Introduction to Adjuncts and Flavourings

A LEARN2BREW PRESENTATION

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What are adjuncts?

In the broadest sense adjuncts are not only sources of fermentable extract other than malted barley but ingredients which provide flavour or colour. Usually in two forms; liquid or solid. ALL MUST BE FOOD SAFE!

Including:

- Malted or unmalted grains – Roast barley, wheat, oats, rye, rice, maize
- Sugar syrups – From cane, beet, wheat and maize
- Dried/solid sugars – Invert, demerara, candi
- Caramel
- Natural liquids - Honey, maple, molasses, treacle
- Fruits – Berries, oranges, pumpkins
- Spices – Coriander, ginger

Main misconceptions about use of adjuncts

- Only big brewers use adjuncts to produce cheap low quality beer
- Quality beers don't contain them
- Not traditional
- Craft brewers don't need to use them; cheating?

Using adjuncts

Very often a great deal of research/testing is undertaken by brewers to improve adjunct performance and fine tune their contribution to final beer characteristics:

- Maize will give beer a fuller, crisper flavour
- Wheat, imparts dryness, breadiness
- Unmalted barley can give a stronger harsher flavour.
- Both wheat and raw barley can considerably improve the head retention.

In terms of worldwide consumption, the most commonly used adjunct materials are roughly:

- maize (46%)
- rice (31%)
- barley (1%)
- sugars and syrups (22%).

Use of adjuncts

Typically, adjuncts contribute no enzyme activity to the mash, which can pose problems.

The major benefits of adjunct use are that they:

- Contribute little soluble nitrogen but provide sources of:
  - ✓ Carbohydrate
  - ✓ Body
  - ✓ Colour
  - ✓ Flavour
- Costs can be reduced compared to malted barley.

Use of adjuncts

Generally, 6 major attributes dictate adjunct type and use:

1. Reduced protein levels lower the potential for beer haze formation and therefore increase beer stability whilst reducing the capacity for microbial infection, therefore improving shelf life.
2. Lower levels of lipid materials decrease staling reactions and also protect against loss of head retention.
3. Less cell wall material reduces b-glucan and pentosan content: improves wort viscosity.
4. Different proteins and their proportions present might improve head retention or have a negative effect.
5. A range of starch gelatinisation temperatures can impose additional processing steps i.e. mash cookers.
6. Altering the fermentable sugar spectrums can affect product flavour profiles and mouthfeel.

Adjunct classification.

Solid Adjuncts	**Liquid Adjuncts**
Roasted	Glucose Syrups
Torrified	Sucrose Syrups
Micronised	Invert Sugars
Flaked	Malt Extracts
Grits	Caramel
Flours	Primings

Why use adjuncts?

Flavour - Produce a different beer style e.g. Wheat beer
Financial - Increase brewing efficiency or cheap alternative to barley malt
Availability - Brew beers with local materials e.g. sorghum in Africa

Sugar Source	Colour impact	Flavour impact	Other effects
Sugar syrup	Reduces colour	Reduces flavour	Add or reduce body
Rice	Reduces colour	Reduces flavour	Reduces body
Maize	Reduces colour	Crisper taste	Can give oily aroma
Wheat	Little change	Low – Dry, bready	Cloudy, improves head
Oats	Reduces colour	Smoother body	Cloudy
Rye	Darker (red)	Spicy & drying	None
Sorghum	Darker	Bitter taste	Cloudy
Fruits (various)	Picks up fruit colour	Picks up fruit flavour	Increases acidity

Some common cereal adjuncts

Dried adjunct forms

Basic raw cereal - barley; wheat; sorghum, triticale

Raw grits - corn (maize); rice; sorghum; barley

Flaked - corn; rice; barley; wheat

Torrefied/Micronised - corn; barley; wheat

Flour/Starch - corn; wheat; barley; rice

Malted cereals (not barley) - rye; oats; wheat

Gelatinisation

The chemistry and structure of starch influences the way in which the adjuncts are processed.

The granular starch of cereals comprises two glucose polymers:

- Amylopectin (70-80%)
- Amylose (20-30%)

The most important property of a starch granule is the gelatinisation temperature at which the starch dextrins are broken down to their individual glucose polymers.

Only after thermal gelatinisation will the starch liquefying (alpha-amylase) and saccharifiying (beta-amylase) enzymes operate efficiently

Gelatinisation temperatures

Source	Gelatinisation Temperature (°C)	Shape	Granule Size (μm) B Type	Granule Size (μm) A Type
Barley	61-62	Round/ Lenticular	1-5*	10-25
Wheat	52-54	Round/ Lenticular	1-5	15-25
Maize	70-80	Round/ Polygonal	10-15	
Rice	70-80	Polygonal/ Compound	2-8	9-30
Sorghum	70-80	Round/ Polygonal	10-12	
Oats	55-60	Polygonal/ Compound	2-10	
Rye	60-65	Spherical/ Lenticular	1-8	10-30

* Small starch granules of barley gelatinise at 75-80°C

Potential problems

Adjuncts with gelatinisation temperatures greater than 65°C cannot simply be added to the mash as part of the normal grist bill, otherwise the starch will not degrade.

