Introduction to

Malts & Malting

A learn2brew presentation
By
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Barley: Main Raw Material

Ca.150 million tonnes grown worldwide.

Approx. 6 milllion tonnes grown in UK per annum

Of which 2 million tonnes suitable for brewing/distilling.

- 2 row – Hordeum Distichon (UK, Europe, some USA)
- 6 row – Hordeum Vulgare (USA and some Europe)

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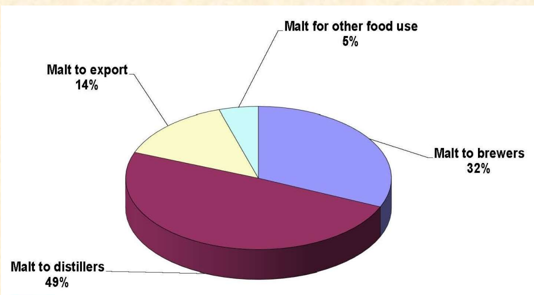
Use of UK Malt 2016



Slide courtesy of MAGB

Why is Barley Used for Brewing?

- Tradition – limited food value.
- Wide growth distribution giving high availability with lower requirements for climate and soil
- Grain contains 62 – 65% by dry weight starch, together with proteins, vitamins and minerals it provides a complete package of nutrition for yeast growth.
- Large husk, > 6% of grain, resulting in:
  - formation of filter bed for mash separation
  - easy malting and good malting yield
- Good enzyme production giving good brewing performance.
- Contains moderate levels of oils and lipids which are present to excess in some other seeds. High levels of oils have negative effects on beer processing or quality.
- Produces beer with "required flavour"

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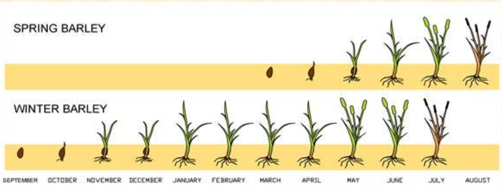
Different Types of Barley



SPRING; sown in March/ April and harvested in end July / early August

WINTER; sown September. Overwinters as a small plant and is ready for harvest in July producing a slightly larger grain

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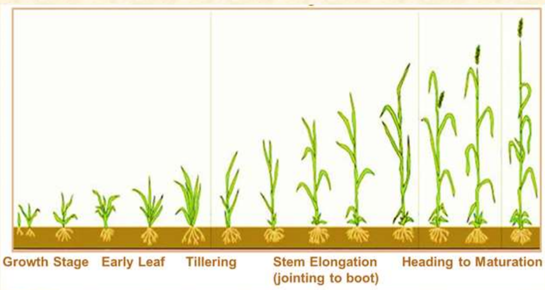
Malting Barley

Typical growth cycle



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Malting Barley

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Who Wants What?

Plant Breeder - A variety that will be a mainstay for 10 years or more: This enables recovery of costs of development.

Farmer - A high yielding, uniform sized, disease resistant variety that performs well in a range of weather conditions.

Maltster - Wants a good quality raw material free from disease with minimal variation which requires lowest levels of processing costs.

Brewer - Reliable supply of raw material which does not impact adversely on beer flavour and provides the yeast with all its nutritional requirements whilst contributing colour and flavour:

"To produce a wort as economically as possible that performs well across all brewhouse operations" (T. O'Rourke, 2002)

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Malting Barley

- Short strawed to counter wind damage and give good yield.
- Grains mustn't germinate in the field if harvest season is wet.
- Trade off between adding nitrogenous fertilisers to increase yield but with subsequent protein content unsuitable for malting.
- More protein; less starch, brewer gets lower extract; 6 vs 2 row.
- More protein; more key enzymes e.g. Beta amylase
- More protein means beer possibly more prone to haze formation and the more amino acids etc. available to beer spoilage organisms.
- Barley variety influences variables; nitrogen or protein, amount of beta-glucan within the endosperm cell walls, proportion of small to large starch granules, corn size, ability to produce enzymes

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Barley Structure

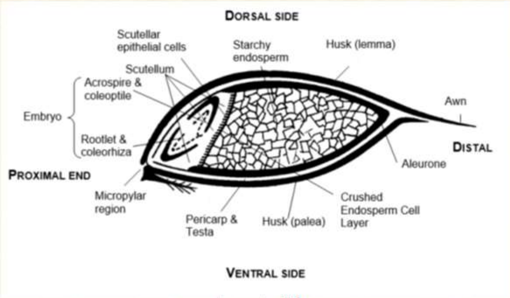
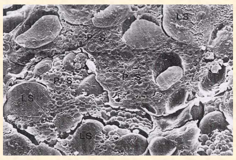
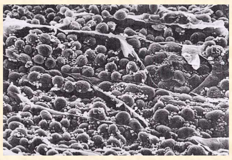


Image courtesy of IBD

Difference: Feed vs Malting





Feed grade barley is often associated with > 2% nitrogen, which makes it “steely” and difficult to malt because of few air spaces and thus lack of free flow of water & enzymes.

