brewery, same recipe, same malt style
-different varieties, location grown and malted

CRAFT MALTSTERS GUILD

2014 Malting Barley Characteristics for Craft Brewers
-The Flavor Debate
-The Need for “less hyperactive” malt



BA BREWERS ASSOCIATION

MALTING BARLEY CHARACTERISTICS FOR CRAFT BREWERS

EXECUTIVE SUMMARY

The brewing industry is evolving rapidly, and the barley malt supply chain should likewise evolve rapidly to meet the very different needs of all-malt beer brewers. Brewers Association member craft brewers have identified malt supply mismatch as a potential impediment to growing their brands. To produce all-malt beer brands, craft brewers seek barley malts with

> distinctive flavors and aromas
> lower free amino nitrogen (“FAN”)
> lower Total Protein
> lower Diastatic Power (“DP”)
> lower Kolbach Index (ratio of Soluble Protein to Total Protein, or “S/T”)

Such malts differ significantly from the current suite of available barley malts produced in North America. The demand for such malts will grow significantly as craft production increases.

2015 Barley Improvement Conference
-One Brewers Observations on Malt Flavor
-Joe Hertrich

Valley Malt

MIND THE GAP

Flavor	Maltsters, Growers, Public Sector, & Academic Communities
FAN	Lower Total Protein, Varietal Breeding & Development
DP	Lower Total Protein, Varietal Breeding & Development
Scale	Malting Companies; Big and Small
Custom Contracting	Relationships between brewers, maltsters, and growers
Geography	Regional adapted varieties, craft malting

Valley Malt

Gaps excerpted from BA Malting Barley Characteristics for Craft Brewers

Pathways to Addressing the Gaps

Trait / Topic	Consensus Target	Breeding	Growing Practices	Malting
Flavor	Most commonly cited tribute	X	X	X
FAN	< 150 ppm	X	X	?
Diastatic Power	<150 Lintner	X	X	X
Protein Modification (S/T)	35% to 45%	X		X
Protein Content	10.5% Maximum	X	X	
Beta Glucan	<140 ppm	X	X	X
Time to take effect		5-15 Years	Seasonal (weather & input dependent)	Days / Hours

Valley Malt

How does Valley Malt fit into this conversation?

Malting Process at a Glance

Grain

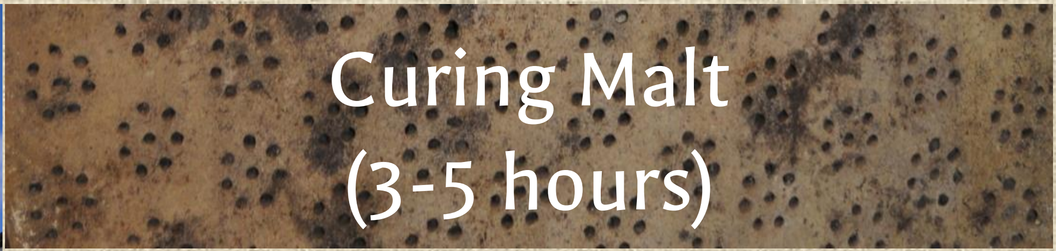
Steep

Germinate

Kiln

- In this study, the last step; Kilning was the only focal point.

Kilning



"Alterations in the way in which kilning is carried out can dramatically alter the enzyme complement of the finished malt."

Dennis Briggs, Malts and Malting pg 219

- Color
- Flavor
- Aroma
- Lower DP and AA

Valley Malt

What We Attempted to Do

In Real Production Setting

Show that one step (curing temp) in the malting process can influence many parameters of malt and beer.

In Real Life, Right Now

Brewers and Maltsters can work together to discover how gaps in the current malt supply can be bridged to meet the current and future needs of craft brewers

WORMTOWN BREWERY

Valley Malt

What We Did

- Malted 3 batches of barley from same lot using 3 different curing temperatures 180F, 190F, 200F
- Brewed 3 beers
- Analyze and evaluate 3 malts
- Analyze and Evaluate 3 beers

