USING A MALT COA TO BREW BETTER BEER

Ashton Lewis
Technical Editor and Mr. Wizard Columnist, BYO Magazine
Manager of Training & Technical Support, BSG
National Technical Committee, MBAA

BSG

BYO NANO CON ONLINE

Malt Quality and the Certificate of Analysis (COA)

Prepared by Juan Medina & Ashton Lewis
Presented by Ashton Lewis

Agenda

- Malt Specifications vs. COA
- Review Malt Quality Factors
- Investigate Components of COA
- Apply Key Points of the COA
- Recap

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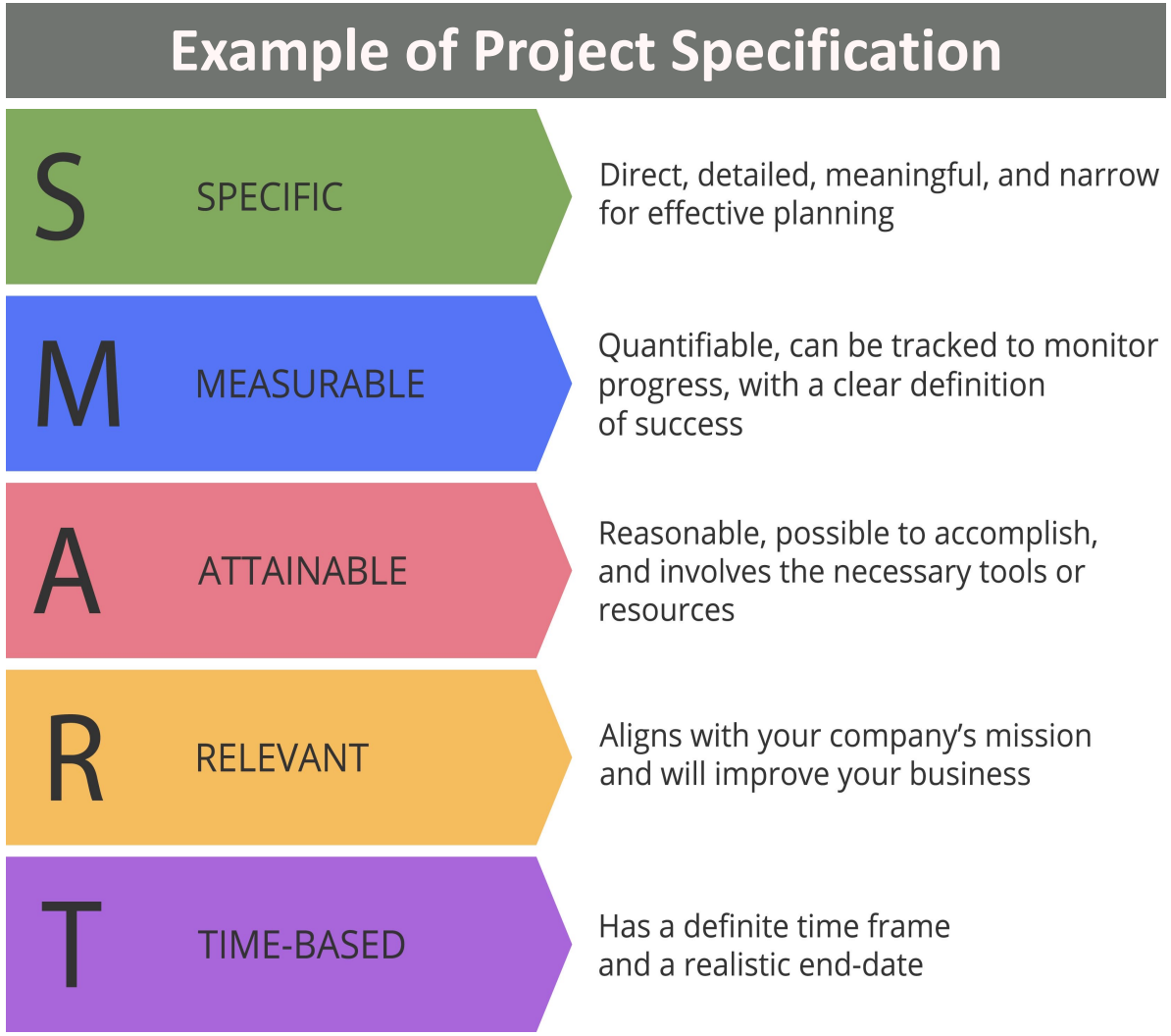
What are Specifications?

- A detailed description used to minimize miscommunication
- Examples include:
  - Product specifications, e.g., malt specifications
  - Engineering/design specifications
  - Functional specifications
  - Project specification



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Same Specification, Different Products

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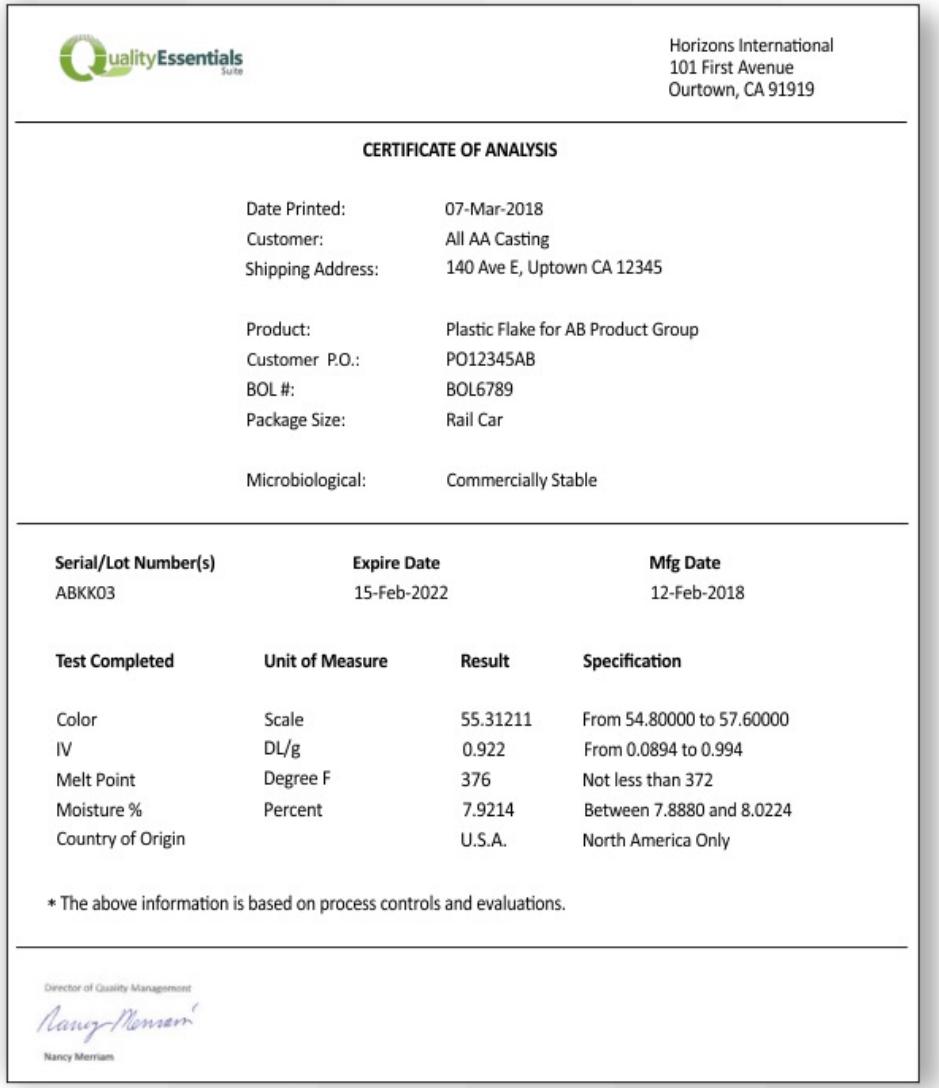
Malt Specification vs. Certificate of Analysis

- A specification applies to a type of malt, for example Rahr Pale Ale malt.
- A Certificate of Analysis applies to a particular lot of malt.
- Many brewers refer to a complete set of malt analyses as “malt specs.” This can lead to confusion about what is being discussed.



QualityEssentials Suite

Horizons International
101 First Avenue
Ourtown, CA 91919

CERTIFICATE OF ANALYSIS

Date Printed:	07-Mar-2018
Customer:	All AA Casting
Shipping Address:	140 Ave E, Uptown CA 12345
Product:	Plastic Flake for AB Product Group
Customer P.O.:	PO12345AB
BOL #:	BOL6789
Package Size:	Rail Car
Microbiological:	Commercially Stable

Serial/Lot Number(s)	Expire Date	Mfg Date
ABKK03	15-Feb-2022	12-Feb-2018

Test Completed	Unit of Measure	Result	Specification
Color	Scale	55.31211	From 54.80000 to 57.60000
IV	DL/g	0.922	From 0.0894 to 0.994
Melt Point	Degree F	376	Not less than 372
Moisture %	Percent	7.9214	Between 7.8880 and 8.0224
Country of Origin		U.S.A.	North America Only

* The above information is based on process controls and evaluations.