Malting barley is “mealy” with nitrogen levels typically between 1.4 – 1.8% for two row barley. This allows for even water uptake and good modification.

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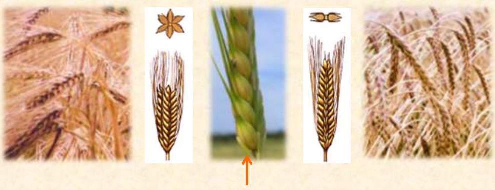
Barley: 2 row vs 6 row



Six row barley has six corns around the stem; smaller corns.

All barleys are actually six row but in two row barleys four of the rows fail to develop

Two row barley has only two developed corns directly opposite each other. Individual corm size is larger

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2 Row vs 6 Row: Key differences

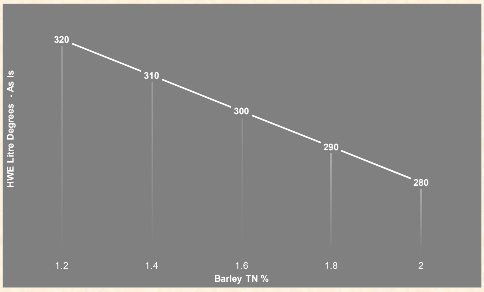
2 - Row

- Nitrogen: 1.5-1.8%
- Starch 63-65%
- Higher yield per ear
- Protein: 9-11%
- Diastatic power (enzyme action): 45-50

6 - Row

- Thicker husk
- Higher yield per hectare
- Nitrogen: 2.0-2.2%
- Protein: 12-13.5% (lower starch; 1-2% less)
- Diastatic power: 145-155

Effect of Barley TN on Extract



Compared to Other Grains

	Maize	Wheat	Rye	Oats	Barley
Starch %	72.0	69.0	68.0	56.0	63.0
Protein %	9.5	12.5	13.0	10.5	11.0
Fat %	4.5	2.0	2.5	7.0	2.0
Fibre %	2.0	2.5	2.5	10.0	5.5

Approval and Variety

Preferred varieties

- UK – Institute of Brewing recommended list becoming "IBD approved"

Does barley variety influence beer flavour?

- Recent evidence (2017) says "yes"
- Maris Otter: Malty, biscuity flavour
- Lager: DMS Pre-cursor

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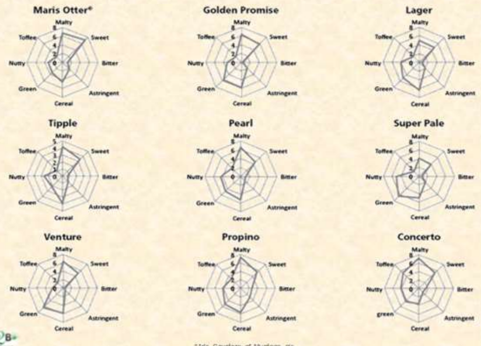
Approved List - 2019

	Winter Varieties for Brewing Use	Spring Varieties for Brewing Use	Spring Varieties for Malt Distilling Use	Spring Varieties for Grain Distilling Use
Full Approval	Flagon Venture Craft	Concerto Laureate RGT Planet Propino	Concerto Laureate KWS Sassy Sienna	Fairing Olympus
Provisional Approval 2		Chanson		
Provisional Approval 1	Electrum	LG Diablo RGT Asteroid	LG Diablo RGT Asteroid	RGT Asteroid

Source MAGB

Wort Flavour Profiles



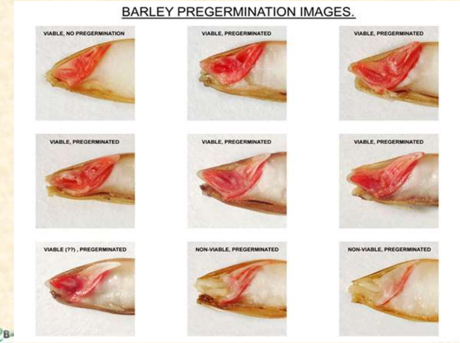
Slide Courtesy of Muntons plc

Basic Requirements

Barley is assessed prior to malting for:

- Uniform size (Good barley should contain >90% corns larger than 2.5mm and <5% below 2.25mm) and colour
- Freedom from odour, mould growth, fungi (ergot), foreign matter and insects
- No admixture with other cereals or barley varieties
- Absence of split skinned or pre-germinated grains
- Moisture: freshly harvested 16-18%, stored at 12-13%
- Capable of growing with a germinative capacity >95% i.e. 95kg out of every 100kg germinates.
- Barley used to produce ale malt total nitrogen should be ideally <1.6% or <10% protein .

Tetrazolium Dye Testing



Proanthocyanidin Free Barley

Breeding programme carried out by Carlsberg in early 1970s

Not genetically modified; achieved by crossing and re-selection.

Early problems included no dormancy; germinated on the ear.

