Malt Analysis

Western New York MBAA
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Canada Malting

Great Western Malting Co.

Objectives of Malt Analysis

External Focus - Customers: Brewers and Distillers

- To give an indication how the malt will perform in the brewery
- To ensure that malt meets contractual specifications
- To meet Food Safety Requirements
- To compare one malt against another, ie monitor consistency

Internal Focus - Maltsters

- To optimize malting process
- To be able to ship consistently to customer expectations
- To compare one malting process against another

Types of Malt Analysis

Standard Testing

- Physical Testing
- Wet Chemistry Analysis

Specialized Testing

- Food Safety
- Customer Specific
- Fermentability
- Customer Requests

Physical Malt Analysis

- Sizing/Assortment – metric & imperial
- Friability
- Bushel/Hectolitre weight
- Growth Count (acrospire length)
- Mealiness
- 1000 Kernel weight
- Damage
- Foreign Seeds
- Dust

Wet Chemistry Analysis

Malt Analysis

- Moisture
- Extract – fine and coarse
- Alpha Amylase
- Fine-Coarse Difference
- Malt Protein
- Diastatic Power

Wort Analysis

- Moisture
- Soluble Protein
- Free Amino Nitrogen
- Sensory Testing
- Colour
- Betaglucan
- Turbidity
- Viscosity
- Saccharification
- pH
- S/T

Specialty Analysis

- DMSP (Dimethyl Sulfide Precursor)
- Sulphur Dioxide
- Fermentation
- Deoxynivalenol (DON)
- Lactic Acid
- LOX (Lipoxygenases)
- AAL (Apparent Attenuation Limit)
- Pesticide Testing
- Customer Requests
- Calcofluor Modification Test
- N-Nitrosamines

Congress Method Lab Equipment

Grinding

Mashing

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Congress Method Lab Equipment

Filtration

Protein Analysis

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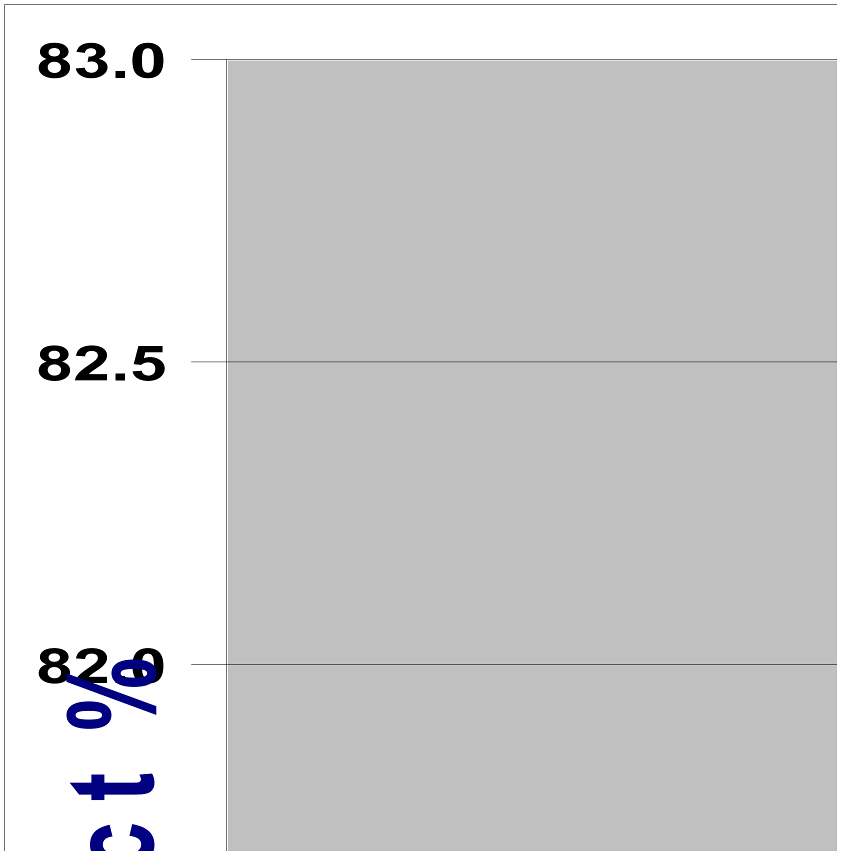
Sizing/Assortment



Kernel Plumpness

- Measured by passing sample over screens of different widths.
- Mill settings. Related to Extract, Protein
- Plumper the kernel the higher the extract.
- Specification varies widely dependent on customer and variety.
- More homogeneous kernel, better brew house performance.

Friability/Homogeneity/Whole Kernels

Friable Malt = easily crumbled or pulverized.