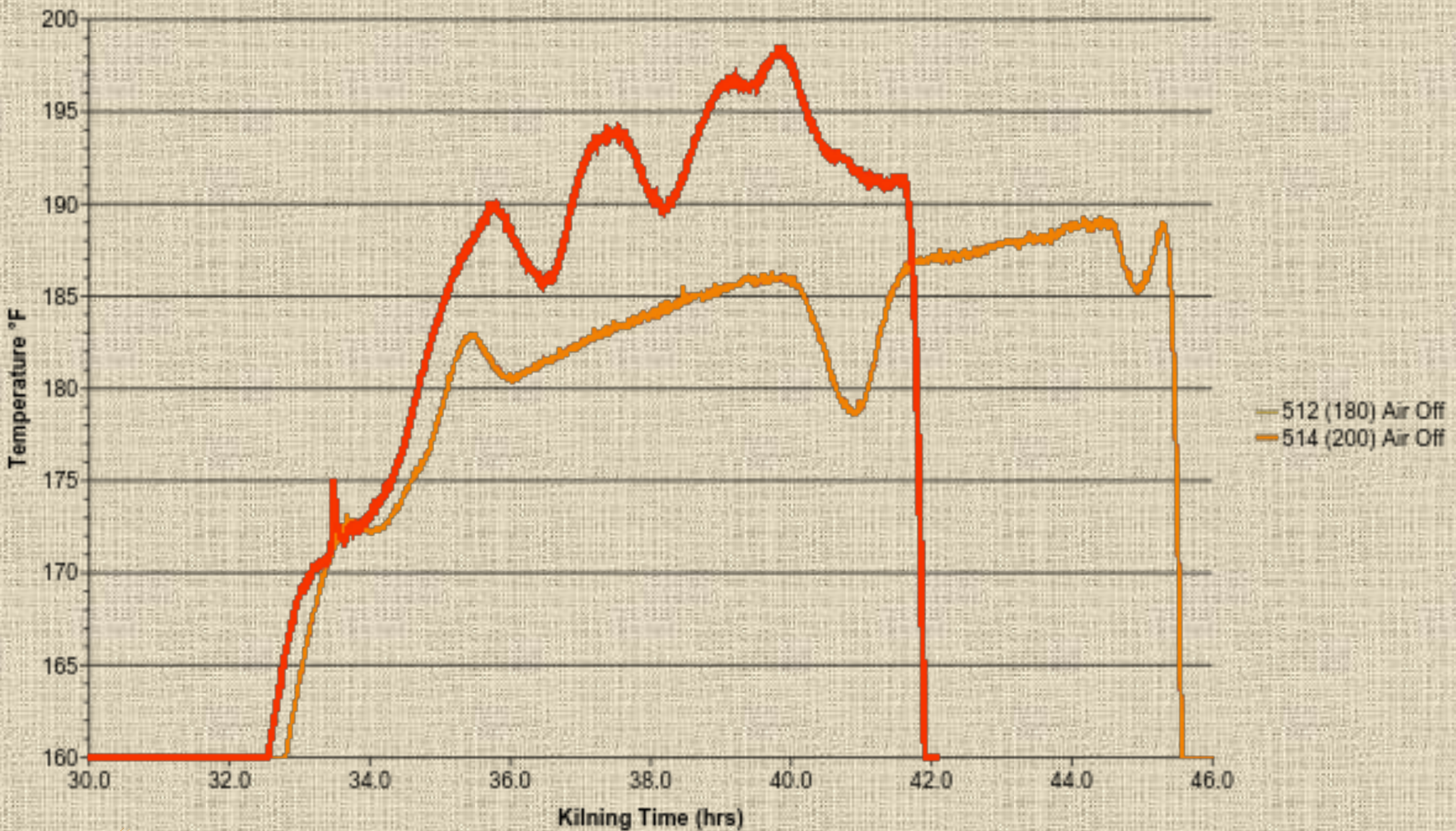
Valley Malt

Malt Comparison – The Numbers

	N. American 2-Row 1960s	N. American 2-Row 1980s	N. American 2-Row Today	European 2-Row Today	AMBA All Malt 2-Row Today	Malt Used For Study
Total Protein	11.0	12.2	12.4	10.4	<11.8	8.9
S/T Ratio	38.0	43.5	47.4	40.9	38 to 45	38 to 45
Soluble Protein	4.2	5.3	5.9	4.3	<5.3	3.5 to 4.2
FAN	*	210	240	138	140 to 190	107 to 149
Diastatic Power	90	135	160	80	110 to 150	61 to 79
Beta Glucan	*	120	95	180	<100	66 to 110
	Betzes Hannchen	Klages Harrington	AC Metcalfe CDC Meredith	Grace Propino		Wintmalt

Valley Malt

Curing Temperature Profile



Analysis on the Malts

Lot #	512	513	514
Cure Temp	180	190	200
Malt Moisture	2.3%	2.9%	2.0%
Friability	95.4%	94.6%	89.4%
PUG	1.7%	3.6%	2.2%
WUG	0.8%	2.3%	0.2%
Wort Color	3.48	2.68	2.88
FG Extract	81.6%	83.3%	79.8%

Valley Malt

BA

BREWERS ASSOCIATION

www.brewersassociation.org

The Maltster's Kiln: A Cure for Your Ales:

Review of Kilning

Dr. Paul Schwarz
Department of Plant Sciences
North Dakota State University

Why Do We Kiln?

1. Develop desired flavor and color.
2. Reduce moisture.
3. Suspend enzyme activity and modification.
4. Reduce undesirable grain flavors.

How Do We Kiln?