Malty, sweet notes in finished beer due to absence of polyphenols

- ✓ Reduced trub volumes
- ✓ Long term haze-free shelf life for packaged beers
- ✓ Cold maturation at +3 or +4°C instead of 0-1°C; cost saving
- Reduced brewhouse yield – use 50/50?
- More expensive?

"Gluten free" Barley

World's first WHO approved gluten free barley has been bred in Australia (2016): "Kebari"

- WHO definition of GF is <20ppm
- Not modified genetically; produced by programme of cross breeding.
- Gluten content about 5ppm.
- Successful brewing trials been undertaken in Germany.
- Gluten free product market growing at 10% per annum

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So What is Malting?

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Malting: Controlled Germination

- Malt is the main source of carbohydrate energy for yeast
- The energy is stored as starch granules in the endosperm
- The starch granules are embedded in a protein matrix surrounded by cell walls.
- Cell walls and protein matrix degraded during malting process.
- Enzymes are produced during malting for use later.

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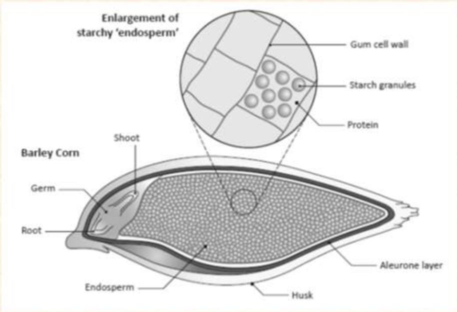
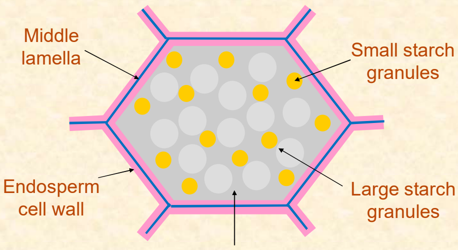
Inside the Grain



Endosperm: Cell Structure



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Endosperm: Cell Structure

Think of it as a Fruit & Nut Chocolate bar!

Protein Matrix (chocolate)

Cell Wall (wrapper)

Large Starch Granules (nuts)

Small Starch Granules (fruit)

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Malting: Controlled Germination

3 Stages:

- **Steeping:** Wetting the grain to initiate growth. The steeping also incorporates air rests so the seed has access to oxygen.
- **Germination:** Allows the growth to be sustained while minimising rootlet growth until maximum modification is reached.
- **Kilning:** Arrests the growth by killing the embryo but is carefully controlled to avoid denaturing (inactivating) the enzymes. Process also develops colour and flavour

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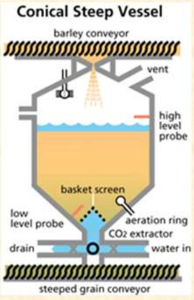
Steeping

- Barley stored with 12% moisture content.
- Hydrated rapidly in the steep tanks to around 44-46% moisture over a 24-48 hour period. Water at 14-15°C.
- Oxygen bubbled through water
- Done with appropriate air rests e.g. 8 hours wet, 6 hours dry, 8 hours wet, 6 hours dry.
- Water is changed two or three times over the period.
- Process also washes the grain



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Germination

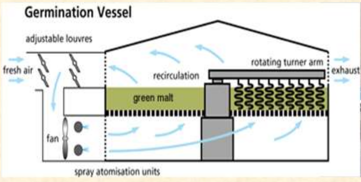

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Image courtesy of Simpsons Malt

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Germination

Breaks down the endosperm cell structure surrounding the starch granules and to produce enzymes

Steeped barley at around 45% moisture; chitting.

Holding under conditions of controlled temperature, humidity and carbon dioxide, to encourage development of enzymes through the corn and breakdown of cell walls.

Resulting in green malt modified with enzymes fully developed.

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Germination: Enzyme Production

DAY 1

Carboxypeptidase – break down of proteins.

β Glucan Solubilase – break down of bonds cross linking chains of β glucans.

Bound β Amylase activated by proteins

DAY 2

Endopeptidase – nonterminal amino acid peptide bonds.

β Glucanase – Degradation of beta glucans.

DAY 2-4

α Amylase – breaks down the 1-4 links in starch chain.

DAY 4+

Limit Dextrinase – starch de-branching enzyme.