Homogeneity = measure of the % of malt that is friable and smaller than 2.2mm after milling in a Friability Meter, the rest is under-modified or unmodified.

Whole Kernels = unmodified malt and/or highly vitrified.

- Friability = Indication of degree of Modification, impacts milling & brew house yield via Milling and Mashing (exposure of kernel to enzymes).
- Poor values can cause issues with run-off performance, haze, poor extract.
- Typical Value - Friability >75%, Homogeneity >96%,Whole Kernels <2%
- Over-all Friability is a good general measure of malt modification.
- Easy rapid test at time of shipping and in malting process.
- Steeping and Germination >> Ensure proper malt modification

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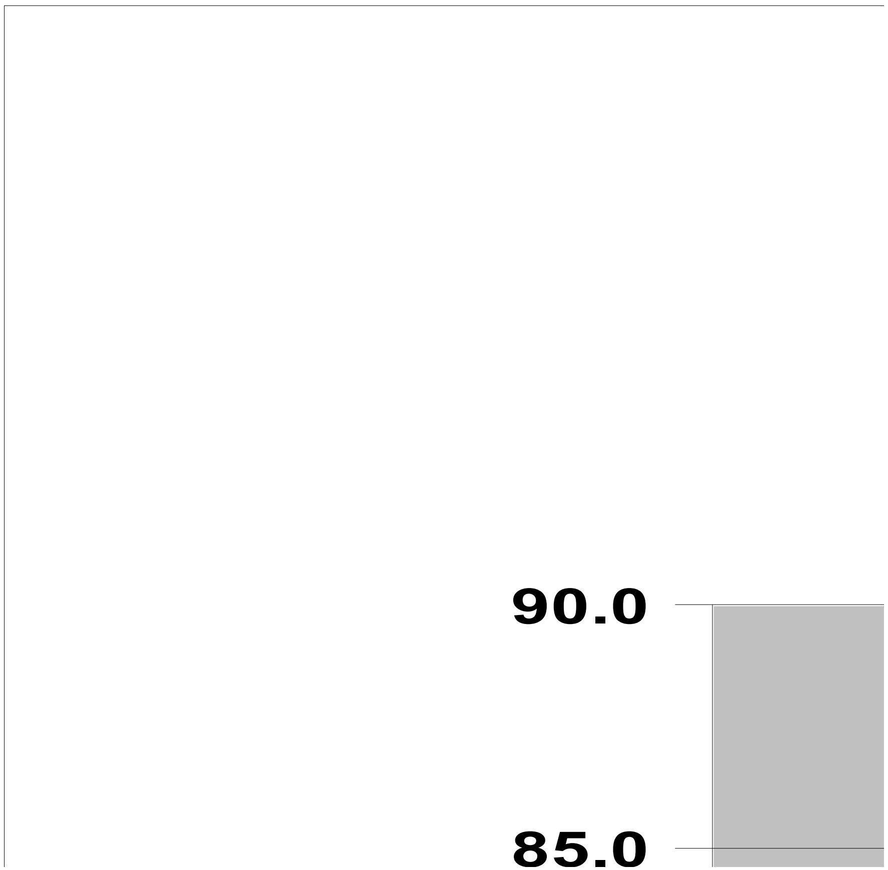
Friability



The relationship of Friability to Betaglucan is dependent on the degree of modification, protein and the barley variety.

Dust

- Aspirated away - loss of malt yield
- Health (allergic reactions, chronic issues)
- Safety (Explosion)
- Fines in brewhouse - poor run off, turbidity
- Heterogeneous malt mass
- Housekeeping

Damage

- Increased dust
- Less husk for filter bed in lautering
- Broken corns can take up moisture
- Broken corns encourage mould & insects
- Increased losses.
- Large amount of chaff at the bottom of the silo
- Loss of Husk/Dust through a malt cleaner, following a pneumatic transfer is usually ~2 – 3%, with a potential extract of ~25 - 30%

