Caramel for beer

Food experts will tell us, with self-evident truth, that we eat and drink with our eyes. The attractiveness of any consumable is greatly affected by its appearance. This is true of roast beef, or ice cream, but it is perhaps particularly true of drinks. I could go on about this at some length, but brewers already know that one long-established means of enhancing the appearance, and character of their beer is by the use of Caramel Colour.

History
Used by brewers for over a century, caramel colours are very dark liquids produced by cooking a carbohydrate solution at a very high temperature, usually with an inorganic reagent.

In a classic text on brewing, H. Lloyd Hind in 1936 quoted a paper on the manufacture of beer caramel published in the Institute of Brewing Journal in 1900.

Originally the carbohydrate would have been a more or less refined sucrose and this is still the main resource in areas where sugar is indigenous and cheap. However, since it became easily available glucose syrup has been a more cost effective raw material in Europe and North America.

In Europe the production and use of caramel colour is now governed by two European statutes, the European Colours in Food Directive (94/36/EC) and the Food additive Purity Directive (95/45/EC). As could be expected, the former lays down which colouring materials may be used in what foodstuffs, while the latter provides a framework of specifications for every permitted type of food colouring.

Although these define the properties of caramel very precisely, they impose very little on caramel use in brewing so I will not refer to them in any great detail.

The colour regulations do recognise that caramels can be produced from a number of raw materials and that the caramel producers themselves have defined four types of caramel, each using different groups of reagents and each as a result having different properties.

Each group was originally defined as Class I, Class II etc. by the FAO/WHO Joint Expert Committee for Food Additives (JECA), and later the same groups were adopted by the EU and given food additive numbers E150a, E150b etc. The groups are quite well known, but perhaps it is worth repeating the groups briefly for the sake of clarity:

Class I or E150a: Carbohydrates heated with or without acids or alkalis; no ammonium or sulphite compounds are used.

These caramels have great stability in alcohol up to 80% v/v and are known as ‘plain’ or ‘spirit’ caramels. They are not stable in acidic solution.

Class II or E150b: Carbohydrates heated with or without acids or alkalis, in the presence of sulphite compounds; no ammonium compounds are used.

These caramels have great stability in alcohol up to 80% v/v and are known as ‘plain’ or ‘spirit’ caramels. They are not stable in acidic solution.

Class III or E150c: Carbohydrates heated with or without acids or alkalis, in the presence of ammonium compounds; no sulphite compounds are used.

These caramels have great stability in alcohol up to 80% v/v and are known as ‘plain’ or ‘spirit’ caramels. They are not stable in acidic solution.

Class IV or E150d: Carbohydrate heated with or without acid or alkalis in the presence of both ammonium and sulphite compounds.

Very stable in acid solution and so preferred for soft (carbonated) drinks.

Within each group there can be very wide variation in both intensity of colour and level of solids giving rise to the many different grades of caramel. However, the hue, or red-brown to grey-brown shade of the caramel is determined by the manufacturing process and final colour and cannot be altered for any given type of caramel. Table 1 shows the typical colour intensity ranges for each type of Caramel and Table 2 the hue indices which relate to these colours.
Chemical reactions occurring in the syrup become exoergic, releasing large amounts of heat, and it becomes necessary to control the process by cooling. The cookers or ‘pans’ are always stirred to even out heating and cooling effects and prevent charring and are vented via a sophisticated scrubbing system which removes oxides of sulphur and nitrogen evaporated from the reaction during cooking. After a due period of time, a target colour is reached, and the cooking process is stopped as rapidly as possible by cooling – usually by both cooling jackets or coils, and by adding cold water to the product. The operator skill is in picking exactly the correct moment to start the cooling process, so after the event, the batch of caramel possesses both the correct colour value and the correct specific gravity. In modern plants this is made much easier by consistent, computerised control of batch quantities and temperatures but the operators’ final intervention remains critical. The cooled product is transferred to a storage tank or delivery vehicle via a sock filter or similar to remove any charred particles. It is important to be aware that caramel never becomes a ‘fixed’ product. Heating, even due to a drum lying for a few hours in the sun, can restart the darkening process. Fortunately even if this happens, it will not normally affect the caramel’s suitability for use, though an adjustment to the usage rate to compensate for the increased colour might become necessary.