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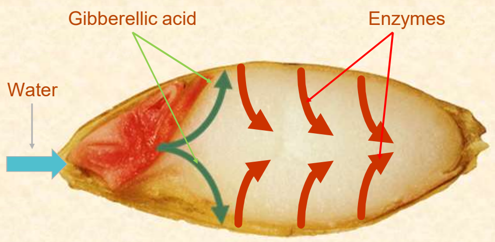
Hormone & Enzyme Flow

1. Hormone: Gibberellic acid (GA)
2. Enzymes dissolve cell walls, protein and small starch granules



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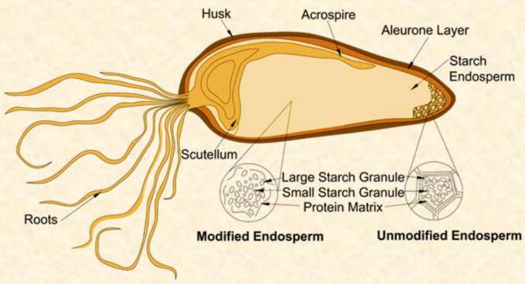
During Germination



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Endosperm Before Malting

This electron micrograph shows the intact cell walls. Some walls have been ruptured by the slicing technique used

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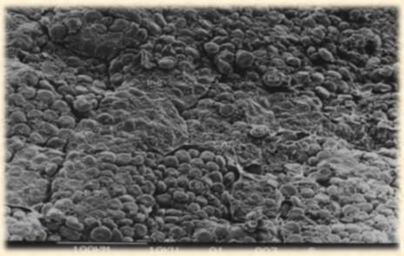
Endosperm During Malting



Starch granules are being exposed as modification proceeds. The large granules are now very prominent.

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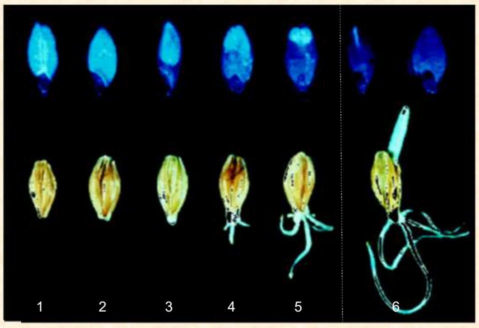
Germination



Changes During Germination

- Small starch granules degraded; sugars for embryo
- Protein matrix broken down to amino acids (proteolysis)
- Cell walls dissolved (cytolysis)
- Enzymes released / formed
- Flavour precursors formed

Modification

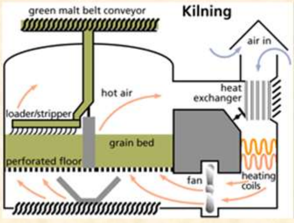
The extent to which the barley is converted into malt is termed the **'Degree of Modification'**.

Previously Lager malts tended to have a lower degree of modification than ale malts, which are normally well modified.

For this reason, some brewers using under-modified lager malt may require some additional processing e.g. stepped or decoction mashing or by addition of commercial enzymes to produce further protein and β - glucan breakdown, during mashing, in the brewhouse.

- *Undermodified malts give reduced extract yield and possible process problems*
- *Overmodified malts give some loss of extract due to barley plant growth and thinner beers.*

Kilning



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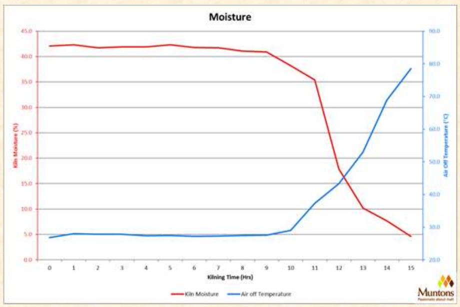
Kilning: Controlled Drying



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Changes During Kilning

- Grain is dried down from 44 - 46% to 4% moisture
- Enzyme activity is halted and “frozen” for later use i.e. mashing
- Some vegetal / green flavours removed
- Sugars and amino acids combine to create colour and flavour compounds (Maillard reaction)

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Summary: Biochemical Changes During Malting

Fraction	% in barley	% in malt	Notes
Starch	63	58	Small starch granules are used up in embryo growth
Simple sugar	1 – 2	3 – 5	Some simple sugars remain in the grain during kilning giving a rough indication of modification
Hemicellulose	8 - 10	6 – 8	Represents beta glucan cell walls broken down in the malting process
Soluble gum	1 – 1.5	2 – 4	These are the smaller soluble beta glucan chains produced from enzymic breakdown
Total protein	8 - 11	8 – 11	Original amount of protein in the grain
Amino acid/ peptides	0.5	1 – 2	This is the soluble protein released by enzymes part of which is FAN (free amino nitrogen)

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Malting Loss

- **Steeping**
  - loose husk, soluble chemicals: 1%
- **Respiration**
  - lost as CO_2 and water: 5 - 6%
- **Rootlets**
  - lost as culms: 4 - 5%
- **Difference in moisture**
  - barley at 12%, malt at 6% maximum
  - 1 tonne dried barley yields about 830kg malt
- **Co-products**
  - screenings and culms may be combined with food supplements and pelletised for animal feeding

