Malt - a vital part of the brewers palette

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Both colour and flavour are influenced by malt and this impacts perceived consumer drinkability.

DESCRIBING BEER DRINKABILITY

GOOD ☺ — POOR ☹

DRINKABILITY

CONSCIOUS: Freshness, Clarity, Aftertaste, Carbonation, Foam, Temperature, Sour, Polyphenols, High Alcohol

SUB-CONSCIOUS: Gastric Emptying, Positive Branding, Excitability, Desire, Sweet, Nationality, Ambience, Homeostasis, Bitter, Gender, Cholecystokinin, Belief, Genetics

Around half of the determinants of drinkability can be affected by malt:

WHICH ASPECTS DOES MALT AFFECT

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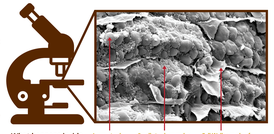
MALT IMPACT ON BEER CLARITY

Starch, beta glucan and protein can cause cloudiness. All these elements can be removed or modified during the malting process

Malt and beer foam
Malt proteins have a positive effect on beer foam plus foam stability via the Maillard reactions. It is an art as well as a science to create a malt that promotes rapid brewing throughput and foam retention.

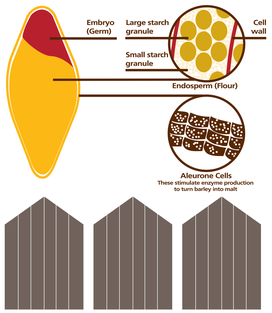
Malt and beer staling
The production of Carbonyls causes "papering" a cardboard taste affecting the drinkability of a beer. This is caused by oxidation of unsaturated lipids and catalysed by the enzyme lipoxygenase.



MALT ANALYSIS

So Malt is really quite important! Lets go right back to the beginning and have a closer look as to why?

INSIDE A BARLEY GRAIN



CHEMICAL CHANGES IN MALTING

GERMINATION
- Small Starch Granules become sugar
- Proteins become amino acids
- Cell walls are dissolved
- New enzymes made
- Precursors of flavour/colour formed (sugars, amino acids)

KILNING
- Grain dries out gradually and green flavours removed
- Sugars and amino acids combine to make flavour and colour
- Enzyme activity stopped but retained for function in further food and beverage processes
- Made stable for storage

BEER FLAVOUR DEFECTS

BACTERIA
These are all spoilage flavours, not pathogens
Acetaldehyde (Green Apples): Zymomonas, Acetobacter
Acetic/Vinegar: Lactobacillus, Acetobacter
Sour/Diacetyl: Pediococcus, Lactobacillus
Dimethyl sulphide/Parsnips: O. proteus
Phenolic: Coliforms
Rancid: Various anaerobes
Hydrogen Sulphide: Zymomonas, Pectinatus
Sweaty, Astringent

OXIDATION
Ingress of oxygen into the packaging process leads to a range of off flavours
Astringent, Catty, Blackcurrent, Ribes, Stale, Cardboard, Toffee

YEAST
Yeast makes a positive flavour & generates alcohol but can also produce negatives
Diacetyl: underpitching, insufficient maturation
Sour/Meaty: autolysis
Estery, Honey, Goaty, Sulphidic, Sulphitic: Related to strain used and its biochemistry
Phenolic, Spicy, Cloves: wild yeast contamination although phenolic can be a positive in wheat beer

HOPS
Cheesy, Sweaty: Hops over aged or stored too hot
Grassy, Onion, Garlic: Poor quality hops
Lightstruck/Skunky: off flavours generated by light ingress

MALT
Malt rarely generates flavour defects in beer but if lipoxygenase is high it can contribute to staling
Bitter: Increased roast barley or malt in grist
Diacetyl: Low wort Free Amino Nitrogen and specifically valine can give stuck fermentation
Dimethyl sulphide: Positive in lager, negative in ale

FERMENTATION
Astringent: Over attenuation
Sweet: Underattenuation
Soapy: Incorrect oxygenation
Estery: Temperature or original gravity too high

PASTEURISATION
Generally the problem here is overpastuerisation, but under pasteurisation can lead to bacterial issues
Bready, Catty, Blackcurrant, Cooked Veg

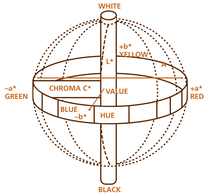
WHAT DOES MALT ANALYSIS TELL YOU?

Malt analysis has been well established for many years.
For most international contracts the specification is based on EBC Congress method of wort production but other methods such as Institute of Brewing or American Society of Brewing Chemists are commonly used.