This gives rise to extract loss and potential for carbohydrate haze formation.

Additionally, unconverted starch will increase wort viscosity and hinder separation and run-off in the lauter tun.

The starch will continue to pass through the brewhouse and generate uncontrollable carbohydrate hazes, affecting beer stability and shelf life.

Cereal cookers

Cereal cookers pre-cook/gelatinise starch from adjunct cereals such as maize, rice and sorghum.

Further milling equipment and storage requirements may also be needed.

Use of flours and starches may demand installation of specialised handling equipment e.g. pneumatic conveyors.

Consequently, extra costs are incurred in the form of further labour, CIP, maintenance expenditure etc.

Diastatic power

Diastatic power; measure of the quantity of the diastatic enzymes present in the grain/malt. Measure of speed and how much starch is converted into sugars.

Most malts have a quantity of diastatic enzymes surplus to requirements; these enzymes can be effectively used to convert the starch in other cereals into fermentable sugars.

The higher the diastatic power of the malt the greater the quantity of these additional cereals it can convert.

Flaked, fine ground (flour) or torrefied cereals are unmalted and do not contain diastatic enzymes.

Highly diastatic malts can be high-nitrogen malts and will possibly give a greater risk of haze formation and a lower fermentable yield.

Diastatic power

- US 6 Row Pale Malt: 150 - 160 °L
- British Pale Malts: 40-70 °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: 90 - 100 °L
- Wheat / Oats / Barley / Rice /Maize (Flour, flaked, torrified): 0 °L
- Crystal Malts: 0 °L
- Amber / Brown / Chocolate / Black Malts: 0 °L

Torrification & micronisation

Cereals are subjected to heat at 260°C in the form of either hot sand or air (torrification) or infrared heat (micronisation).

Heating increases the internal water vapour rapidly causing the grain to expand until it pops. This heat partly cooks and disrupts the starch structure, rendering it pre-gelatinised and eliminating this step in the brewhouse.

Heating has the added benefit of denaturing major portions of the protein in the kernel, to the extent that only 10% of the wort soluble protein remains.

With reduced protein levels, the proportions of malt and adjuncts in the grist can be varied, to adjust beer characteristics. For example, extra flavour and colour can be introduced without compounding excessive protein levels from malt.

Flaking

Flaking of cereals to produce adjuncts is typically, a two-stage process.

Firstly, the cereal is partially gelatinised either through mild pressure-cooking or by steaming at atmospheric pressure.

Secondly, the semi-processed cereal grits are passed through rollers held at approximately 85°C, before the moisture content of the flake is reduced to 8-10%.

Flaked adjuncts, as with the torrified and micronised adjuncts can be added directly to the grist bill and processed throughout the brewhouse without any special requirements, depending on the cereal variety. For example, flaked barley does not need pre-cooking but flaked maize and rice, which have higher gelatinisation temperatures will.

Grits

Grits of various adjuncts are prepared through coarse milling.

The milling process removes the husk and outer layers of the endosperm along with the oil-rich germ, leaving behind almost pure endosperm fragments. These fragments can be further milled and classified according to each brewer's specific requirements.

Some grit products can be processed through the brewhouse without additional processing, but this is dependent upon the cereal gelatinisation temperature.

Grits tend to have high beta glucan levels that increase wort viscosity and can hinder wort separation.

Starches & flours

Starch and flours used in brewing predominantly consist of wheat and maize, although others are used. Starch and flours are produced via wet milling.

Flours produced mainly through sequential milling, although hammer mills are often used to produce the final fine flour. Flours can also be pelletised.

Refined starches are the purest extract source available to the brewer.

Although starches and flours can be added directly into the mash, additional storage and handling problems are incurred.

Grist compositions containing a high proportion of fine flours can lead to "set" mashes (Bed is too thick to allow efficient enzyme mixing and saccharification).

Particle size is important, too large and extract losses ensue, whilst too small and haze and wort separation problems follow.

Sugars & syrups

Hydrolysed starch syrups

Wheat and maize starch converted to liquid giving fermentable carbohydrates.
Added in copper or as primings in cask beers.

Sucrose

Cane or beet
Clear or dark (unrefined or caramelized)
Added in copper or for secondary fermentation
Candy sugar ("candi") in Belgian beers
Fermentation and flavour

Glucose syrups

Glucose is the most common name for dextrose.

Glucose syrups are solutions of a large range of sugars and contain dextrose, maltose, maltotriose, maltotetraose, and larger dextrins.