Chemistry

The chemistry of caramel formation is complicated, and it seems probable that more has been written about these reactions than is actually known and understood! There are certainly condensation reactions in the glucose syrup, and water and carbon dioxide are evolved. Complex ‘Maillard’ reactions occur, where the nitrogen from the ammonia forms glycosylamines which also condense and polymerise into coloured molecules. The result is a very great mixture of molecules with wide diversity of size. There is some residue of small, colourless molecules which give caramel odour and flavour, and many very large complex molecules which create the colour. Depending on the process parameters, most caramels also contain some residual reducing sugars, typically between 5% and 20% of the dry solids.

Caramel is a colloid, in effect a suspension of minute droplets in water, and like many particles the caramel particles carry an electrostatic charge. There is therefore an electrostatic potential, the isoelectric point, at which these particles become unstable, coalesce with one another or some external matrix, and usually precipitate into a haze. As the isoelectric point depends on the type of caramel, this is a major determinant in deciding which type of caramel should be used for any given application.

Application

By contrast to its chemistry, the application of caramel, particularly in brewing, is relatively simple. Caramel is inert, physically stable when stored appropriately, and bacteriostatic if not totally sterile. Perhaps the only slight constraint on its use is that it tends to be a quite viscous liquid at room temperatures. Even here, improved modern manufacturing techniques have resulted in better products with much lower viscosities than used to be the case twenty or thirty years ago. For short periods, caramels can also be diluted and stored ‘ready for use’ in a more easily handled form.

Caramel in drum can simply be stored in any sound store-room, provided it is kept at a reasonable ambient temperature and out of direct sunlight. Bulk caramel should be stored in a stainless steel lagged tank. Trace heating of the tank should not be necessary as the product will normally be delivered warm and should not cool down to such a low temperature as to cause handling difficulties. It may be desirable to trace heat the pipework carrying the caramel when it is used, particularly if this pipework passes out of doors or through unheated areas.

As bulk tanks are emptied, moist air drawn in can result in some condensation in the headspace of the tank. This could be a source of infection, and there are two common ways of dealing with this. Either the air can be kept out of the headspace by a minimal pressure of nitrogen or carbon dioxide, or the storage tank can be agitated. This mixes any tiny droplets of condensation into the bulk of the caramel so that infection cannot develop. It has the secondary advantage of keeping the caramel consistent if tanks are topped up, and at an even temperature.

Another option is to fit a sterile filter to the tank vent. Unfortunately this also necessitates a bursting disc to avert any risk of collapsing the tank during washing or if the tank ever overflows, and the result can be a complicated and costly vent system.

Generally speaking there are two traditional methods of adding caramel to beer, either by putting caramel in to the wort, typically by injecting it into the boiling brew in the copper or by metering (usually diluted) caramel into fermented beer at some stage before packaging.

The former method has the advantages of (a) giving a long and thorough mixing opportunity to allow the caramel to be absorbed intimately into the beer and (b) ensures total stabilisation of the caramel after addition. It has the disadvantage that some colour will subsequently be lost in the trub and yeast separation processes, but is the preferred method where larger additions of caramel are to be made for a dark beer quality.

However, the colour of a brew, even a pale one, will vary due to several factors such as the wort boiling time and efficiency, malt colour etc. There is therefore often a need to make a fine adjustment to the colour of the beer before packaging, where addition of caramel to fermented beer becomes necessary.

There is good evidence that, quite apart from simple mixing for consistent colour, caramel mixed into beer retains a little time to fully homogenise. If beer does not get this time, final beer filtration will remove more colour from the beer than is absolutely unavoidable.