Director of Quality Management
Nancy Merriam

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Defining the COA

Issued: 01 Jun, 2023

RAHR MALTING CO.

RAHR MALTING CO. SHAKOPEE, MN 55379
952-496-7115 (Theresa Kukar)

Certificate Of Analysis

Customer	Ship Date	Car Number	Grade	Destination
BREWERS SUPPLY GROUP	4/28/2023		North Star Pils	BSG SHAKOPEE WAREHOUSE

Shipment Wt. Lbs.	Rahr Ref No
159,368	0084591BSG

Crop Year	Variety	Percent
	Approved Malting Varieties	100

Assay	Methodology	Shipment	Min Spec	Max Spec
Moisture, %	ASBC-Malt-3	4.12		5.00
Fine Grind, As Is, %		78.3		
Fine Grind, Dry Basis, %, %	ASBC-Malt-4	81.7	79.0	
Fine/Course Difference, %	ASBC-Malt-4	0.3		2.0
Course Grind, As Is, %		78.0		
Course Grind, Dry Basis, %	ASBC-Malt-4	81.4		
Color, SRM	ASBC-Wort-9	1.80	1.50	2.00
Diastatic Power, ºLintner	ASBC-Malt-6C	131	110	180
Alpha Amylase, DU, DU	ASBC-Malt-7D	61.4	50.0	70.0
Total Protein (Leco), %	ASBC-Malt-8B	11.33		12.5
Soluble Protein, %	ASBC-Wort-17	4.78		
S/T Ratio		42.2	37.00	44.00
Viscosity, cP	ASBC-Wort-13B	1.49		1.55
Beta Glucan, mg/L	ASBC-Wort-18B	127		150
Don, mg/L		0.10		0.50
FAN, mg/L	ASBC-Wort-12B	177	150	215
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Thru	ASBC-Malt-2B	1.2		2.0
Turbidity, NTU		10.3		
Friability	ASBC-Malt-12	89.3		
Friability %WK	ASBC-Malt-12	0.36		
bushel Weight, lb/bu	ASBC-Malt-2A	41.2		

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What is a Certificate of Malt Analysis (COA)?

- Report card of malt quality analytical data (malting and blending outcome) as measured by laboratory analysis.
- Description of specific malt lot.
- Allows brewers to track changes and modify brewing process.

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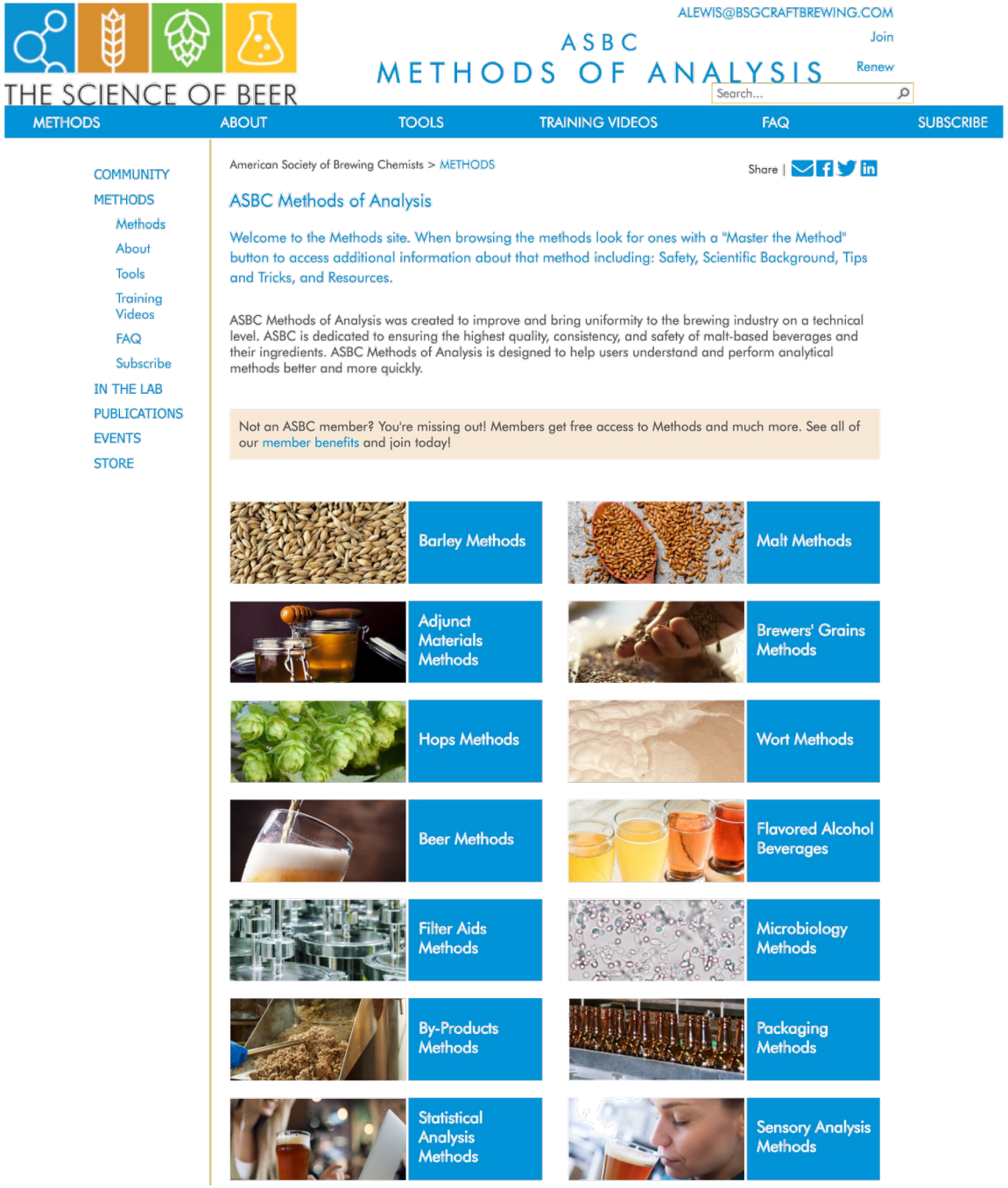
It's all About Analytical Data!



- COA data result from different standardized malt analyses.
- The American Society of Brewing Chemists (ASBC) sets standards primarily used in the US and Canada.
- ASBC member laboratories regularly validate test results.
- European Brewing Convention (EBC) and Brewery Convention of Japan (BCOJ) provide comparable standards in other countries

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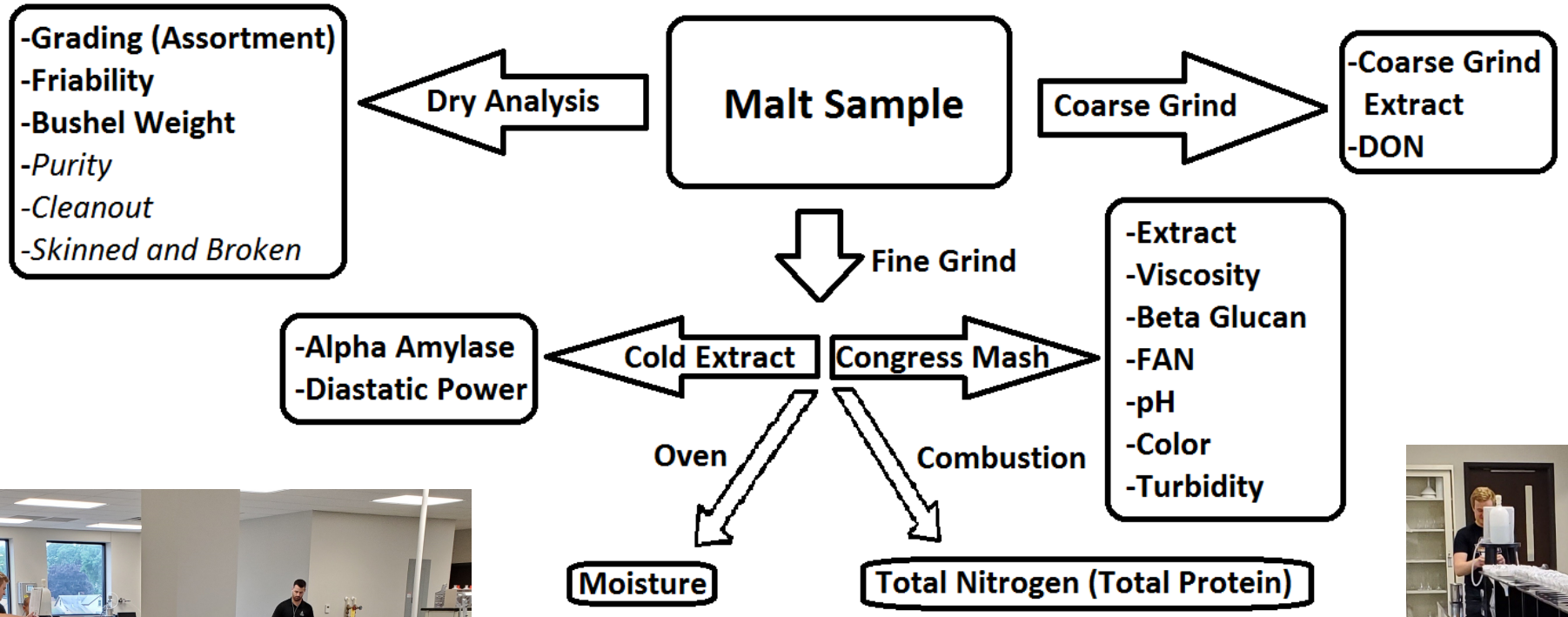
Malt Analysis Map



Lots of hard work!