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Malting Process Video

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Typical Malt Specifications

Parameter	Abbreviation	Pale Ale Malt	Lager Malt
Moisture %		3-4	5-6
Hot Water Extract %	HWE	79.5-81.5	79-81
Extract (LDK) DWB.	LDeg	310-315	305-310
Fine Coarse Diff. %	F/C Diff	<1.5	1.5 - 2.0
Total Nitrogen	TN	1.4-1.6	1.7 - 1.9
Soluble N ratio	SNR	38-42	-
Kolbach		-	36-40
Free Amino Nitrogen	FAN	150-170	140-150
DMSP/SMM	DMS	< 2	2-8
Beta Glucans mg/l		<150	<200
Colour	EBC	4-5	2-3
Diastatic Power	DP	35-50	65-80
Friability %		>85	>80
Homogeneity %		>96	>96

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Malt Modification

Degree of modification can be measured in a number of ways:

Soluble nitrogen/total nitrogen (% SNR or Kolbach Index)

Indicates how much of the protein structure has been broken down. The higher the value of SNR; the greater the degree of modification:

Course and fine grind difference

When malt is ground finely, all cells are broken up; all extract can be recovered. In mash/lauter tun brewing we require a coarser grind to form a filter bed for for wort separation.

Difference in extract between the grinds shows how much of the structure of the endosperm has been broken down. The smaller the difference the better the modification: <1.5% in ale.

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Malt Modification

Friability (measure of the softness/hardness of malt.)

As the endosperm structure is broken down the grain becomes easier to mill. The friability meter measures the amount of energy required to mill the grain. The lower the energy the better the modification. It also measures the evenness of modification. The higher the friability the higher the modification.

Cold water extract (CWE)

During germination some starch is broken down into fermentable sugars. The germinating corn uses these.
Test is carried out at 20°C (68°F) using water with added ammonia to stop enzyme action. CWE ranges from 16-22%.
Cold water extract measures soluble solids formed during malting: simple sugars, peptides/amino acids etc.
Higher cold-water extracts indicate higher modification.

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Malt Specifications: What Use?

HWE – Useful as a monitor of the consistency of the material you receive, variation indicates change of quality. Potential ABV. Difference between DWB and "as is".

TN – Too much might be problematic; haze forming. Too little might mean lack of Diastatic Power for starch conversion.

SN – Too low might mean a slow, cloudy runoff lacking in extract. Too high might mean thin beer with reduced foam and a wort prone to colour formation.

DMSP/SMM – More DMS possible produced by yeast degrading DMSO?

FAN – Measure of individual amino acids and small peptides (one to three units) which can be utilized by yeast for cell growth and reproduction. Very variety dependent; >150 is generally accepted as "safe" minimum.

Friability – Variety dependent, >90 in one might be same as >70 in another.

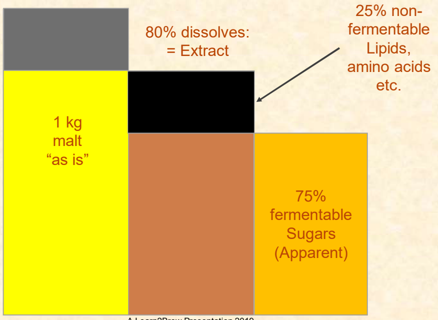
HW Extract

The amount of material in the grist which dissolves in the liquor in the mash tun is known as the extract.

- This extract is the brewer's source of sugar; the more extract the stronger the beer, within reason.
- Amount of extract can be measured using a hydrometer, also known as a saccharometer
- Hydrometer gives a density reading known as "Original Gravity" or "OG". (It compares the weight of the wort to that of a similar volume of water).
- Not all extract is fermentable, only about 75-80% is in the form of simple sugars which the yeast can utilise.
- The rest e.g. lipids, dextrins and proteins is not fermentable but is thought to give body and mouthfeel to beer.

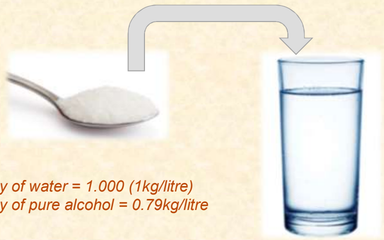
HW Extract

1 Kg of malt with extract value of 80% "as is"



HWE to Original Gravity

If you dissolve spoons of sugar in a glass of water then the density of the water will change i.e. become heavier: *Its gravity increases.*



Gravity of water = 1.000 (1kg/litre)
Gravity of pure alcohol = 0.79kg/litre

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Litre Degrees Extract

Amount of extract can be measured using a hydrometer (saccharometer) which gives a density reading known as "Original Gravity" or "OG".

Around 80% of the dry malt goes into solution.

Convert "%" ectract to Litre degrees (L°/Kg) approx. by multiplying by 3.85.

A malt with an extract value of 300 L°/Kg, as is, will yield a wort with Original Gravity (OG) of 1.001 when dissolved in 300 litres of water (at 100% efficiency).

10 litres of such wort would weigh 1.010Kg compared to 1.000kg for 10 litres of water.

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Calculating Extract

You require 30 litres of 12 Plato (1.048 OG) wort

12 Plato = 12g sugar/100ml wort = 120g sugar/litre wort

Therefore, 30 litres = 30 litre x 120g = 3600g = 3.6kg sugar

Assuming 80% extract efficiency from the pale malt you will require additional malt to achieve the 3.6kg:

3.6kg/0.80 = 4.5kg malt

if you also want to add an efficiency factor for your brewhouse (75%?)