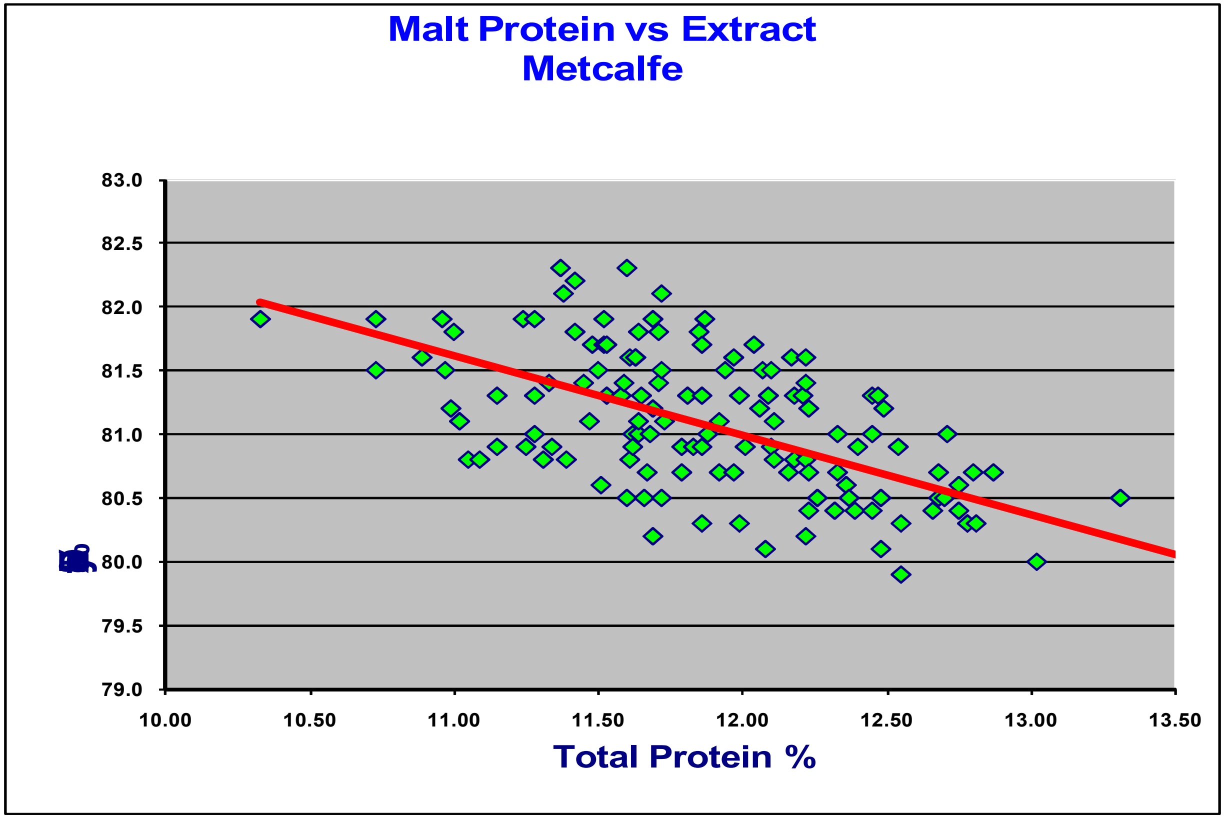
Malt Moisture

- Typical value - 3.5% to 4.5%
- Too dry – damage and dust can increase during handling and transportation.
- Too wet – mould issues, flavour issues.
- In the Lab - used for calculation of 'dry basis' results.
- Commercial reasons - "water vs. malt".
- Seasonal impacts on colour.

Extract

- Calculated from a Laboratory Mash
- 90 to 92% carbohydrates
- Remaining = Nitrogenous substances, Polyphenols, Salts, etc
- Coarse extract – generally the maximum figure achievable in the brewhouse.
- Fine extract - theoretical figure
- Good correlation of brewhouse yields from lab yields
- “As Is” vs “ Dry Basis”
- A drive to a higher extract results in: increased colour, higher S/T, higher friability.

Extract



- Important in brewhouse yield
- Related to variety, protein, and modification
- Specification is 78% to 81.0

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Limits with Laboratory Extracts

- Laboratory Extracts only a predictor of brewhouse yield
- Milling not the same as breweries
- Lab Mash is Congress Method
- Breweries do not use distilled water
- Lab mashes are much thinner
- Breweries use a range of temperature programmes
- No sparging of spent grain in lab mashes
- Using sucrose tables to predict % extract has inherent problems
- Little control of filtration
- Little information on run-off etc

Fine – Coarse Difference

Indirect measure of malt modification

- Fine Grind Extract % – Coarse Grind Extract % = Fine/Coarse Difference
- Under-modified malt yields a higher result:
- Endosperm less "broken-down" / "modified"
- Cell walls in the endosperm less disrupted
- Less exposure of starch granules/endosperm exposure to enzymes

Analytical Limitations

- Difficult to reproduce exact two types of grist required
- Time consuming and costly analysis
- Poor test for statistical evaluation

Typical Value for well-modified malt - < 1.5%

New methods are a better indicator of modification

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Wort Colour

General correlation with Beer Colour

- Consistency is essential.
- Soluble Protein & brewing process also contributes to beer colour.
- Wort colour method is the Congress Method – Does not include a boil.