Congress Mash Method

- Mix 200 ml water at 47ºC with 50 g milled malt (fine and coarse).
- Immediately place mash sample in mash bath and turn on mash stirrer.
- Hold at 45ºC for 30 minutes.
- Heat mash to 70ºC at a rate of 1ºC/min (25-minute ramp).
- Add 100 ml of 70ºC water and hold for 60 minutes.
- Cool to 20ºC by adding cold water, then adjust net weight to 450 g.
- Note that total mash time = 115 minutes.
- Transfer to filter, collect wort, and measure density.

Note: The congress mash is based on step-mashing methods.

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Reviewing Malt Quality Factors

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Fundamental Malt Quality Factors

- Initial Barley Qualities
- Modification
- Kilning
- Handling and Storage

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Variety, Environment, Handling and Storage

- Composition sets the stage before malting begins
- Total protein
- Assortment
- Bushel weight
- Purity (chaff, straw, foreign seeds)
- Germinative Energy (non-dormant)
- Capacity (viability)
- Damage (pre-harvest sprout, heat damage, breakage)
- DON

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Key Malt Quality Concept: Modification

- Describes the degree of biochemical transformation during the malting process, especially germination
- Influences several COA metrics
- Three main drivers:
  - **Cytolysis -** Degradation of cell walls made of structural non-starch polysaccharides (β-glucan and arabinoxylan)
  - **Proteolysis -** Degradation of proteins into Soluble proteins, peptides, and amino acids
  - **Enzyme Development** – Synthesized by the aleurone layer and scutellum and moved by diffusion into the endosperm during germination

Modification is a product of biological activity. It tends to correlate with growth of rootlets and acrospires. This picture shows **overgrown** kernels that are atypical of brewers malt.

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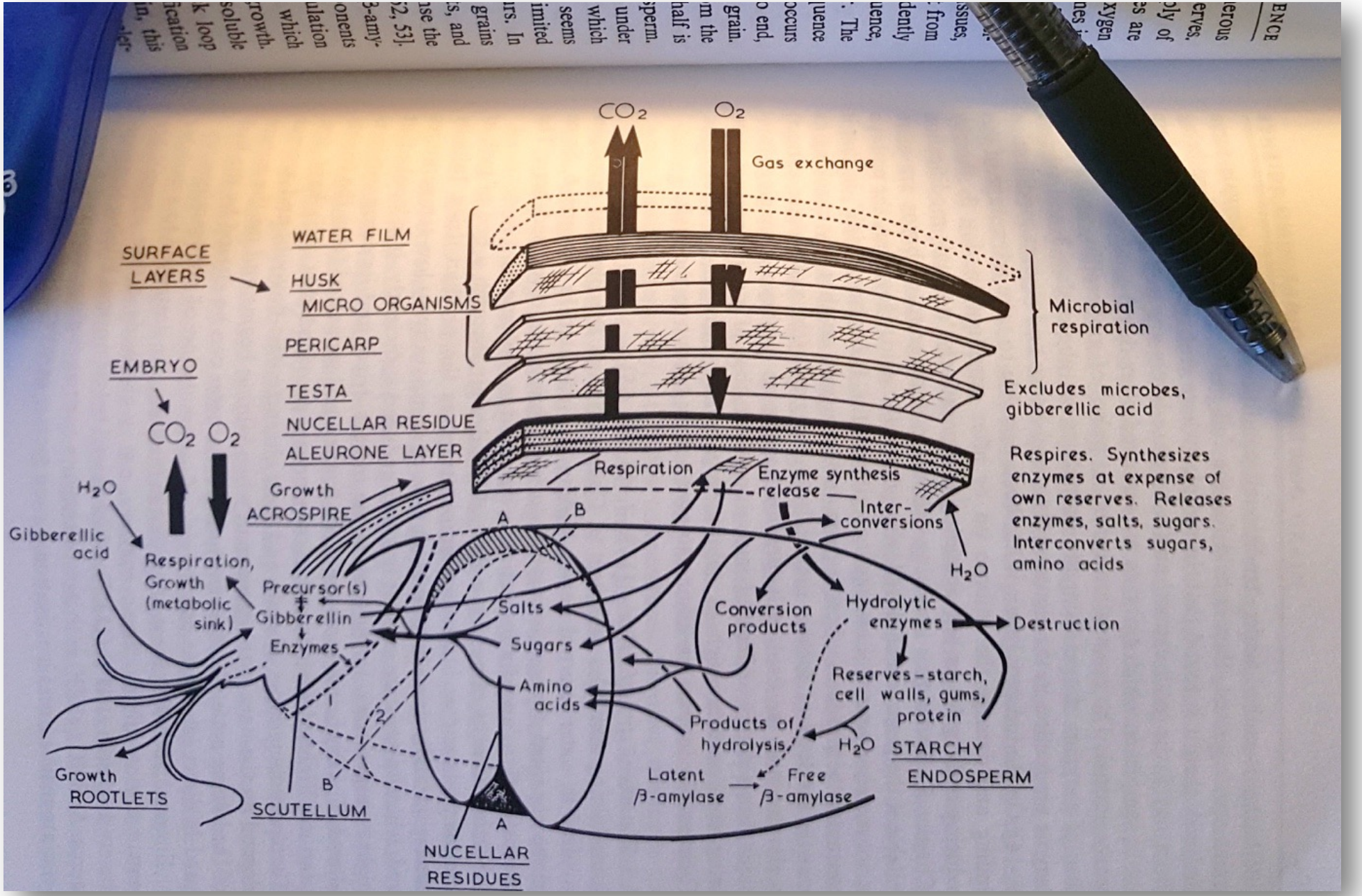
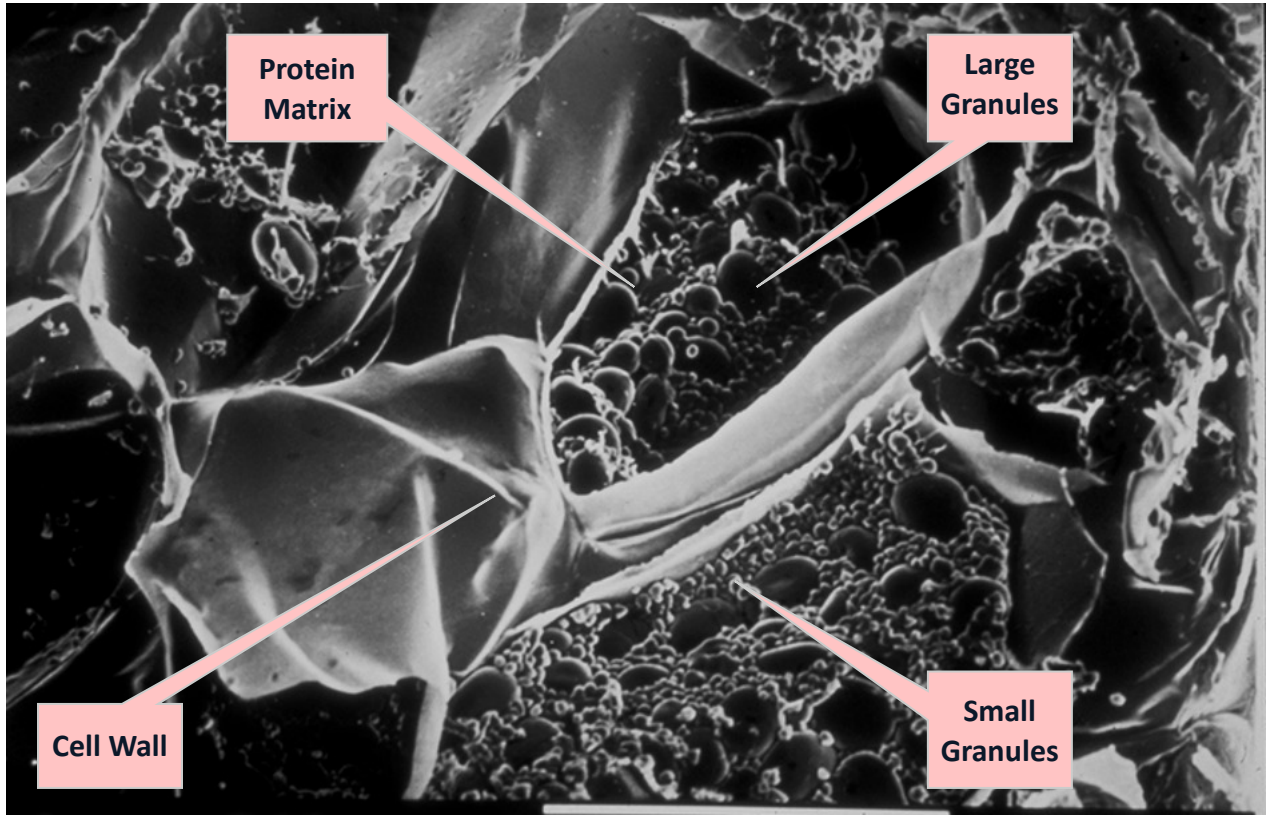
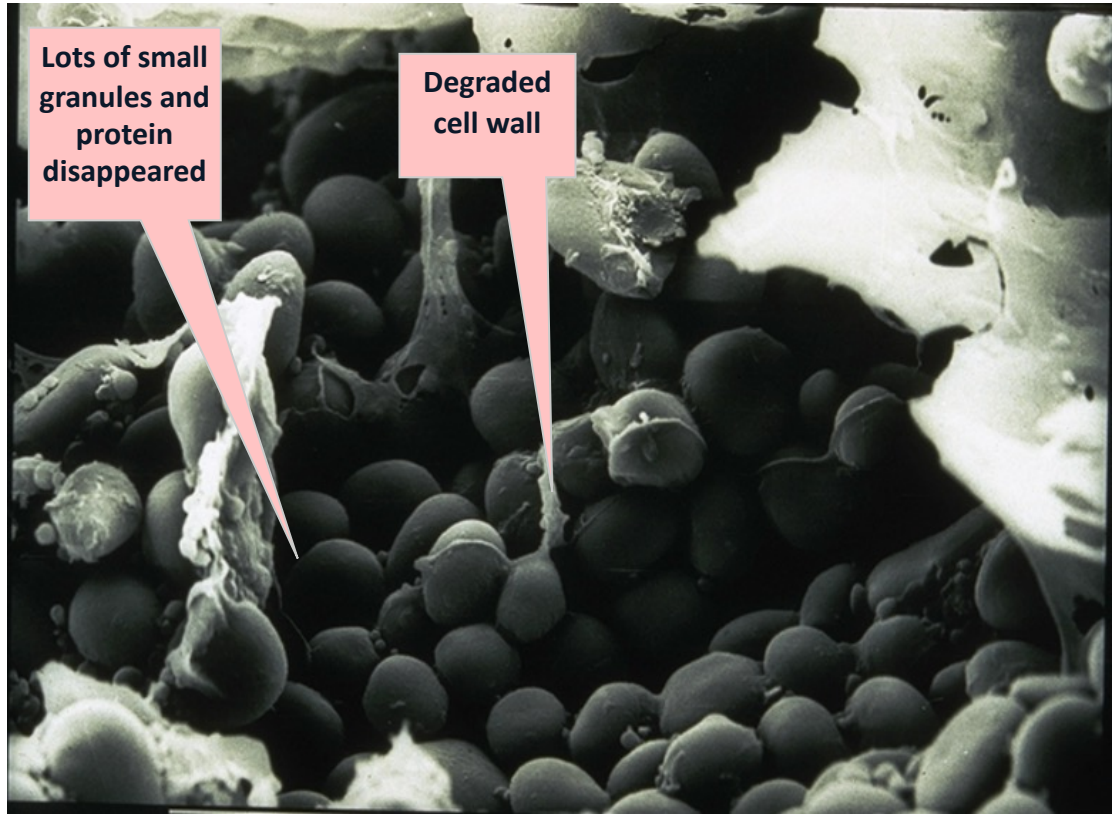