4.5kg/0.75 = 6kg of malt

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Measuring Original Gravity

OG (original gravity) = Density

Measured by hydrometer (or saccharometer)

Units: Degrees Plato and Degrees Gravity.

- 10g of sugar + 990ml water = 1% solution w/v
- 1% sugar solution = 1 Plato
- 1 Plato = 4 Degrees gravity i.e. 1.004

So wort with an OG of 1.048:
= 48 degrees gravity
= 12 Plato
= 12% solution by weight i.e. 1.048kg/litre

Diastatic power

Diastatic power (DP) for a grain is measured in USA in degrees **Lintner** (°L) or in **Windisch-Kolbach** units (WK) in Europe. It is a measure of total amylase activity.

Conversion between the two:

$$^{o}\text{Lintner} = \frac{\text{WK} + 16}{3.5}$$

$$\text{WK} = (3.5 \times {}^{o}\text{Lintner}) - 16$$

Malt with enough power to self-convert has DP >35 °Lintner (94 WK).

British 2 row pale barley malt has DP 35-50

US six-row pale barley malts can have DP up to 160 °Lintner (544 WK).

Diastatic Power (DP)

- US 6 Row Pale Malt: 120 - 160 °L
- British Pale Malts: 40 - 60 °L
- German Pilsner Malt: 100 - 110 °L
- Munich Malt: 25 - 50 °L
- Vienna Malt: 40 - 50 °L
- Wheat Malt: 60 - 90 °L
- Malted Oats: 20 - 30 °L
- Malted Rye: 80 - 100 °L
- Wheat / Oats / Barley / Maize / Rice (Flour, flaked, torrified): 0 °L
- Crystal Malts: 0 °L
- Amber / Brown / Chocolate / Black Malts: 0 °L

Calculating Diastatic Power

Multiply weight of all mash grains requiring conversion i.e. base malts and starchy adjuncts by their individual DP and total up. Then divide total DP by total of the weight of these malts and adjuncts; >40??

E.g.

Pale ale malt: 150kg x 45DP	= 6750 DP
Amber malt: 10kg x 0DP	= 0
Torrefied wheat: 25kg x 0DP	= 0
Maize flakes: 10kg x 0DP	= 0
Total weight for conversion	= 195 kg
Av. DP/Kg	= 6750/195 = 35

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Various Malts

Malt Type	Moisture (%)	Colour (EBC)	Extract L° DWB	Final kilning/roasting temp °C
Lager	<4	2.0	310	80
Ale	<4	5.0	312	100
Amber	<4	40-100	270	150
Crystal	4-6	100-300	270	180
Chocolate	<4.5	900-1100	265	220
Black Malt	<4.5	1100-1400	265	230
Roast Barley	<4.5	1000-1500	260	230

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Malt Flavours

Malt gives us colour and flavours such as:

Lager

Pale

Coloured

Roasted

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Maillard Reaction

Reaction of amino acid with a reducing sugar in the presence of both water and heat.

Sugar + Amino acid + Heat

↓

Reductones

Melanoidins (Colour)

Thiophenes
Pyrroles
Furans
(Flavour)

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Common Maillard Reactions

The Maillard reaction is responsible for many colours and flavours in our everyday foods:

- Browning of meats e.g. steak, sausages
- Toast
- Golden crust of bread, brioche etc.
- Golden-brown colour of crisps & chips
- Colour and flavour of condensed milk: Banoffee Pie!
- Roasted coffee
- Brewer's caramel
- Chocolate
- Lightly roasted peanuts

….and in the colour and flavour of malt

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Colour Formation

Caramelisation vs Browning

Caramelisation

May sometimes cause browning in the same foods in which the Maillard reaction occurs, but the two processes are distinct. They both are promoted by heating, but the Maillard reaction involves amino acids, as discussed above, whereas caramelization is simply the pyrolysis of certain sugars.

Melanoidins

Are brown coloured compounds generated in the late stages of the Maillard reaction from reducing sugars and proteins or amino acids during food processing and preservation.

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Wort Colour

A number of systems exist for colour measurement: EBC (European Brewery Convention), SRM (Standard Reference Method) and Lovibond grade from light to dark.

An SRM colour chart. (EBC = approx. 2 x SRM value)

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Calculating Wort Colour

For each coloured malt/adjunct ingredient in the mash tun:

- Multiply the weight (kg) by colour in EBC units, add the results together.
- Multiply the total by 10. Then multiply by the mash efficiency (as a decimal fraction).
- Divide the total by the brewlength volume (litres).
- When using syrups/caramels then just multiply their weight by their EBC units then multiply that result by 10 and add to above.