Analysis	Brief description of scope	Typical values	Relevance
Extract IOB Fine grind 0.2mm Coarse grind 0.7mm	Mashing at 65°C	Good 315 L°/kg Poor 290L°/kg Fine:Coarse difference Good <4	Quickly inactivates all enzymes except alpha amylase, designed to mimic traditional ale mash
Extract EBC Fine grind 0.2mm Coarse grind 1.0mm	Mashing at 45°C raising gradually to 70°C	Good > 82% Poor < 79% Fine:Coarse difference Good <2	Gradually inactivates amylase and allows proteolysis, designed to mimic lager mashing
Extract Hartong (Hx) x = mash temperature	Shows the effect of enzyme deactivation Expressed at Hartong at different temperatures H_{60}, 45°C: α and β amylases and proteases active H_{70}, 55°C: α and β amylases active H_{80}, 65°C: α amylase active	H_{60} = 35 - 40 Lower values indicate under-modification Higher values indicate over modification	Matches more complex mashing profiles
Cold Water Extract	Ammonia is added to deactivate malt enzymes to indicate base level of modification present	18 – 22% Good malt < 18% under modified; >22% over modified	Hot water extract = 75-82%. Cold Water extract = 15-28%. Therefore about 50% of extract is due to enzyme action
Viscosity	Due to β glucan in cell walls; small starch granules that only partially gelatinise in mashing.	< 1.60 cP (mPa.s)	Causes stickiness or poor filtration or haze if too high
Friability / Homogeneity	Malt ground in a Friabilimeter. Measures the evenness of modification	Friability > 80% Homogeneity > 95%	Measure of evenness of modification when samples ground
Dextrinising Units (DU) Diastatic Power (DP) Saccharification time	Measures amylase (diastatic) activity in malt	e.g. lager malt DU >40 DP > 60 Saccharification time < 10 minutes	DU is a measure of just α amylase DP measure both α and β amylase and limit dextrinase Saccharification measures starch breakdown due to amylases
Colour	Wort can be measured visually using colour comparator discs or using a spectrophotometer set at 430nm	e.g for ale malt EBC 3 – 4 IoB 2.5 – 3.5 ASBC 1.6 – 2.0	Varies significantly depending on mashing protocol and measurement type. Can measure the red/green/blue proportions in a wort by tristimulus using either a spectrophotometer or custom made device, but not generally specified for malt
Fermentability	Reflects the suitability of the wort for yeast to ferment	> 80% different yeasts give different fermentabilities for the same wort	Endogenous enzymes are inactivated first before yeast is added and fermentation started. It measures wort and yeast quality
Nitrogen / Protein (= N x 6.25) Total nitrogen (TN) Total soluble nitrogen (TSN) Free Amino Nitrogen (FAN) Soluble Nitrogen ratio / Kolbach	Important for beer foams, to determine protein breakdown for good yeast nutrition (fermentation), related to enzyme levels since they are proteins. Higher nitrogen barleys are more difficult to malt, are good for foam, but can contribute to beer haze. TSN shows the amount of protein modification in malting. FAN indicates the gross level of amino acids available for yeast nutrition	e.g. lager malt TN < 1.6% TSN 0.6 – 0.7% FAN >140mg/litre Kolbach* 38 – 44 *soluble:total nitrogen ratio measured on EBC wort. Where IoB wort method used it is termed SNR	• Important for foam proteins in beer • Important for texture etc foods • Break down to amino acids for yeast nutrition and interaction with sugars to create colour • Need sufficiently high nitrogen for positive factors above • Nitrogen directly related to proteins hence enzymes • Very high nitrogen content makes more difficult malting and possibly greater unevenness of modification • High N good for foaming but can contribute to haze

COLOUR

Measured by conventional EBC analysis or more accurately tristimulus measurement



PROBLEMS

Perceived Colour
Colour Quality
Extracted Colour

Modern colour measurement describes the colour quality rather than just the degree of "brownness" of the older methods. This is called tristimulus colour measurement.

BEER ANALYSIS

Fermentation performance

FINAL ATTENUATION	Shows the amount of alcohol that can be attained
FERMENTABLE CARBOHYDRATE	This generates the alcohol and a measure of specific sugars is sometimes added in line with the order in which yeasts use them
WORT NUTRIENTS	Generally to assess if they are sufficient for yeast nutrition
TOTAL NITROGEN	Sufficient must be present to allow yeast function
FREE AMINO NITROGEN	Yeasts need key amino acids. The prime one is valine
IONIC MIX	Can affect the manner in which yeasts flocculate

Alcohol measurement

TOTAL ALCOHOL	Legal declaration in label
ETHANOL	The primary alcohol generated
HIGHER ALCOHOLS (CONGENERS)	Although in small amounts these are said to be responsible for hangover even in low alcohol beers
GRAVITY: ORIGINAL/FINAL	The theoretical amount of alcohol can be predicted based on gravity before and after fermentation