Endosperm Modification During Malting



Barley



Malt

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Kilning

- Temperature and airflows vary to aim for specification targets
  - Modification continuation during withering (free drying)
  - Modification lock-in by end of kilning
  - Color and flavor formation
  - Determination of final malt moisture
- Conversion of S-methylmethionine (DMS-P) into DMS
- Destruction of some sensitive enzymes, especially lipoxygenase, some proteases and beta-glucanase

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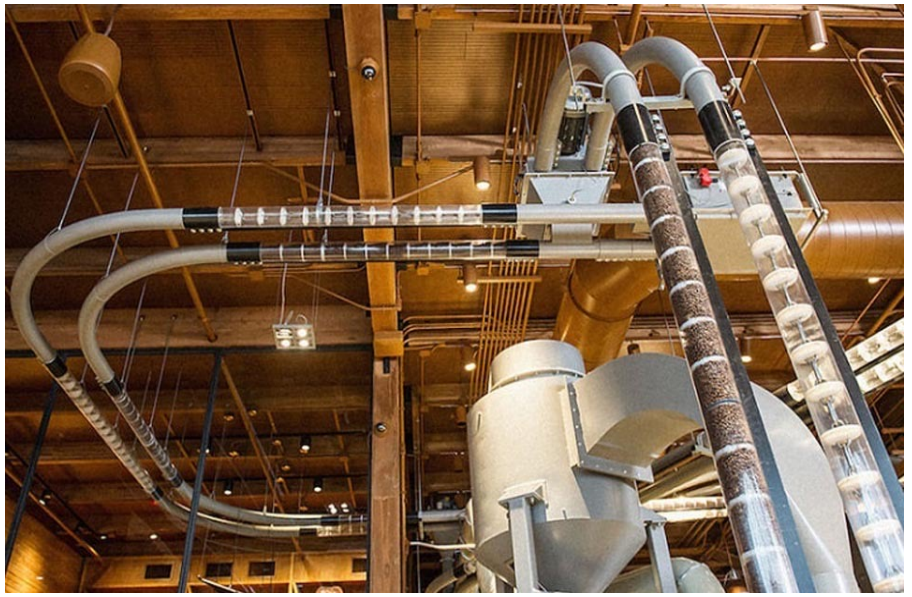
Handling and Storage

- Includes:
  - Transfer into storage silos
  - Movement during malting
  - Truck and railcar loading
  - Transloading
  - Bagging
- Handling dry malt usually causes some damage; malt is easier to damage after initial damage
- Malt quality can also be affected by storage conditions (temperature, moisture, oxygen, pests) and duration



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The Components of the COA

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Dry, Physical Analysis

- Measurements about the physical properties of malt
- No chemical testing involved
- Among the oldest analytical techniques
- Some correlations to chemical properties of malt

Metrics

- ***Assortment (sizing)***
- ***Friability***
- ***Bushel Weight***
- *Purity*
- *Cleanout*
- *Skinned and Broken*

Analyses not typically included in COA

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Assortment

- Kernel size distribution measured using separation screens and reported as %
  - Screens are 7/64”, 6/64”, 5/64”, with a bottom pan
- Kernel size affects malt milling; uniformity is preferred
- Influenced by barley assortment and malting process
- Correlations
  - Bushel weight (+)
  - Extract (+)
  - Total protein (-)

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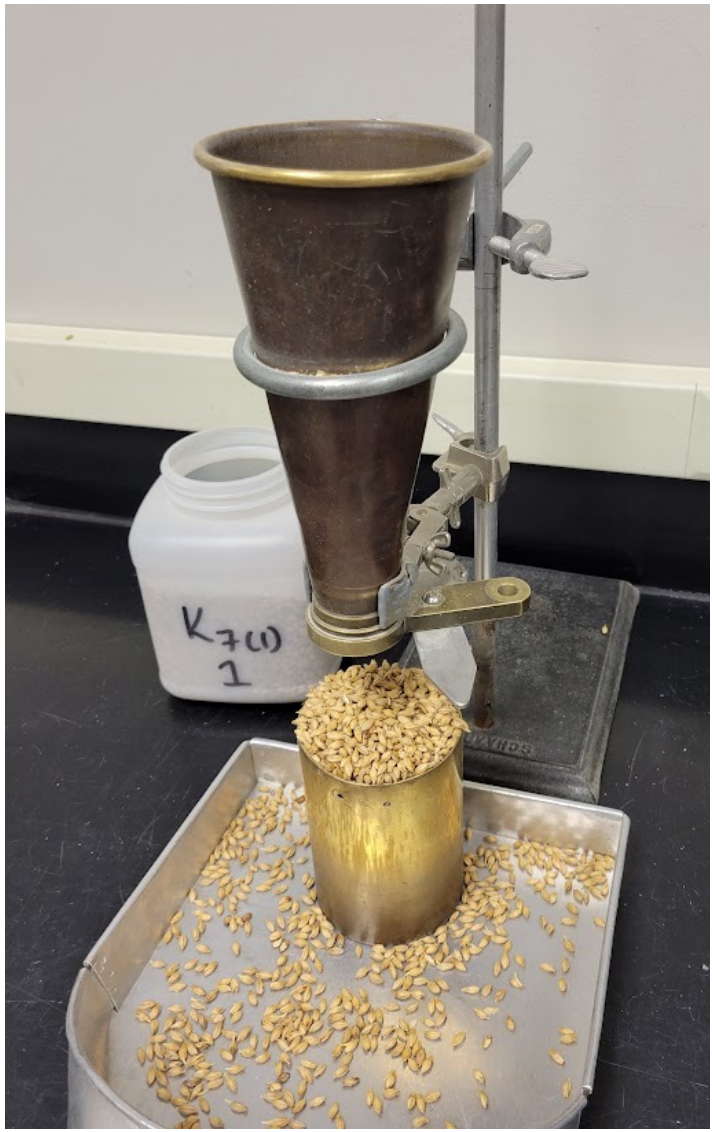
Bushel Weight