- The drying process is influenced by:
  - Temperature of air entering and leaving the grain bed
  - Relative humidity
  - Volume of air-flow
  - Surface area of the grain
  - Moisture content of the grain
  - other

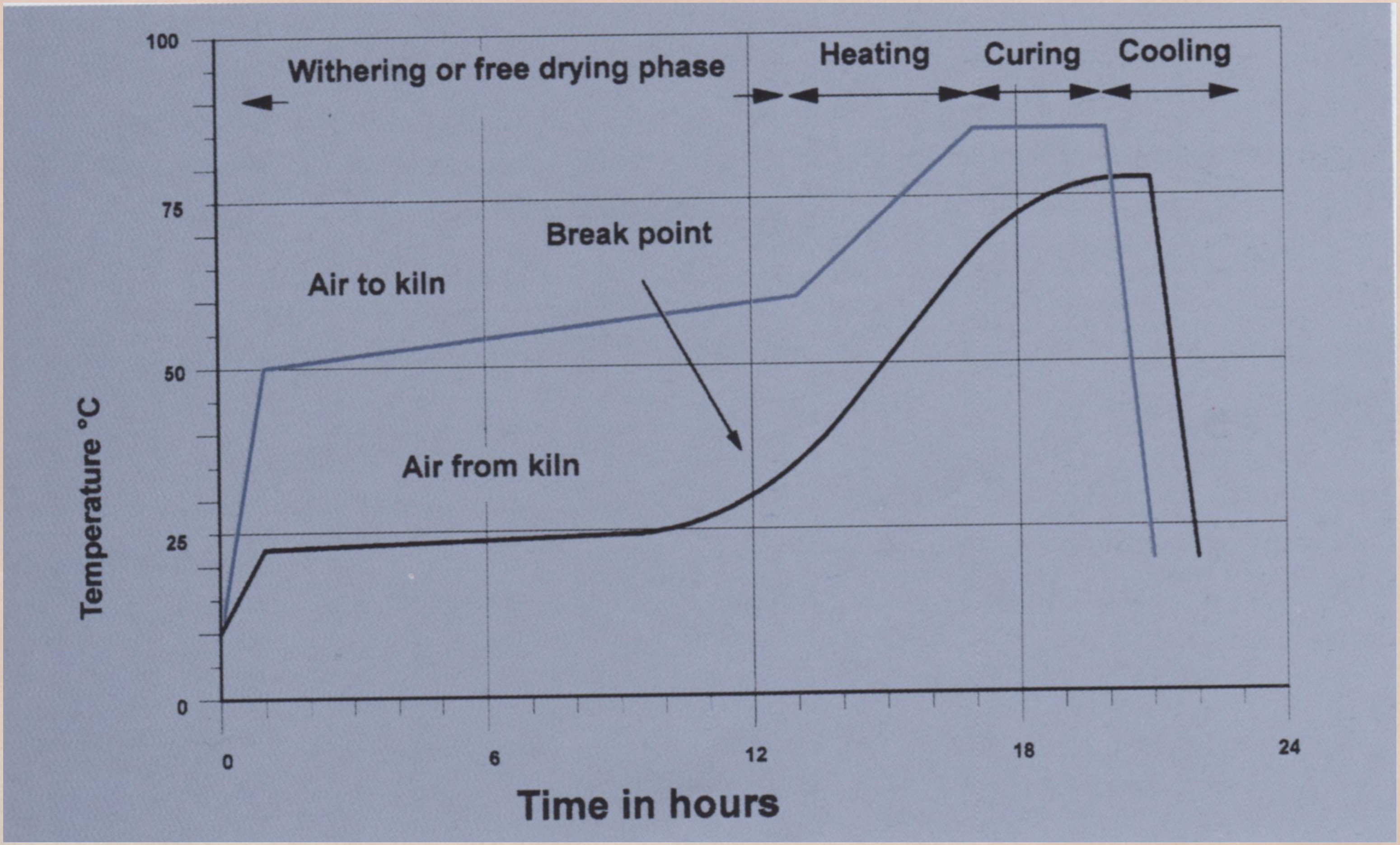
How Do We Kiln?

General Principles

- Remove the bulk of the moisture at low temperature (≈45% to 12%)
  - helps preserve enzyme activity
- Increase temperature only at lower moisture (≈12%)
- Final cure (≈4 hrs)
  - Color and flavors formed
  - Moisture to 4%

Actual process depends on the malt and equipment.