Direct correlation with malting conditions

- Kilning process >> inherent increase in colour (and flavour)
- Heat as catalyst of the complex “Maillard Reaction”: (amino acids, oligopeptides and polypeptides + carbohydrates) = “Colour”
- Steeping and Germination >> highly-modified malt = higher colours

Colour Comparators or Spectrophotometers are used for analysis

Typical Value for Pale malt: 1.5 - 2.5 ºASBC or 3.5 - 5.5 EBC units

Alpha Amylase, DU (Dextrinizing Units)

Degradation of Starch

- In Mashing, Alpha amylase together w/ beta amylase, ensures complete saccharification and ‘production’ of fermentable sugars (70 to 75% wort fermentability)
- Activity stabilised in presence of Calcium ions

Malting conditions

- Germination >> steady low temperature = higher a-amylase production
- Alpha is produced in the Aluerone Layer, triggered by the hormone Gibberellic Acid
- Kilning >> a-amylase less readily degraded (more thermostable) than beta amylase
- Barley variety & growing season can significantly impact

Typical Value - 40 to 60 DU

Brewers with Decoction / Step Mashes may prefer lower values “Cooler Malt”

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Diastatic Power, ºDP or ºW-K (Windisch-Kolbach), EBC

Indication of β -amylase and Limit Dextrinase activity

- Mashing >> Mostly important when adjuncts are used for brewing as high enzymatic activity is required

Malting conditions

- Germination >> frees b-amylase attached to insoluble proteins
- Kilning >> has to ensure enzymes are preserved (ca 20-30% lost)

Typical Value - 100 to 180 ºDP, <150 for All-Malt grists

Considerations:

- β -amylase present in barley, not synthesised during germination
- Dependent on variety, agricultural procedures and climate conditions (barley physiology in the field)
- DP directly linked to protein content of barley.
- DP can be affected by kilning.

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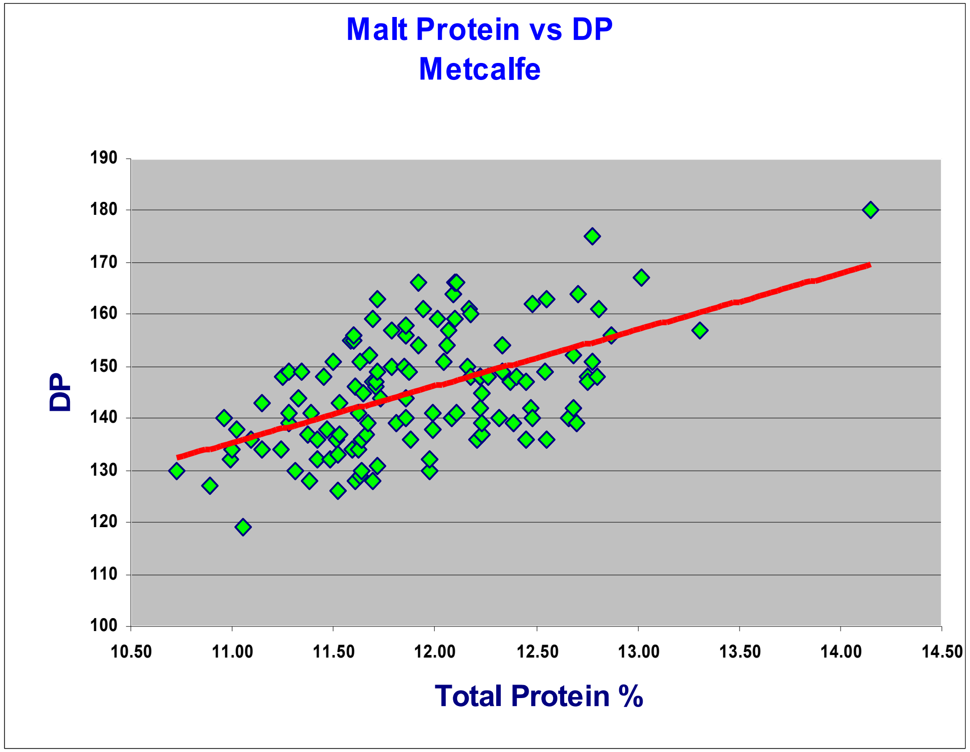
β-Amylase - Diastatic Power



- Level strongly influenced by Total Protein
- Barley variety and growing season also impact
- Virtually all solubilised during malting
- Thermolabile (ca 20-30% lost in kilning)

Malt Protein, % dry basis

Total Nitrogen Determination (TN)

- Kjeldahl (digestion of organic material)
- Dumas Techniques (sample combustion and nitrogen reduction)
- NIR (Near Infra-Red) Method now more commonly used
- Determined from solid (malt) samples – not from wort