The spectrum of sugars in the syrup depends upon the manufacturing process used.

Glucose syrups are produced mainly from maize and wheat.

The degree of starch conversion in the final syrup is expressed as **Dextrose Equivalent (DE)**. This is a measure of the reducing power of the solution. Starch has DE = 0 and glucose DE = 100

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Sucrose syrups

Comprise two varieties; sucrose syrups and invert syrups. Both are derived from sugar cane or sugar beet.

The benefit of invert sugars is the additional fermentable material achieved on inversion, termed the “inversion gain”.

$$C_{12}H_{22}O_{11} + H_2O \longrightarrow 2C_6H_{12}O_6$$

342 MW disaccharide to 360 MW monosaccharide

By transforming a disaccharide such as sucrose into two monosaccharides (glucose and fructose) through hydrolysis, there is a molecular weight gain equivalent to a 5.26% increase. This gain in weight is effectively transferred into a gain in product volume.

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Sucrose syrups

Sucrose is used mostly in liquid form, it is highly fermentable but syrups vary; 60-90%. Usually added to the boiling vessel (copper/kettle).

Invert sugar can be liquid or solid. It is added to the copper/kettle and is used for the same reasons as sucrose although it has a more distinctive flavour. Range of colours, numbers 1-4. It is 95% fermentable and its extract value is from a range of 320-325° litre per kg

Both used as a wort extender to supplement the malt where malt processing plant (storage, mills, mash tuns etc.) is a limiting factor.

Sucrose can be added to the beer after fermentation as ‘primings’ to provide sugar to encourage conditioning or increase sweetness and/or mouthfeel (particularly in low alcohol beers i.e. <3% ABV).

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Typical Analysis of 4 Common Syrups

	Wort	VHM	Maltose	High Glucose	Raw Cane
Extract (LD)	295-305	310-315	310-315	310-312	260-265
Dry Solids (%)	78-80	78-80	78-80	78-80	67-69
Colour (EBC)	3-6	<5	<5	2-10	30-40
Sucrose (%)	5	0	0	0	94-98
Invert (%)	0	0	0	0	<2
Glucose (%)	10	<4	35-43	94	0
Maltose (%)	50	>68	30-38	3-4	0
Maltotriose (%)	15	13-20	15-18	0	0
Higher Sugars (%)	20	8-13	10-15	2-3	2-6
Fermentability (%)	73-77	87-92	80-85	91-96	94-97

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Effect of syrup addition on wort nitrogen

In general, an effective fermentation requires >150mg/L FAN

Grist	Malt N	Wort TN	Wort TSN	Wort FAN
100% malt	1.65	1.65	740	200
+20% syrup	1.65	1.32	590	160
+30% syrup	1.65	1.16	520	140

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Other liquids & syrups

Caramels

Caramels add colour. Produced by heating invert sugars or acid hydrolysed starches. The colour is produced via the Maillard reaction. Extremely dark and has a sweetish burnt toffee flavour. Used in porters, stouts and dark milds.

Honey

Added for flavour at the end of the boil to copper/kettle or direct to the fermenter. Can also be used for priming (sweetness and honey notes in the finished product).

Molasses/treacle

Imparts a rich depth of flavour, works well in darker beers such as porters or milds. Again, like honey, can be used for addition to the kettle or for priming.

Maple syrup

Delicate flavour best added direct to fermenter or used as primings.

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Possible problems when using adjuncts

- Incomplete attenuation can more than likely be attributed to excessive use of adjuncts, particularly use of glucose syrup.
- Lack of essential ions: Zn, Mg etc.
- Glucose level (>10%) may cause stuck fermentations through catabolite repression; high glucose concentrations suppress the uptake of other sugars by the yeast.
- Critical dilution of the wort protein content (FAN) can also cause stuck fermentations through a change in pH. FAN dilution can also lead to excessive diacetyl production
- If the protein content of the wort is too low there will be no pH buffering action. Therefore, as the fermentation proceeds the pH can drop and inhibit cell growth and halt the progression of attenuation.
- Ideally total adjuncts should not exceed 30%

Some typical flavourings

Fruits, vegetables, spices etc.

- Cherry
- Raspberry
- Strawberry
- Peach
- Banana
- Orange or lemon peel
- Juniper berries
- Pumpkin & 'field beers'
- Coriander (Belgian witbiers)
- Ginger
- Spruce needles
- Pepper
- Chilli
- Liquorice
- Cinnamon
- Coffee
- Chocolate

Types of addition & considerations

- Fruits: Whole, pulp, puree, juice concentrates (pectin?)
- Spices: Fresh, dried, whole, powder (haze?), coarse grind
- Coffee and chocolate: rough grind, nibs, beans, powder (haze?)
- When to add?
- Fermentability?
- Stability?
- How much to add? – Is more, better?

Thank you.

Any questions?