Air Temperatures in a Typical Kiln



Malting Technology. EBC 2000

Stages of Kilning: Drying Events

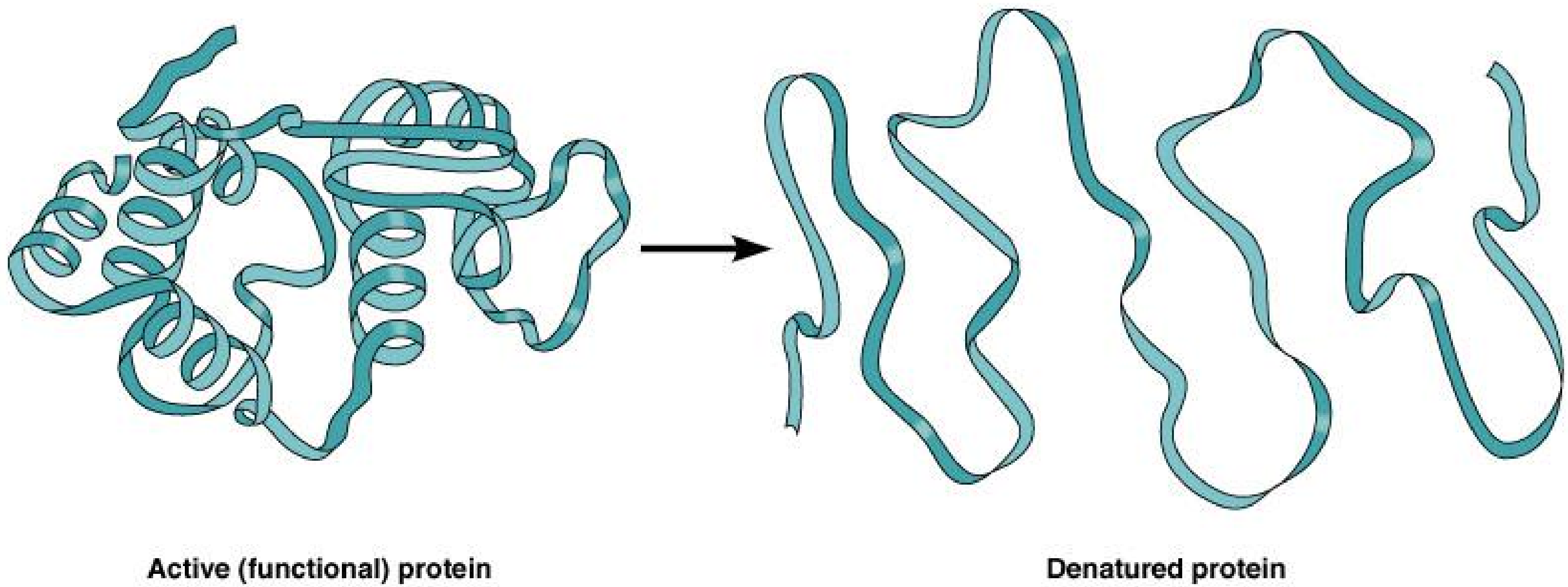
1. **Grain warming** (1 hr)
   1. ambient to 50ºC (120 F)
2. **Linear (steady state)** (12-24 hrs)
   1. removal of "free water"
   2. ≈45% to 12% moisture
   3. ≈ 50-60 ºC/120-140 ºF
3. **Intermediate (**4-6 hrs)
   1. ≈ramped 60-85 ºC/140-185 ºF
   2. Moisture becomes more difficult to remove
4. **Slow Drying** (4 hrs)
   1. Moisture is tightly "bound"
   2. A set temperature of 85 – 105 C/ 185-220ºF

Stages of Kilning: Chemical/Biochemical Events

1. **Germinative phase**
   1. Grain continues to germinate with temperatures below 50ºC and moisture > 40%
2. **Enzymatic phase**
   1. Many enzymes remain active 60-65ºC as long as there is enough moisture for reaction
   2. Formation of color precursors
3. **Chemical (curing) phase**
   1. Strictly chemical reactions (e.g Maillard)
   2. 85-105ºC

Reactions in Kilning: Development of Flavors and Colors

Kiln Concepts: Heat Denatures Protein



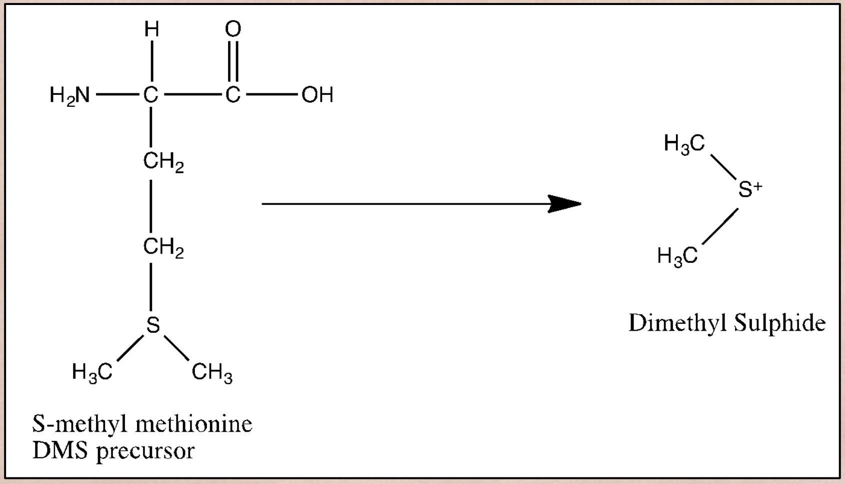
Kiln Concepts: Heat Denatures Protein

- Denaturation renders soluble protein insoluble.
- Denaturation renders active enzymes inactive.
- Effects of heat are more pronounced at higher moisture
  - This is why kiln temperatures are not increased above 60ºC (140ºF) until moisture has been reduced.
  - Higher kiln cure temperatures will also denature some protein, even when moisture is low.