Malt Protein = 6.25 x TN

- Very dependent on barley varieties and crop conditions
- Inverse correlation with Extract

Affects Brewing Process and Beer Stability

- High >> wort clarification and beer filtration/stability - haze
- Low >> poor foam, ‘empty’ body, potential enzyme deficiency

Wide range - 9.0 to 13.5%

Wort (Soluble) Protein, % dry basis

Soluble Nitrogen Determination (SN)

- Determined from wort – not malt, thus represents the "Soluble" portion of the protein

Wort Protein = 6.25 x SN

- Very dependent on barley varieties and crop conditions
- Composed of peptides, FAN, low molecular weight polypeptides
- Germination
  - Length impacts Protein modification
  - Long periods/High-modification = High SN

Affects Brewing Process and Beer Stability

- Beer Stability - haze, foam; Colour and Flavour; Yeast growth

Specification range: 4.5 - 6.0%

Soluble : Total Ratio, % (ASBC) or Kolbach Index, KI (EBC)

Malting Process

- Indication of Overall Modification and Protein Modification
- Germination Time >> Longer, yields a Higher S/T Ratio
- Low Total Protein barley modifies faster = Higher S/T Ratio

Brewing Process and Beer Stability

- Indication of beer stability - Haze, Use of Stabilisers (e.g. PVPP), Foam
- High S/T drives a higher colour, both in malt, and in brewing process
- High S/T increases SMM (DMS-Precursor)
- Lower S/T Ratio >> Poor lauter & filter performance = Longer times, higher wort losses
- Lower S/T can affect Fermenatability and Attenuation due to potential FAN deficiency
- Lower S/T Ratio >> Turbidity, Increase foam stability.

Typical Value - 40 to 48%

Free Amino Nitrogen (FAN), mg/L

Measurement of total free amino acids in lab wort (colorimetric method)

Malting Process

- 50% to 70% of FAN may be pre-formed in malt
- During Germination >> hydrolysis of proteins = FAN increase