- The weight of one bushel (9.31 gal) of grain
- Used to calculate malt volume of a defined volume
- Influenced by grain plumpness, grain type, and purity
    - Huskless grain (e.g., wheat, rye) has higher bushel weight
    - 2-row barley has higher bushel weight than 6-row
    - Straw, chaff or other impurities can decrease bushel weight
- Correlations
    - Assortment (+)
    - Extract (+)
    - Protein (-)



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Friability

- Friability describes how easily malt crumbles
  - % friability = percentage of sample crushed
  - %WK: percentage of whole kernels surviving crush test
- General indication of malt modification and homogeneity
- Mill changes may be required when friability is low
- Under-modified endosperm difficult to crush because of cell walls
- %WK is indicator of dead or dormant kernels going into malting
- Correlations
  - (+) Soluble protein, FAN
  - (-) Beta-glucan, Viscosity

Photos

Top Left: retained malt that was not pulverized

Top Right: Friabilimeter in action

Left: whole kernels and non-friable fragments ready to be weighed

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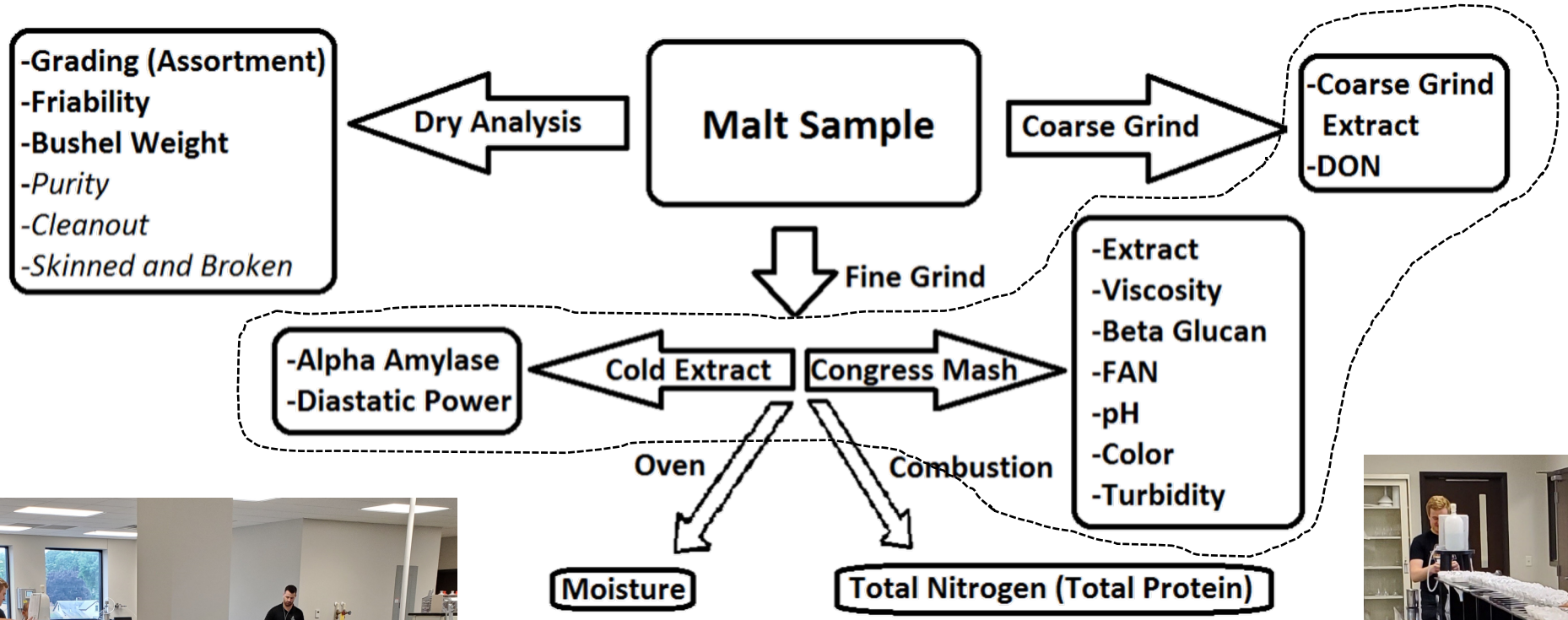
Wet Methods



Lots of hard work!

Wet and Chemical Analysis

- Milling of malt followed by:
  - Congress Mash
  - Cold water extraction
  - Use of chemical reagents, heat, and/or light to examine a chemical or physical property
- These analytical techniques provide more specificity compared to physical analysis
- Results reported as % Dry-basis and/or % As-is
  - % Dry-basis = results expressed as malt without moisture (all malt used for analysis contains moisture)
  - % As-is = results based on malt weight with moisture (how brewers use malt)

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Sample Prep for Wet Analysis

- Congress Mash
  - Produces standardized (congress) wort
    - Coarse and fine grinds of malt mashed separately
    - Temperature ramping allows all mash-relevant malt enzymes to be active; not representative of most modern mash methods
    - Continuous stirring used during mashing
  - Fine grind maximizes extraction of malt carbohydrates, proteins, and color
  - Coarse grind approximates brewery grist
  - Wort is cooled to room temperature and filtered

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Sample Prep for Wet Analysis

- Cold water extraction for enzymatic measurement
  - Fine grind using room temperature water
  - Does not activate enzymes or result in starch conversion
  - Preserves enzymes and allows for measurement
  - 2 hours with intermittent shaking
- Cold water extraction for DON
  - Very coarse grind
  - Less than 10 mins extraction using vigorous shaking and centrifugation for separation
  - Assessed using ELISA method (enzyme-linked immunosorbent-assay)

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Extract

- Total wort dissolved solids after the congress mash
  - Includes sugars, dextrins, polysaccharides, proteins, enzymes, FAN, free ions, and more
  - Reported as % as-is and % dry-basis for fine grind and coarse grind
  - Used to calculate grist weight
- Influences
  - Barley genetics and growing environment
  - Malt modification
  - Grain size
- Correlations
  - (+) bushel weight, assortment, S/T, friability

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Extract: Fine-Coarse Difference

- Fine Grind
  - Laboratory maximum extract
- Coarse Grind
  - Comparable to brewery grist
- F/C Difference
  - Generally considered an outdated metric because modern malts have a low F/C Difference
  - F/C Difference > ~1.5% considered undermodified
- One of the terms we need to know because some brewers still think F/C is relevant

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25-minute mark!