Enzyme Stability in Kilning

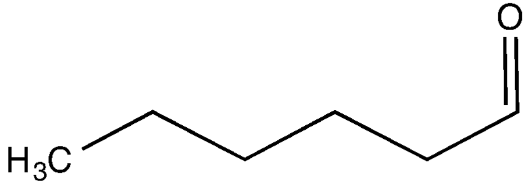
- Alpha-amylase is relatively stable in kilning
  - Little is lost in pale malt production
  - 50-60% lost in dark malt production.
- Diastatic Power (beta-amylase) is less heat stable
  - >30% may be lost in pale malt production
  - 70% lost in dark malt production
- Beta-glucanase is very heat sensitive
  - >50% is destroyed in pale malts
- Proteases show mixed heat stabilities
  - Fairly stable

Removal of Undesirable Flavors

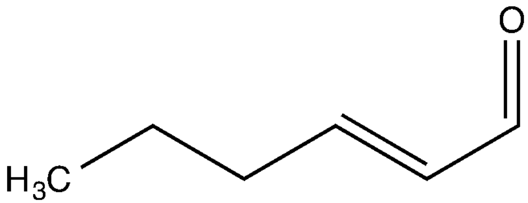


- S-methyl methionine is the precursor (DMSP) of dimethyl sulphide (DMS) in malt.
- DMSP is broken down to DMS in curing and lost with the kiln exhaust.
- Higher cure temperatures can reduce DMS potential in beer.
- DMSP also depends and barley variety and protein content

Removal of Undesirable Green Malt Flavors



Hexanal



trans-2-Hexenal

- Some green malt flavor/aromas are associated with lipid metabolism.
- Higher cure temperatures can reduce these compounds.
- Higher cure temperatures will also reduce lipoxygenase (LOX), which can cause beer staling.

Formation of Desirable Flavors and Colors in the Kiln

Temperatures in standard kilning generally do no exceed 100ºC (212ºF). As such colors and flavors are largely derived from:

1. Maillard Reaction
2. Strecker Degradation

Higher temperatures are seen in “roasting”: caramelization (110-180ºC, 230-356ºF) and pyrolysis (>150ºC) occur in addition to the above reactions.

Maillard Reaction: The Basics

- Begins with reaction between an amino acid and a reducing sugar (maltose, glucose, fructose).
- Favored at 140 to 165 °C (284 to 329 °F) but can occur at lower temperatures.
- Favored at alkaline pH, but does occur at pH of malt
- Possible formation of 100's of flavor compounds
- Polymeric products called melanoidins are responsible for color.
- Specific reactions depend on composition of the germinating barley, time, temperature, moisture and pH.

MAILLARD REACTIONS

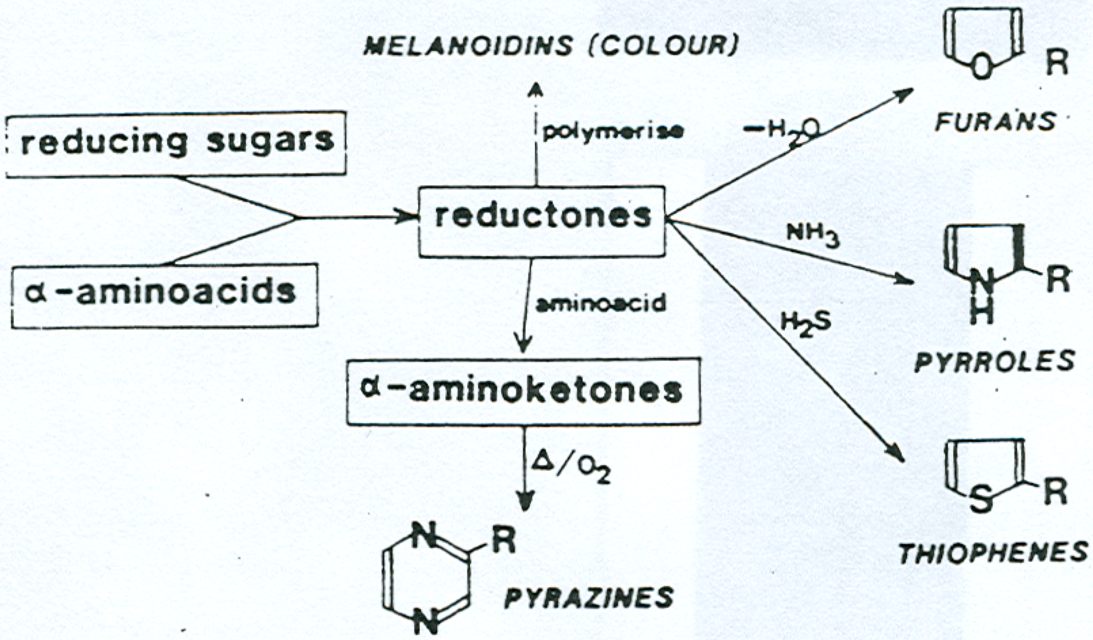


Fig. 3

This is the most important mechanism for the production of flavour and colour during food cooking and processing.