For example:

500kg Pale malt at 5 EBC: 5 x 500 = 2500
25kg Crystal at 130EBC: 25 x 130 = 3250
Total EBC = 5750

Using a mash efficiency of 75% (0.75) we get: 5750 x 10 x 0.75 = 43125

Divided by the brewlength volume of 1000 litres = 43125 / 1000 = 43EBC

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White (Base) Malts

During kilning, through careful process control, it is possible to produce a range of coloured malts, the lightest being:

- **White malt:** 2 EBC. Lightly kilned malts, very high enzyme activity and neutral taste. Sulphidic (DMS) and grassy aromas / flavours.
- **Lager (pils) malt:** 3 EBC. Standard malt, light flavour but also tends to have DMS character.
- **Pale ale malt:** 4 EBC. Biscuity, "malty" flavour, hint of toffee or caramel.
- **Mild malt:** 7 EBC darker product provides the rich nutty, toffee and caramel flavours

- *In these malts, the enzymes are largely intact, but in more highly coloured malts, the enzymes are denatured.*

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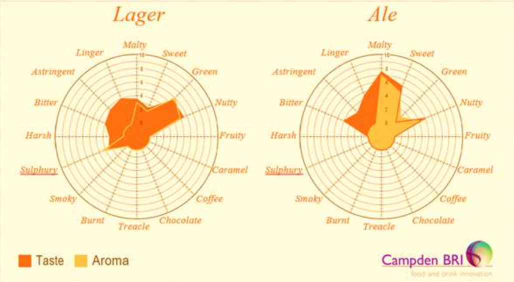
Malt Flavour Profiles



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Coloured Malts

Possible to produce more intense flavours but at the expense of enzymes and extract by stewing the green malt to produce sugars and amino acids. It is then kilned at a high temperature to caramelise.

- **Munich malt -** stew <40°C kiln to 120°C. 17EBC retains some enzymes; used to produce dark lagers particularly in Bavaria.
- **Caramalts -** uses warm air to produce partial caramelisation in the wet grain at 65°C followed by heating to 80°C. 15-35EBC. Limited or no fermentable sugars.
- **Crystal malt -** "stewing" green malt with conversion of starch to sugar at 65°C followed by heating to 135-160°C. 100-400EBC. Limited or no fermentable sugars. Produce red/ruby hues and rich sweet caramel notes.
- Little, if any, extract is fermentable in Crystal and Cara malts

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Malt Flavour Profiles

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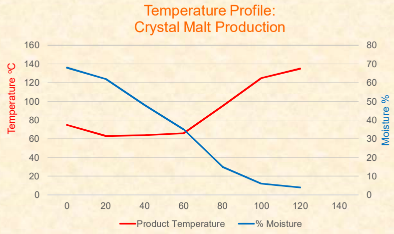
Coloured Malts – Crystal & Cara

Stage	Temperature	Time
Stewing	60-80°C	20-60mins
Roasting	135-180°C	80-100mins



Courtesy of Ross Turner | Pure Malt Products Ltd

Comparison of Coloured Malts

Color (°L)	American	British	German	Belgian
>10	Carapils	Cara Gold	CaraPils/CaraFoam	
10 - 20	Caramel 10 - 20	Caramalt, Light Carastan	CaraHell, CaraRed	Cara 20
20 - 40	Caramel 20 - 40	Light crystal, Carastan	Caramunich I	
40 - 60	Caramel 40 - 60	Crystal, Medium crystal	Caramunich II/III	Cara 50
60 - 80	Caramel 60 - 80	Dark crystal	Caramunich III	
120+	Caramel 120	Extra dark crystal	CaraAroma	Cara 120, Special B

Courtesy of Craft Beer & Brewing Magazine

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Carafa Special Malts

Produced by Weyermann of Germany:

- Grain is de-husked prior to roasting
- Gives colour and flavour
- Reduces bitterness and astringency

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Drum Roasting

The roasting temperatures are critical, and towards the end of roasting the malt may often be just below the ignition point i.e. temperatures of 230^{o}C.

The carbonation/combustion temperature of malt is 248.8^{o}C.

Water quenching is often used during and to halt the process when the required amount of colour is attained.

The roasting process produces a range of dark coloured malts but destroys enzyme capacity and reduces extract.

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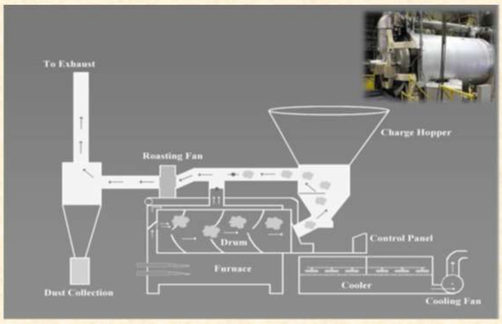
Drum Roaster



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Probat Drum Roaster

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Roasted Malts

Roasted malts made by drum roasting of standard malts.