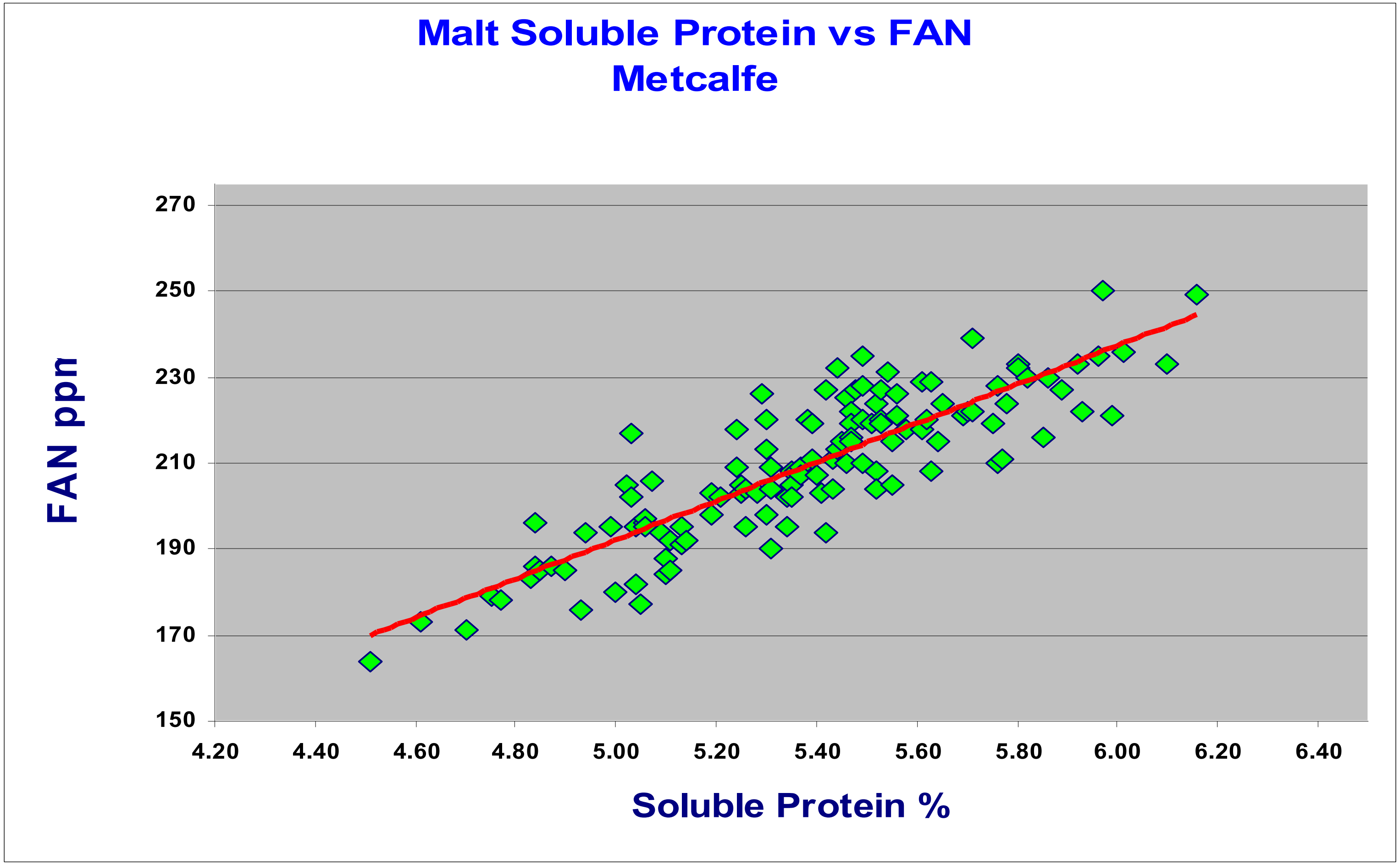
Relation to Brewing Process

- Important role as yeast nutrient > cell wall, protein synthesis = yeast growth
- Amino Acid synthesis and assimilation by yeast >> impact on beer flavour
- Low FAN may lead to poor yeast nutrition
- High Adjunct Beers may require increased FAN to avoid Diacetyl

Minimum required = 150 mg/L (up to 250 mg/L)

FAN vs Soluble Protein

Good correlation to soluble protein & degree of modification.



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Wort β-Glucan, mg/L

Malting Process

- Barley β-glucan content depends upon varieties and to a great deal upon growing season
- Under-modified malts >> Higher β-Glucan level
- Main contributor to high viscosity in wort
- Steeping and Germination >> ensure proper malt modification
- Degraded by β-glucan solubilase, endo-b-glucanases
- β-glucan solubilase continues to work in Kilning (slow drying at low temp.)
- Indication of modification