Reductones, maltol
Condensation lead to
Colored compounds

1-deoxy compounds

Furfural, HMF, pyrole
and
pyradines

3-deoxy compounds

4-deoxy compounds

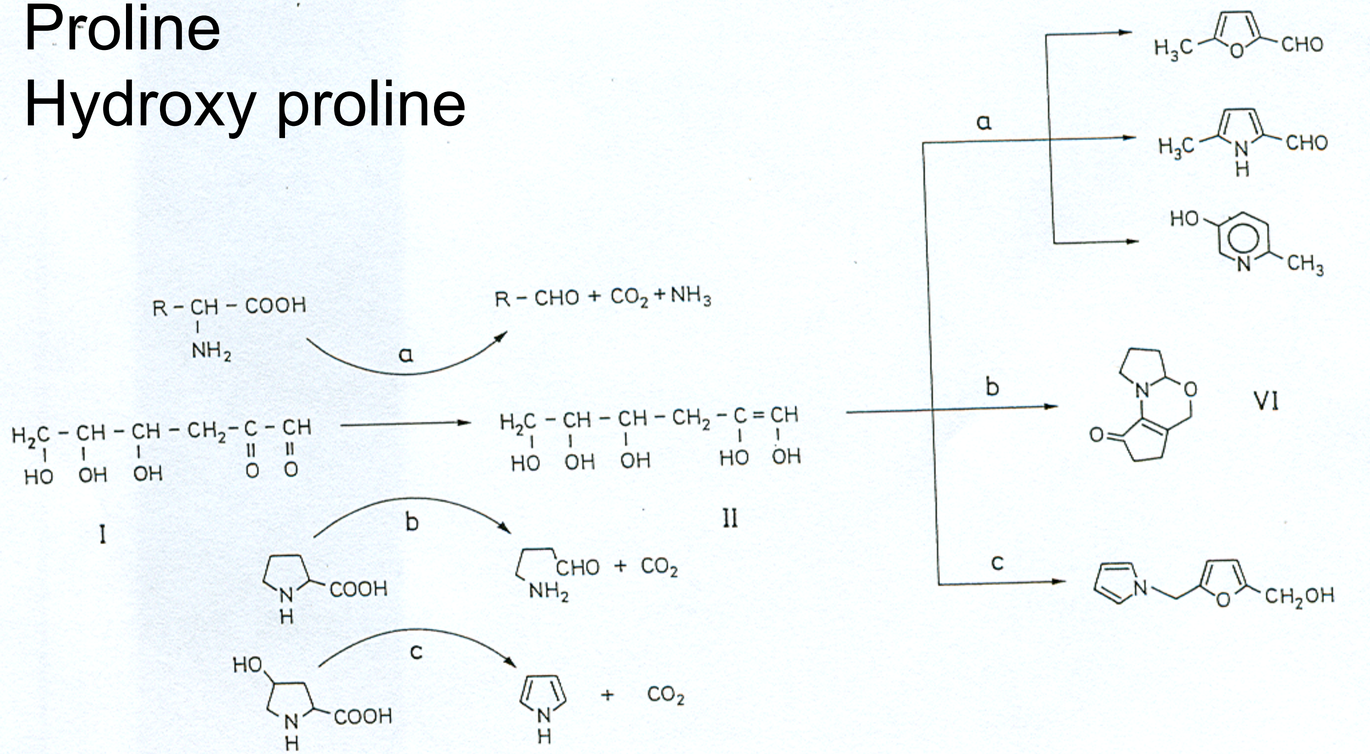
Hydroxyacetyl furan, and pyrole
and pyradines

Strecker Degradation of Amino Acids

- Connected with Maillard Reaction
- Strecker Degradation occurs at elevated temperatures
- Alpha-dicarbonyl compounds formed in Maillard reaction will cause the degradation of an amino acid to the corresponding aldehyde
- Strecker aldehydes are often food aroma constituents