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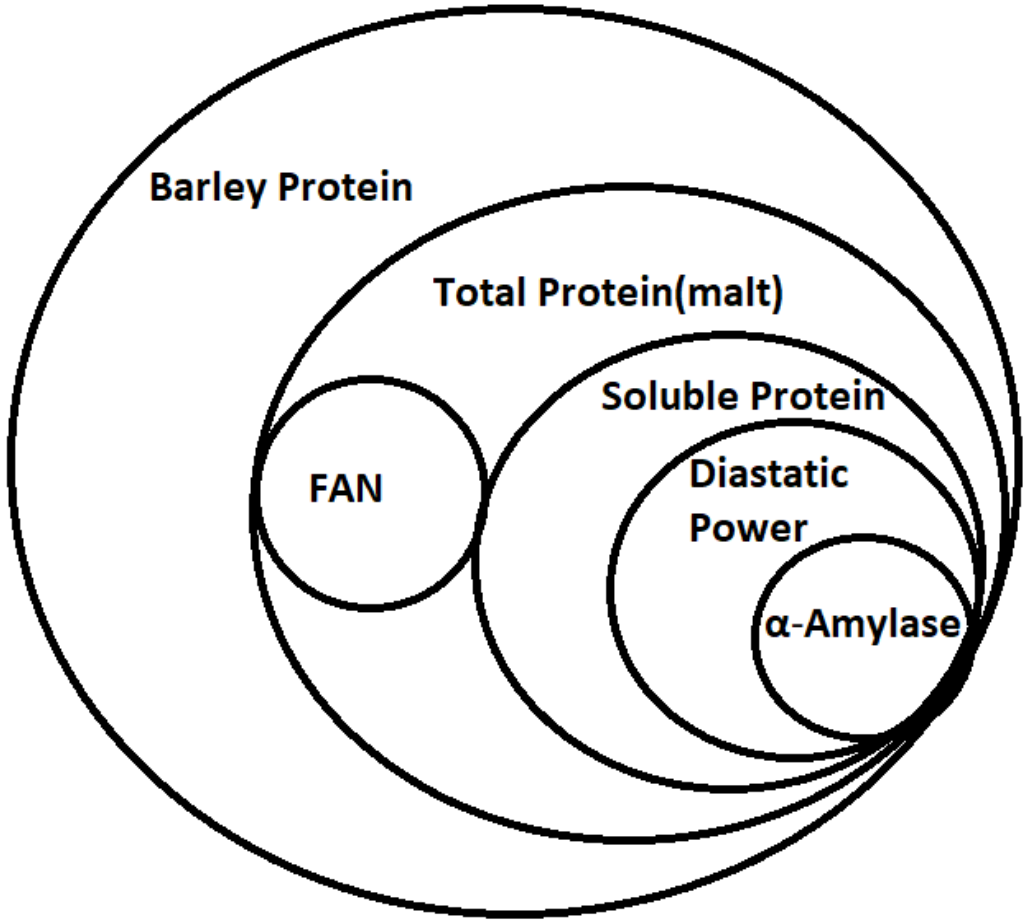
Protein Related Components



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Total Protein

- Reported as % dry-basis
- Importance
  - Source for all protein related components: soluble protein, FAN, enzymes
  - Mashing, color and flavor formation, foam stability all trace back to protein
- Influences
  - 2-row, 6-row, variety, crop year, terroir
  - Grain size
- Correlations
  - (+)diastatic power, alpha-amylase, FAN, soluble protein, S/T
  - (-) assortment, bushel weight, extract

Malt protein contributes important building blocks for all the brewing chemistry

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Soluble Protein

- Percentage of malt protein that dissolves into congress wort
- Importance
  - Color formation during the boil
  - Yeast nutrition in fermentation
  - Foam structure in the final beer
  - Reacts with polyphenols to form beer hazes
- Influences
  - Barley protein
  - Degree of modification
- Correlations
  - (+): FAN
  - The soluble part of S/T

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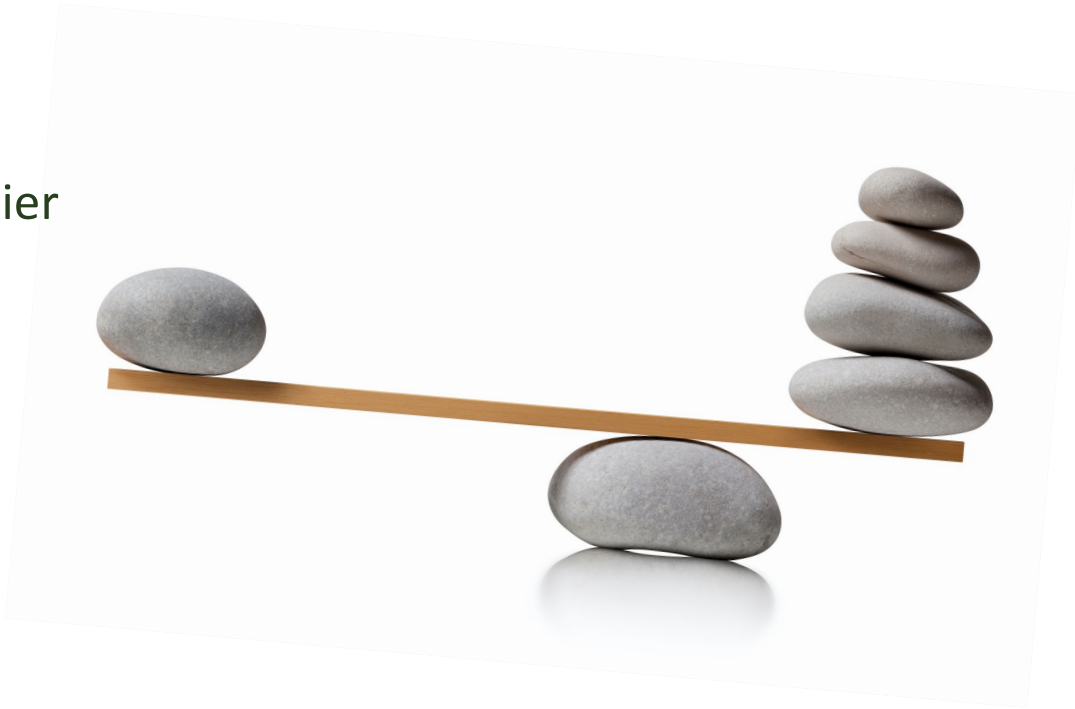
S/T Ratio (aka Kolbach Index)

- Ratio of soluble protein total protein
- General indicator of overall modification
  - Higher S/T value allow for shorter mash and result in easier wort recovery, and higher brewhouse yield
- Influences
  - Barley: total protein, germinative vigor
  - Malting process: germination control metrics
- Correlations
  - (+) friability, FAN, color,
  - (-) beta-glucan, viscosity, F/C difference



S/T is a balancing act

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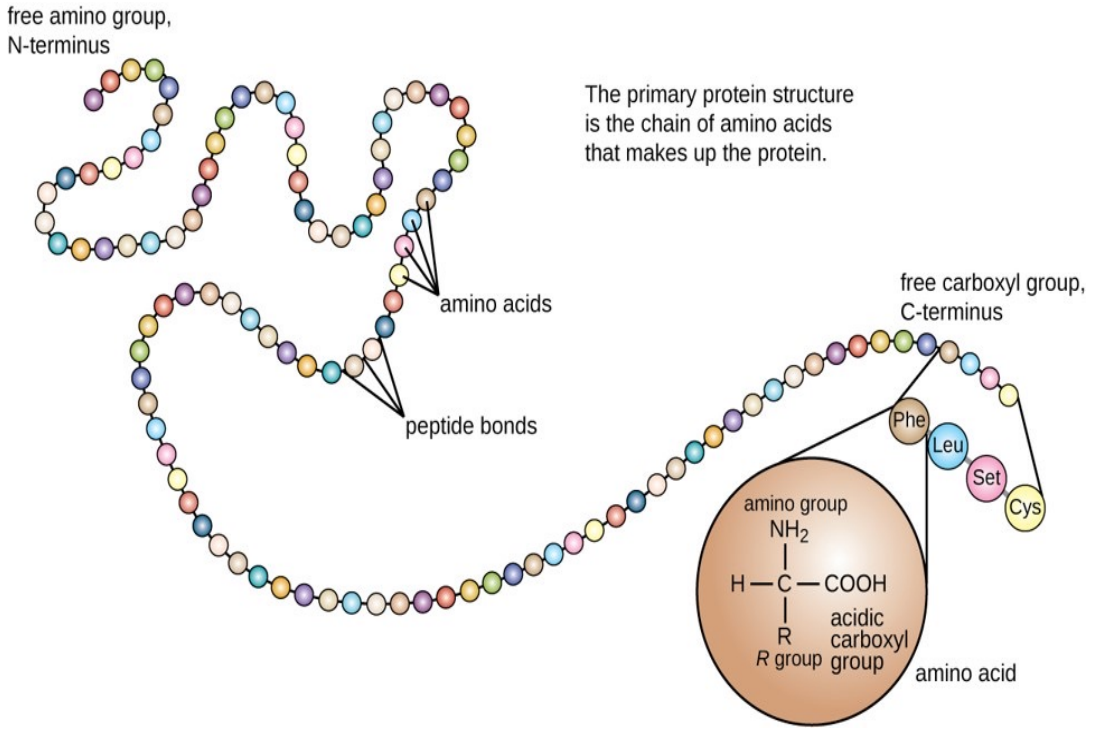
Free Amino Nitrogen (FAN)

- Measure of “free amino” groups at the end of a polypeptide chain. FAN increases as protein hydrolysis occurs in malting.
- Vital to yeast health
- Contributes to color and flavor formation
- FAN surviving fermentation can contribute to beer staling
- Influences
  - Barley protein
  - Modification
- Correlations
  - (+)soluble protein, color, friability
  - (-) beta glucan, viscosity



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Diastatic Power

- Sum of all enzymes that degrade starches into sugars and dextrins
  - Reported in DP units (°L or degrees Lintner, archaic)
- Necessary to convert starch into fermentable sugars
- Adjuncts and specialty malts dilute DP from base malt
- Influences
  - Barley variety, growing conditions, and total protein
  - Barley modification
  - Kilning intensity
- Correlations
  - (+), somewhat: total protein, alpha-amylase, S/T, moisture
  - (-), malt color

Starch granules pitted from enzyme action

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Alpha-Amylase

- Breaks starch into dextrins and some fermentables
- Reported as dextrinizing units (DU)
- Major component of DP
- More stable at high temperatures than other malt enzymes
- Influences
  - Barley: variety, growing conditions, protein level
  - Degree of modification: synthesized during germination
- Correlations
  - (+)DP, moisture, S/T
  - (-)color

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Gums; Non-Starch Polysaccharides

RAHR MALTING CO.