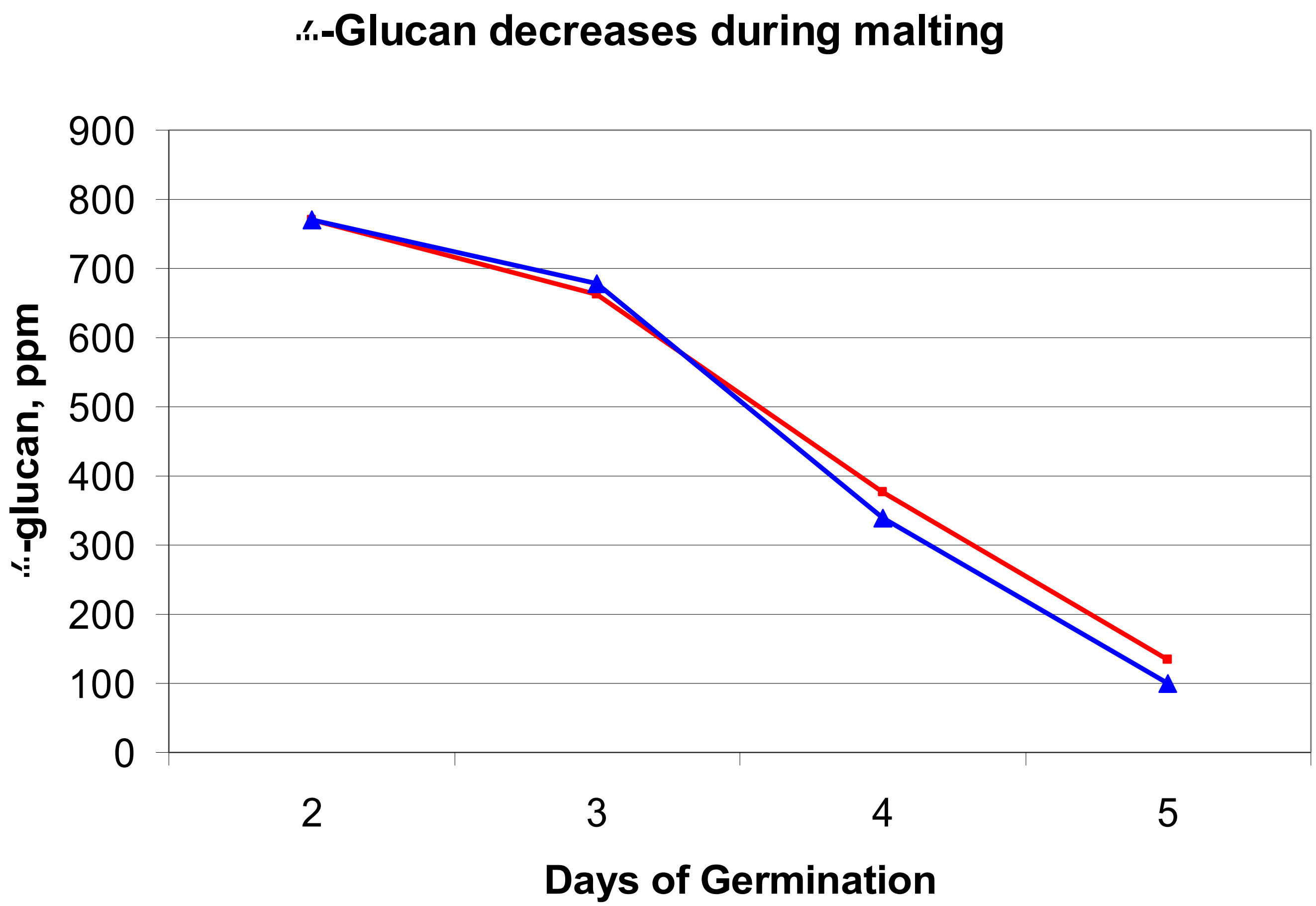
Relation to Brewing Process

- BG is directly correlated to Run-off performance, Beer filtration and Haze problems
- When β-glucans high > some brewers add heat-stable glucanase

Typical Values < 120 mg/L – Highly dependent on customer specifications

- High values will cause brewing problems
- Brewers with membrane filters very sensitive to higher β-glucan levels > 150 mg/L
- Many brewers now establishing minimum BG levels

B-Glucan Decrease during Malting



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Wort Viscosity, cP

Malting Process

- Under-modified malts >> Higher Viscosity
- Factors contributing to wort viscosity:
    - β-Glucans
    - Pentosans
    - Proteins
- Steeping and Germination >> ensure proper malt modification

Relation to Brewing Process

- Directly correlated to Run-off performance, sometimes to beer filtration and haze problems
- Mash oxidization > complex gel-protein that slow down Run-off process
- Typical Value - 1.35cP to 1.60cP (problems over 1.80cP)

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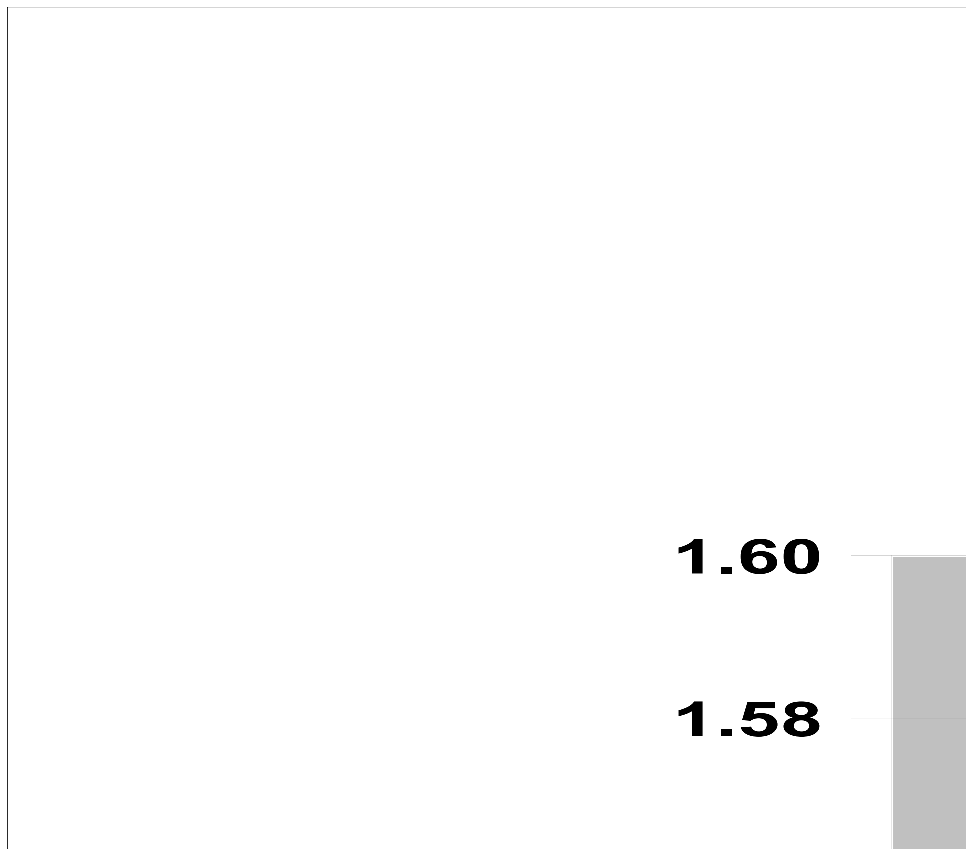
Wort Viscosity vs BG