Strecker Degradation of Amino Acids

a. Primary amino acid
b. Proline
c. Hydroxy proline



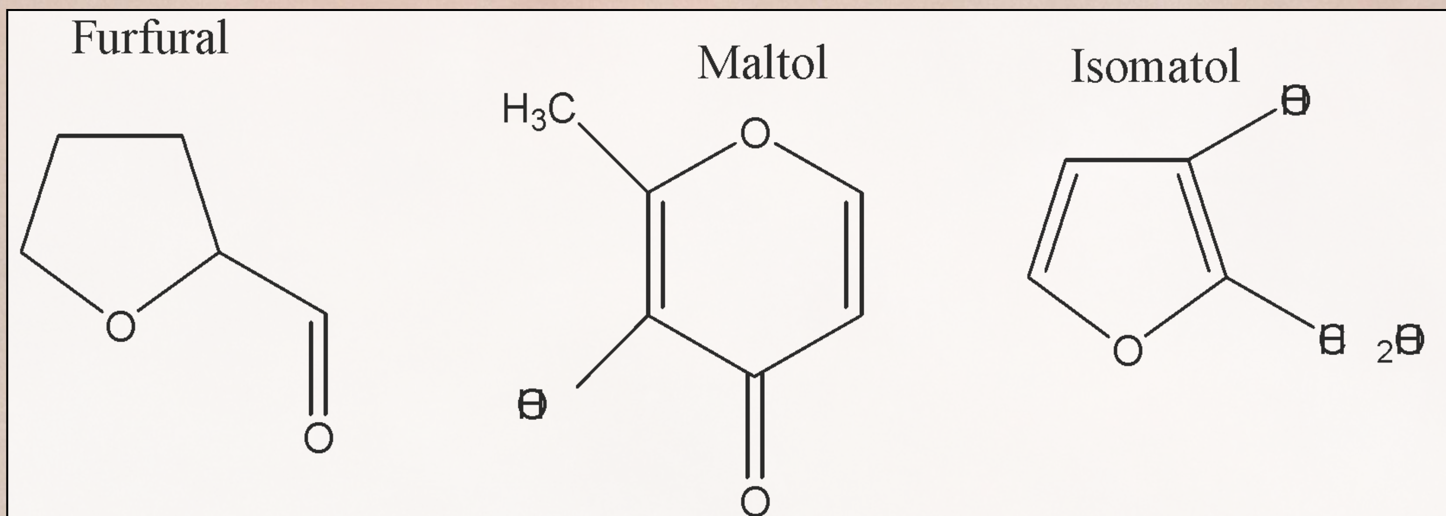
Strecker Degradation of Amino Acids

Amino Acids and Corresponding Strecker Aldehydes

• Valine	isobutyraldehyde
• Leucine	isovaleraldehyde (malty)
• Methionine	methional

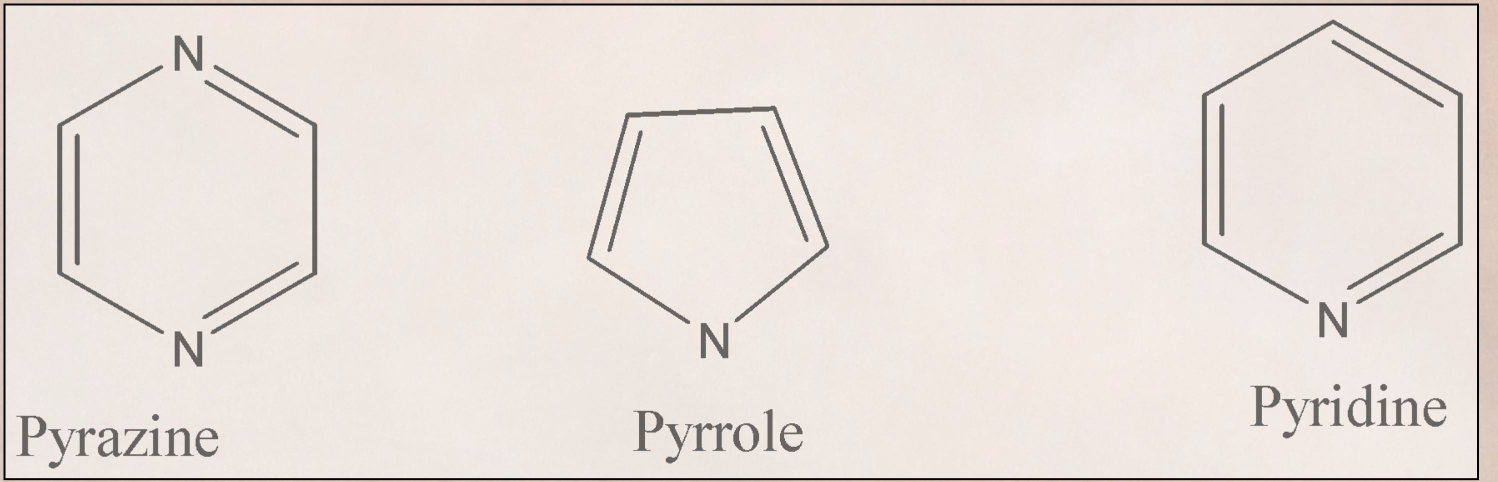
Malt Flavors/Aromas

- Oxygen heterocylics responsible for toffee-caramel flavors which are found at higher levels in crystal malt



Malt Flavors/Aromas

- Pyrazines: nutty to coffee flavors in roasted malt of barley



Malt Flavors/Aromas

		Flavor Substance				
Malt	Beer Flavor	Lipid	DMS	Strecker	N-heter	O-heter
Green Malt	Grassy, sulphidic	+++	+++	++		+
Pale Malt	sulphidic caramel	+	++	+++	+	++
Pale + 1% crystal	Caramel malty		+	+++	++	+++
Pale + 1% Roast Barley	Nutty, Coffee		+	++	+++	+++

Promoting Color and Flavor in Malt

Barley

- Higher protein
- Variety?