- **Amber malt**: 35 - 75EBC. Gives a ruby red hue to the beer.
- **Brown malt:** 120 - 500EBC. Used to produce mild ales, porters and winter warmers.
- **Chocolate malt**: 800 - 1100EBC. Used in porters, stouts and dark beers. Strong coffee and roast flavour notes.
- **Black malt**: 1100 - 1600EBC. Used in stouts and dark beers.

Pyrroles and pyrazines formed from the Maillard reaction lead to increasing acridity as the colour increases.

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And Don't Catch Fire!

Kiln fire – Newark Maltings 1990

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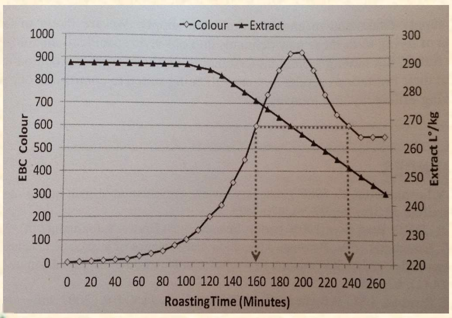
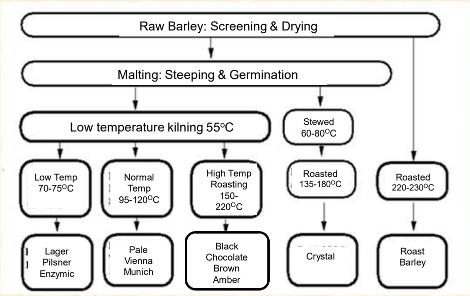
Roasting: Extract vs Colour



Slide courtesy of Dr. N Davies, Muntons plc

Summary: Production of Various Malts



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Other Malted Cereals

Can be used to impart subtly different flavours or textures:

- **Oats:** enhance dryness and smoothness e.g. oatmeal stouts, NEIPAs
- **Rye:** increase palate fullness at high levels but rye has no husk so wort run off can be difficult. Nutty and spicy notes
- **Wheat:** 5% addition will improve head retention with no effect on flavour. German style wheat beers at up to 75% wheat have a dry refreshing clovey taste.
- **Sorghum:** Gluten free beers

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Milling

Objective:

Before brewing malt has to be milled which involves splitting the husk and grinding the endosperm into small grits.

It is necessary to keep the husk as whole as possible for mash tun use since it will be used to form the filter bed during run off.

The endosperm must be broken down to allow the enzymes to attack the starch.

Match milling and grist to wort separation system

- *Too coarse grind - poor extract & starch carry-over.*
- *Too fine grind - run off problems & set mash.*

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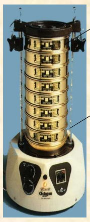
Grist Analysis

Pfungstat Plansifter used in EBC analysis



Sieve	Mesh width mm	Materials held
1	1.27	Husk
2	1.01	Husk
3	0.547	Coarse Grits
4	0.253	Fine Grits
5	0.152	Normal flour
6 Base	No sieve	Fine Flour

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Grist Analysis

	Typical grist composition % EBC			
	Husk Sieve > 1.25 mm	Course Grits Sieves 1.25 – 0.50 mm	Fine Grits Sieves 0.50 – 0.125 mm	Flour Bottom < 0.125 mm
Mash Tun	30%	24%	40%	6%
Lauter Tun	20%	45%	25%	10%
Mash Filter	< 1%	9%	55%	> 35%

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Calculating Strike Temperature

Quick method of calculating strike temperature for HLT:

$$T_{(strike)} = \frac{0.4 \times (T_{(mash)} - T_{(malt)})}{\text{Mash Density (L/Kg)}} + T_{(mash)}$$

Where T = Temperature

So if we want a mash at 65°C and our malt temp is 10°C and mash density is 3:1 i.e. 3 litres of liquor per kilo of grist then:

$$T_{(strike)} = \frac{0.4 \times (65-10)}{3} + 65$$

$T_{(strike)} = 72.3°C$

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Simple Quality Checks

Take time to compare samples of different malts to give you a reference point.

Appearance: Majority of the kernels should be of similar size, modification, and colour with no visible signs of disease (that is, discoloured or seriously misshapen kernels).

You should be able to easily crush the malt with your fingers.

Pre-crushed malt should be milled evenly, longitudinal sections of husk in evidence. Test sieve: Correct particle distribution?

Smell/Chew the malt: friability (softness), flavour and aromatics.

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Summary

Malt contributes greatly to the appearance, final character and taste of the beer:

- Most beer colour comes from the malt but also developed during the brewing process e.g. boiling.
- Colour compounds give beer both colour and flavour from light biscuity to strong burnt/roast.
- Beer foam is made up from malt hydrophobic proteins
- Colour compounds improve foam stability (?).
- Mouthfeel comes mainly from the residual unfermentable sugars
- pH of wort and beer regulated through the precipitation of malt components (phytins) with mineral ions (calcium) from the water.
- Other protein fractions are involved in beer haze.
- Other malt compounds impact flavour e.g. DMS
- **Malt quality is key!**

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Thank you

Any questions?

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