Very good correlation between Viscosity and Betaglucan



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Dimethyl Sulphide (DMS) + precursors, mg/L

Importance >> Beer Flavour

- "onion", "sweet corn", "cooked vegetables" aroma
- Flavour Threshold in beer at 30 µg/litre, at above 100 µg/l can give negative flavours

Precursors:

- S-Methylmethionine (**SMM**) >> converted into DMS and eliminated during Kilning
- Dimethylsulphoxide (**DMSO**) >> reduced to DMS by yeast (potential problem)

Malting Process

- Barley >> rich in Nitrogen (amino acid Methylation) = higher SMM content
- Well-modified malt = higher SMM content
- Kilning > Time and High Cure Temperature = SMM elimination

Relation to Brewing Process

- Wort Boiling reduces SMM to DMS via heat, DMS (Hydrophobic) lost in steam during boiling. Vigorous boil & short whirlpool stand important.
- Fermentation (DMSO to DMS)

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How are Brewing and Malting Processes Correlated?

The Malting Process

- *Steeping*
- *Germination*
- *Kilning*
- *Malt Cleaning*
- *Blending*

Malt Moisture

The Brewing Process

- *Malt Storage*
- *Milling*
- *Mashing*
- *Wort Filtration*
- *Wort Boiling and Cooling*
- *Fermentation and Aging*
- *Beer Filtration*
- *Beer Stability, Flavour & Appearance*

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Extract and Fine-Coarse Difference

The Brewing Process

- *Malt Storage*
- *Milling*
- *Mashing*
- *Wort Filtration*
- *Wort Boiling and Cooling*
- *Fermentation and Aging*
- *Beer Filtration*
- *Beer Stability**

* Flavour/Appearance

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Wort Colour

The Brewing Process

- *Malt Storage*
- *Milling*
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* Flavour/Appearance

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Diastatic Power & Alpha Amylase

The Brewing Process

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- *Mashing*
- *Wort Filtration*
- *Wort Boiling and Cooling*
- *Fermentation and Aging*
- *Beer Filtration*
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* Flavour/Appearance

How are Brewing and Malting Processes Correlated?

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The Malting Process

- *Steeping*
- *Germination*
- *Kilning*
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- *Blending*

Malt Protein, Wort (Soluble) Protein and S/T Ratio

The Brewing Process

- *Malt Storage*
- *Milling*
- *Mashing*
- *Wort Filtration*
- *Wort Boiling and Cooling*
- *Fermentation and Aging*
- *Beer Filtration*
- *Beer Stability**

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* Flavour/Appearance

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How are Brewing and Malting Processes Correlated?

The Malting Process

- Steeping
- Germination
- Kilning
- Malt Cleaning
- Blending

Wort Viscosity

Friability, Homogeneity

Wort β-glucan

The Brewing Process

- Malt Storage
- Milling
- Mashing
- Wort Filtration
- Wort Boiling and Cooling
- Fermentation and Aging
- Beer Filtration
- Beer Stability*

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* Flavour/Appearance

How are Brewing and Malting Processes Correlated?

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The Malting Process

- *Steeping*
- *Germination*
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- *Blending*

Wort Fermentability and FAN

The Brewing Process

- *Malt Storage*
- *Milling*
- *Mashing*
- *Wort Filtration*
- *Wort Boiling and Cooling*
- *Fermentation and Aging*
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* Flavour/Appearance

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How are Brewing and Malting Processes Correlated?

The Malting Process

- $^{35}_{17}$*Steeping*
- $^{35}_{17}$*Germination*
- $^{35}_{17}$*Kilning*
- $^{35}_{17}$*Malt Cleaning*
- $^{35}_{17}$*Blending*

Dimethyl Sulphide, Sensory Analysis

The Brewing Process

- $^{35}_{17}$*Malt Storage*
- $^{35}_{17}$*Milling*
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- $^{35}_{17}$*Beer Stability**

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* Flavour/Appearance

Conclusions

- Malt specification depends on customer requirements/needs with input from what is available in the crop
  - Quality = *"Fitness to use"* (Juran, 1974)
  - Quality = No brewing problems, flavour stability, shelf life, consistency

- Good barley + Good Malting Practices = Homogeneous Malt
  - Homogeneous Malt > a consistent brewing is possible

- Essential > Good communication - Brewers and Maltsters and Farmers