Process

- Extend modification
  - Steep moisture
  - Germination time
- Moisture and temperature in kilning (stewing)
- Roaster vs Kiln (same color will not have same flavor)

Promoting Color and Flavor in Malt

- Colors greater than 20 SRM (16 EBC) are generally achieved in a roaster.
- Maillard reaction begins at temperatures > 80ºC.
- Melanoidin production are generally formed at >100ºC
- Caramelization requires 110-180ºC
- Pyrolysis >150ºC and lower moisture.

Developing Color and Flavor in Pale Malt (< 5 SRM)

- Higher protein barley
- Promote modification
  - Higher steep out moisture
  - Extend germination time
- Higher cure temp (90 vs 85ºC)
- Raise temperature (55-65ºC) at higher moisture (>10%). Reduce air.
- Increasing color will reduce DP and perhaps increase malt loss.

Malting Trials

Trial 1

- Conlon
- Protein: 11%
- Identical Steep and Germination
- Variable Cure temp (longer than trial 2)
  - 82ºC (180 F)
  - 88ºC (190 F)
  - 93ºC (200 F)

Malting Trial 1 - Protein

Variety	Cure Temp	Malt Protein %	Soluble Protein (%)	Kolbach Index (S/T)
Conlon	180 (82 C)	11.3	5.47	48.3
Conlon	190 (88 C)	11.1	5.10	46.0
Conlon	200 (93 C)	11.2	4.54	40.5

- Malt protein did not change
- Soluble protein decreases as increasing cure temperature denatures more protein
- Soluble/Total (Kolbach Index) follows the same pattern

Malting Trial 1 – FAN and Wort Color

Variety	Cure Temp	FAN (mg/L)	Wort Color
Conlon	180 (82 C)	184	2.7
Conlon	190 (88 C)	181	2.5
Conlon	200 (93 C)	142	3.3

- Most compounds contributing to FAN are low molecular weight (amino acids) are not as sensitive to denaturation.
- FAN and color really only changed at the 200 F cure.
  - Some denaturation of protein, and conversion of more amino acid to color and flavor compounds at the higher temperature.

Malting Trial 1 – Enzymes and Beta-Glucan

Variety	Cure Temp	Alpha-Amylase (DU)	DP(ASBC)	Beta_Glucan (mg/L)
Conlon	180 (82 C)	55	85	373
Conlon	190 (88 C)	50	73	484
Conlon	200 (93 C)	35	47	714

- Alpha-amylase decreased significantly at 200 F
- DP is more heat sensitive and decreased with increasing cure temperature
- Beta-glucanase is very heat sensitive. Beta-glucans increased with with cure temperature, as less glucnase survived into mashing

Malting Trials

Trial 2

- Wintmalt
- Protein: 9%
- Steep and Germination were same for 190 and 200ºF. 180 was floor-malted
- Variable Cure temp (shorter than trial 1)
  - 82ºC (180 F)
  - 88ºC (190 F)
  - 93ºC (200 F)

Malting Trial 2 - Protein

Variety	Cure Temp	Malt Protein %	Soluble Protein (%)	Kolbach Index (S/T)
Wintmalt	180 (82 C)	9.2	3.84	41.6
Wintmalt	190 (88 C)	9.3	4.19	45.0
Wintmalt	200 (93 C)	9.2	3.51	38.1

- Malt protein did not change lower than trial 1 (Conlon)
- Soluble protein was lowest at highest cure temp. Impact of floor malting on 180 treatment
- Soluble/Total was lowest at highest cure

Malting Trial 2 – FAN and Wort Color

Variety	Cure Temp	FAN (mg/L)	Wort Color
Wintmalt	180 (82 C)	132	3.5
Wintmalt	190 (88 C)	149	2.7
Wintmalt	200 (93 C)	107	2.9

- Most compounds contributing to FAN are low molecular weight (amino acids) are not as sensitive to denaturation.
- FAN decreased at the 200 F cure.
  - Impact of floor malting on the 180 treatment

Malting Trial 2 – Enzymes and Beta-Glucan

Variety	Cure Temp	Alpha-Amylase (DU)	DP(ASBC)	Beta_Glucan (mg/L)
Wintmalt	180 (82 C)	35	64	110
Wintmalt	190 (88 C)	38	80	66
Wintmalt	200 (93 C)	30	62	108

- Alpha-amylase decreased at 200ºF
  - Impact of floor malting on 180 treatment
  - Lower protein in Wintmalt yielded lower enzymes
- DP decreased at 200ºF
- Beta-glucanase was in activated to greater extent at 200ºF