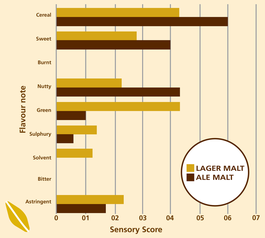
Fermentation performance

COLOUR	Sometimes a boiled wort colour is specified: colour darkens when boiling wort
BITTERNESS	Mostly from hops but roasted barley or malt in the grist also gives some bitterness
POLYPHENOLS	If husk high in anthocyanin it can contribute to higher polyphenols
IRON	Most likely from Hops
SO_2	Usually derived from yeast
VICINAL DIKETONES	Butterscotch: Positive in ale - Negative in lager
DISSOLVED OXYGEN	If malt is high in Lipoxygenase it can contribute to staling of beer due to oxidation
DIMETHYL SULPHIDE	Sweetcorn: desirable flavour in lagers, never in ales
FOAM STABILITY	Derived from malt proteins of higher molecular weight
CARBONATION	Yeast activity generates carbon dioxide
CATIONS/ANIONS	Important for yeast nutrition, particularly Zinc
HAZE, SHELF LIFE	Can be due to protein, starch or glucans derived from poor malting or mashing

Malt Flavour

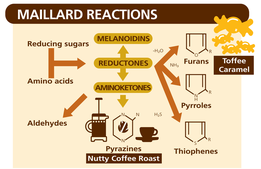
Simple flavour descriptions can be used to profile malt flavours

Descriptor	Terms included	Descriptor	Terms included
CEREAL	Malty, Biscuity, Malted drink (Horlicks, Ovaltine), Cereal, Hay, Husky, Pastry, Rusks, Rye/ita, Malt loaf	TOFFEE	Toffee, vanilla
		CARAMEL	Caramel, cream soda
		COFFEE	Bitter, coffee
SWEET	Honey, Sweet	CHOCOLATE	Dark chocolate
BURNT	Burnt, Toast, Roast	TREACLE	Treacle toffee / syrup
NUTTY	Chestnut, Peanut, Walnut, Brazil nut	SMOKY	Bonfire, wood ash
		PHENOLIC	Spicy, medicinal, cloves
GREEN	Beany, Cauliflower, Grainy, Grassy, Bean sprouts, Uncooked	FRUITY	Raspberries, Strawberries, Currants, Raisins, Jam, Fruit cake
SULPHURY	Cooked vegetables, DMS, sulphidic, sulphitic, parsnips		
SOLVENT / WET	Cardboard, Chlorine, Earthy, emulsion paint, muddy, papery, mouldy	BITTER	Bitter, Sour
		ASTRINGENT	Mouth puckering, drying

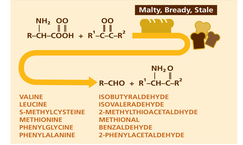


MALT FLAVOURS DERIVED BY KILNING

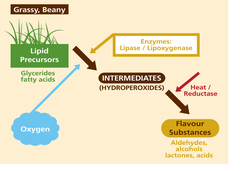
MAILLARD REACTIONS



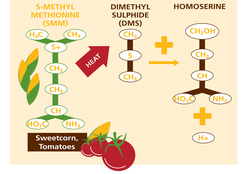
STRECKER DEGRADATION



LIPID OXIDATION



SMM & DMS



How can malt colours and flavours be used in product development?
The use of malt extract made from speciality malts e.g crystal, chocolate, black or roasted barley can have dramatic effects. It is simple to add these to the wort kettle to modify beer flavour and colour.

THE MALTSTER'S PALETTE

Colour and flavour are brought together in the maltster's palatte

From Green Malt → From White Malt

	White	Lager	Pale	Vienna	Cara	Crystal	Amber	Low Chocolate	High Chocolate	Black
Colour	2	3	6	7	35	145-400	110-140	600-800	900-1100	1200-1500
Flavour	Grassy Sulphidic	Cereal Sulphury	Biscuit Toast	Nutty Toffee	Caramel	Sweet Toffee Fruity Burnt	Dry, Bitter Nutty, Biscuit	Dark Chocolate Burnt Fruit Toast	Dark Chocolate Sharp, Smokey, Bitter	Bitter, Sharp Coffee

Q

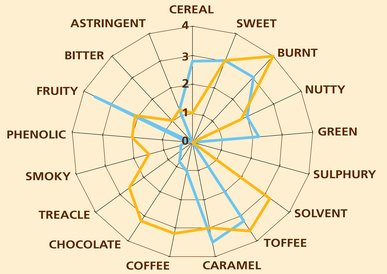
HOW DO YOU MAKE A LAGER INTO A SWEET PORTER WITHOUT CHANGING THE GRIST?

A

ADD SPECIALITY MALT EXTRACTS TO THE WORT KETTLE. ONLY 2% HIGH CRYSTAL +1% CHOCOLATE DID JUST THIS!

THE BREWER HAD A NEW PRODUCT, NEEDED LESS HOPS AND DIDN'T CHANGE ANY OTHER BREWING PROCESS CONDITIONS.

Choose your Crystal Malt Carefully



CRYSTAL MALTS VARY WIDELY IN TASTE