Issued: 01 Jun, 2023

RAHR MALTING CO. SHAKOPEE, MN 55379
952-496-7115 (Theresa Kukar)

Certificate Of Analysis

Customer	Ship Date	Car Number	Grade	Destination
BREWERS SUPPLY GROUP	4/28/2023		North Star Pils	BSG SHAKOPEE WAREHOUSE

Shipment Wt. Lbs.	Rahr Ref No
159,368	0084591BSG

Crop Year	Variety	Percent
	Approved Malting Varieties	100

Assay	Methodology	Shipment	Min Spec	Max Spec
Moisture, %	ASBC-Malt-3	4.12		5.00
Fine Grind, As Is, %		78.3		
Fine Grind, Dry Basis, %, %	ASBC-Malt-4	81.7	79.0	
Fine/Course Difference, %	ASBC-Malt-4	0.3		2.0
Course Grind, As Is, %		78.0		
Course Grind, Dry Basis, %	ASBC-Malt-4	81.4		
Color, SRM	ASBC-Wort-9	1.80	1.50	2.00
Diastatic Power, °Lintner	ASBC-Malt-6C	131	110	180
Alpha Amylase, DU, DU	ASBC-Malt-7D	61.4	50.0	70.0
Total Protein (Leco), %	ASBC-Malt-8B	11.33		12.5
Soluble Protein, %	ASBC-Wort-17	4.78		
S/T Ratio		42.2	37.00	44.00
Viscosity, cP	ASBC-Wort-13B	1.49		1.55
Beta Glucan, mg/L	ASBC-Wort-18B	127		150
Don, mg/L		0.10		0.50
FAN, mg/L	ASBC-Wort-12B	177	150	215
pH	ASBC-Wort-8	5.99		
7/64	ASBC-Malt-2B	71.5		
6/64	ASBC-Malt-2B	20.8		
5/64	ASBC-Malt-2B	6.5		
Thru	ASBC-Malt-2B	1.2		2.0
Turbidity, NTU		10.3		
Friability	ASBC-Malt-12	89.3		
Friability %WK	ASBC-Malt-12	0.36		
bushel Weight, lb/bu	ASBC-Malt-2A	41.2		

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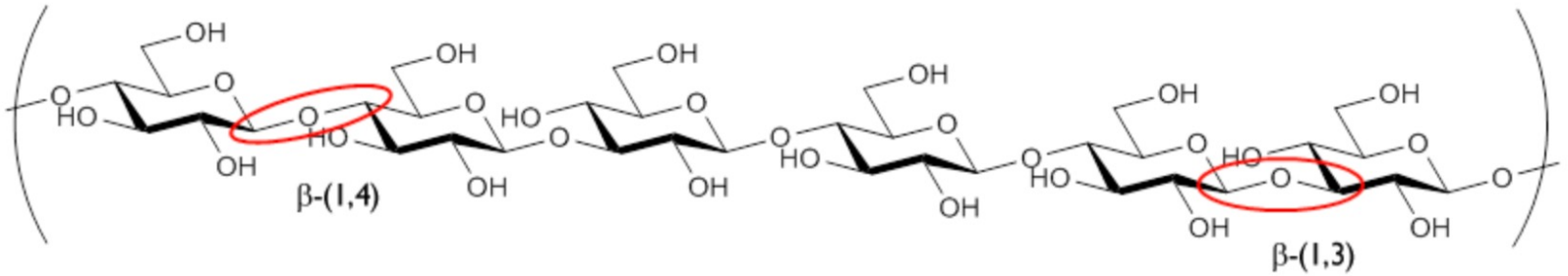
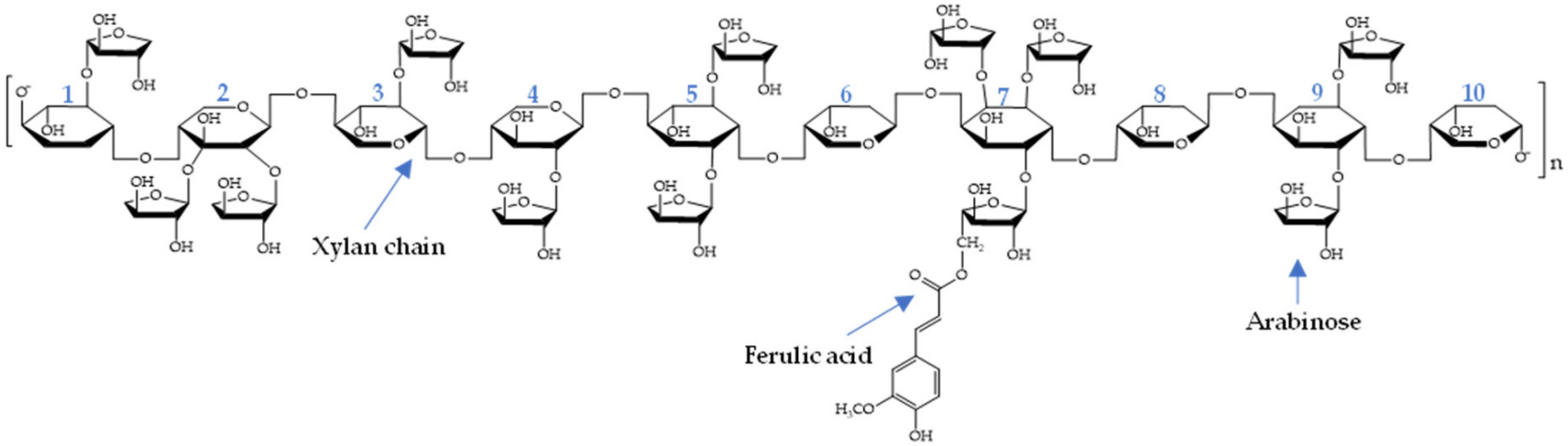
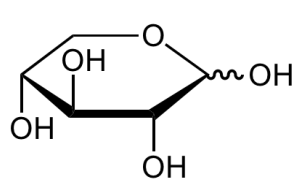
Beta Glucans and Arabinoxylans



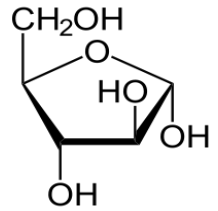
Beta glucan is a glucose polymer with β 1-3 and β 1-4 bonds.



Arabinoxylans contain xylose arabinose (both 5-carbon sugars) and sometimes contain ferulic acid.



Xylose



Arabinose

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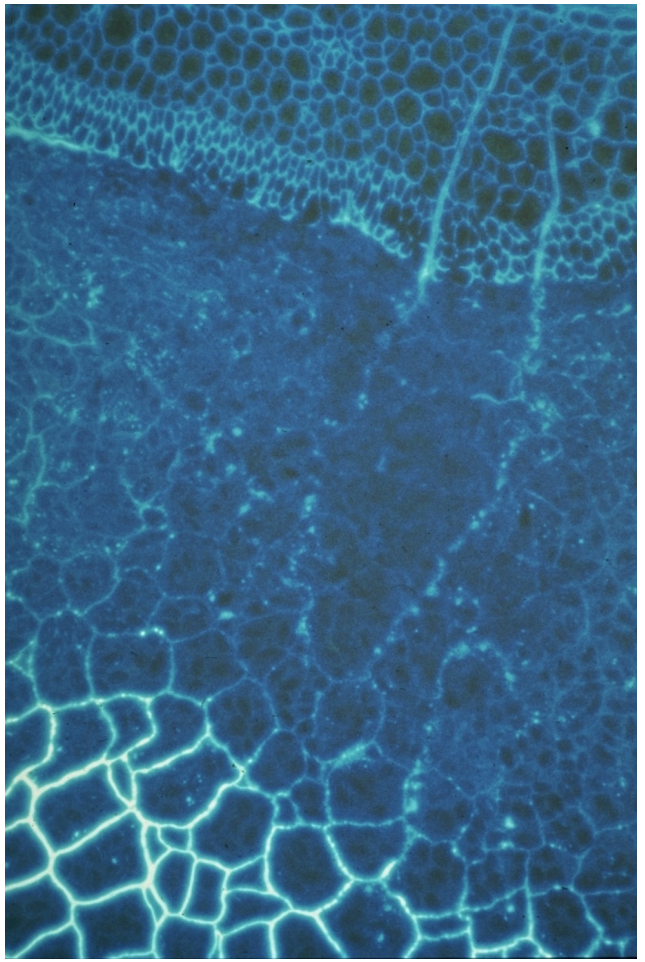
Beta-Glucan

- Primary structural polysaccharide found in barley cell walls
  - Type of dietary fiber
  - Reported in ppm, dry-basis
  - Contributes to wort viscosity
  - Can affect lautering and brewhouse yield
  - Can contribute to beer haze
- Influences
  - Barley: genetics and terroir
  - Modification: direct connection to cytolysis
  - Molecular size: not all β-glucan the same
- Correlations
  - (+) viscosity, turbidity
  - (-) friability, S/T, FAN



Microscopic image of barley endosperm stained with calcofluor. Calcofluor binds β-glucan and fluoureses.

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Viscosity

- Measure of congress wort's resistance to flow
- Reported as Centipoise (cP)
- Indicates ease or difficulty for wort separation (lauter/yield)
- Influences
  - Barley: genetics and terroir
  - Modification: cytolysis breaks down β-glucans and arabinoxylans
- Correlations
  - (+) β-glucan, turbidity
  - (-) friability, S/T, FAN

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Turbidity

- A measure of light scattering in congress wort
- Reported in NTU (Nephelometric Turbidity Units)
- High levels may be associated with lautering issues or haze in beer
- Influenced by modification
- Weakly correlates with:
  - (+): beta-glucan, viscosity, maybe color
  - (-): soluble protein, S/T, FAN

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Color

- Defined by the color of the congress wort
- Determined by measuring absorbance of 430 nm light in a spectrophotometer
- Expressed in SRM, EBC, IOB, or Lovibond units
- Used in recipe calculations to estimate beer color
- Influence by modification and kilning schedule
  - Modification increases FAN and reducing sugars (Maillard reactants)
  - Kilning schedule major driver of color development
- Correlations
  - (+): soluble protein, S/T, FAN
  - (+): flavor (bready, caramel, roasted, etc.)
  - (-): diastatic power and alpha-amylase

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Moisture

- Water content of malt
- Measured by completely drying finely ground sample and measuring change in weight
- Reported as % moisture by weight
  - High moisture: reduces malt stability (flavor, enzymes, pests)
  - Very dry: increases susceptibility to damage during handling
  - Used to calculate dry-basis malt values in brewing math
- Influenced by kilning and storage after kilning
- Correlations (sometimes)
  - (+): diastatic power, alpha-amylase
  - (-): color, friability, dusty malt (not a COA value)

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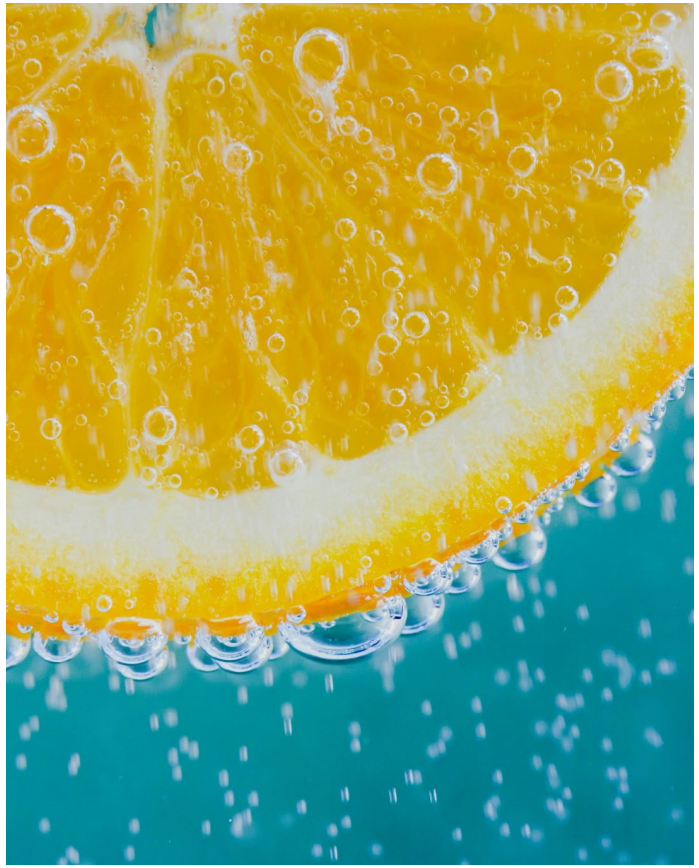
pH

- Measurement of the acidity or basicity of the congress wort
- Malt pH usually in the pH 5-6 range
- COA pH is a predictor of mash pH
- Mash and wort pH influence enzyme activity, color and flavor development during wort boiling, and hop acid isomerization
- Influences
  - Barley genetics and terroir
  - Malt modification, lactic acid bacteria (anaerobic bed), kiln temperature
  - Steeping water chemistry
- Correlates with malt color, especially in specialty malts



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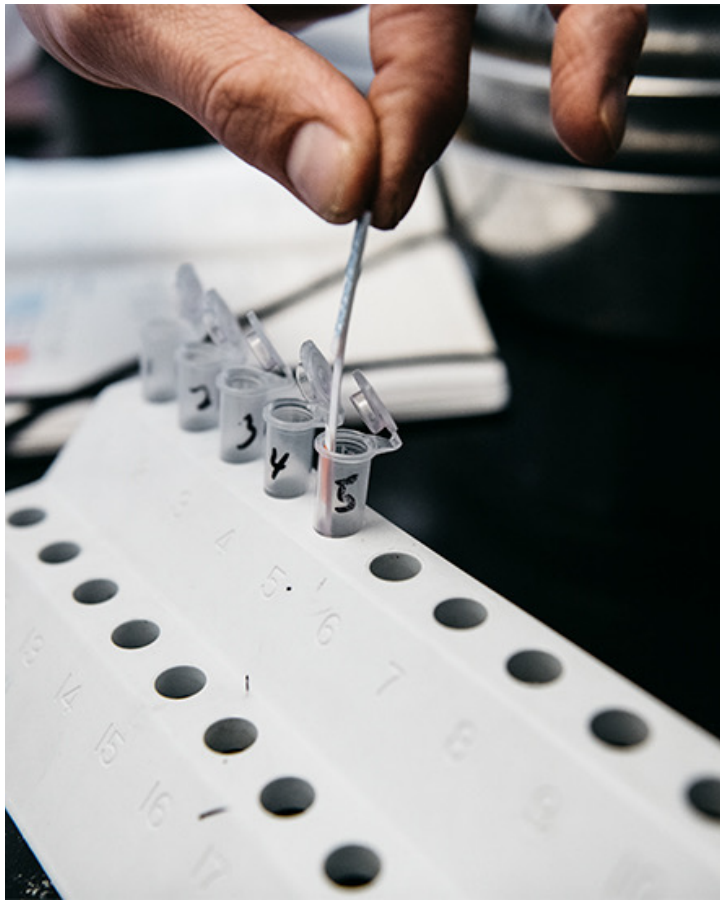
DON (Deoxynivalenol)

- Produced by Fusarium Head Blight (fungal disease affecting cereals)
- Measured by ELISA assay and reported in mg/L or ppm
- Commonly called vomitoxin because causes vomiting
- Legally regulated to ensure food safety (1 ppm maximum)
- Associated with beer gushing in packaged beer and premature yeast flocculation (PYF) issues during fermentation
- Influences
  - DON measurement of barley
  - DON levels in cereal grains drop during storage
  - DON is water soluble; levels drop during after steeping
- No COA correlations



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45-minute mark!

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Summary

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COA Summary

- **Color**
  - Used in brewing calculations
  - Flavor expectations
- **Extract**
  - Critical in brewing calculations
- **Assortment** & **Friability**
  - Influence mill setting
  - Relates to extract efficiency in brewing
- **DP & AA**
  - Dictates adjunct usage in recipes
  - Short or long mash?
- **FAN**
  - Must have enough for yeast nutrition
  - Excess can lead to beer flavor instability
- **Soluble Protein**
  - Relates to wort color and flavor development
- **Viscosity, Beta-glucan, F/C diff, S/T**
  - All are indices of modification
  - Malt modification influences brewing process
- **Crop Year and Varietal Composition**
  - Genetics + terroir is especially important with crop year changes

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Questions?

Review Questions

1. What is the difference between a malt specification and a COA?
2. Two lots of malt have identical COAs, but the malts behave very differently in the brewery. Based on what you understand about how malt is made, what is a possible explanation of this? Note that this question is not specifically covered in this section and answering requires recalling material from other sessions. Also note that there are several correct replies.
3. Why is the congress mash used for malt analysis?
4. List 3 indices of modification.
5. Why do some brewers prefer malt that is lightly modified?
6. You have a customer who is a bit lax when it comes to reviewing malt COAs. For such brewers, when is a good time to take special note of their malt COA?

RAHR

Thank You!

Ashton Lewis

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