There is therefore a compromise to be made as to how late in the process the colour adjustment can be made with confidence that it will achieve the necessary effect. Ideally, with some experience a final adjustment into the flow of beer into cold storage will give the correct final colour. However it is also possible to add small quantities of Caramel to the filtered bright beer before packaging.

Until 1990, the use of brewing raw materials was closely controlled by H.M. Customs & Excise as a means of policing beer duty. Wort was ‘declared’ for duty before fermentation, and if any fermentable material was to be added after this point the addition had to be declared in detail and in advance in the Brewing Book – a complete record of all the brewing operations and the bane of most junior brewer’s lives.

The Excise rules defined caramel as a ‘fermentable material’. For addition to the beer any caramel had to be cut (diluted) to a specific gravity no higher than 1.150 and stored in a measured holding tank for inspection before use. This inspection did not often take place, but the brewer who started to use a caramel batch early on the night when the Excise Officer decided to make a surprise visit would be in deep trouble!

After due dilution and declaration, the caramel could be measured into the beer as required. Ideally, this corrective addition would be made to the beer after most of the yeast had been removed, and at the start of any cold storage period. However, even this would not always get the colour spot-on, and small final additions could be made to bright beer before packaging. A large amount of caramel added at this stage could sometimes increase the bright beer’s haze slightly.

Under current conditions, there is minimal Excise control, but addition methods remain
largely the same. In some breweries, the caramel is now bought ready diluted, or diluted on site and metered into a flow of beer in a pipe to ensure thorough mixing.

The rate of addition can be simply determined by proportionation. To colour 1000hl. beer up from say 20EBC to 25EBC units, using a caramel of 30,000EBC colour, the following formula applies:

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\text{Weight of caramel required} = \frac{(\text{Weight of beer} + \text{weight of caramel} \times \text{Desired colour}) - (\text{Weight of beer} \times \text{Start colour})}{\text{Weight of caramel required} \times \text{colour of caramel}}
\]

The weight of caramel will be insignificant compared with the weight of beer, and for these purposes we can assume an s.g. of 1.000 for the beer, so the formula becomes:

\[
(100000 \times 25) - (100000 \times 20) = \text{Wt. caramel} \times 30,000
\]

Weight of caramel required therefore = 500,000 ÷ 30,000 = 50 ÷ 3 = 16.7kg.

Unfortunately, we cannot ignore the s.g. of caramel, so to correct this to the usually more convenient volume we have to divide 16.7 by the s.g. of the caramel, typically around 1.320, which would give us a requirement for this operation of 12.65 litres of caramel.

Caramelised syrups

Up to now I have been concerned with Caramel Colour, as defined by the Food Regulations. However, there is also a less well defined range of products produced by lightly cooking syrups without the use of any catalyst. This produces a range of slightly sweet, toffee flavoured products collectively known as Caramelised syrups or in Europe Caramel aromatique, and the raw material for these can be either glucose or sugar or some blend of the two.

The products are still not the same as the confectionery caramel found in sweets and wafer biscuits, but are used as ice cream ripple or crème caramel topping, and also have application as a brewing syrup.

Unlike simple glucose syrups, caramelised syrups can contribute significant flavour to a beer. However, because they are lightly cooked, they can also retain a high level of fermentability. They can therefore give some flavour and mouthfeel, and they can provide fermentable material. The balance between these two will depend on both the properties of the caramelised syrup and the point at which it is added to a brew.

Clearly if the syrup is added before fermentation, that part of it which is fermentable will be converted to alcohol by the yeast. However, if added after fermentation, both fermentable and unfermentable syrup will remain as flavour material in the finished beer unless a secondary fermentation in cask or bottle is allowed to take place. Table 3 shows the relative fermentability of the range of D.D. Williamson's brewing syrups.

In conclusion

The use of caramel in beer is both long established and cost effective, whether it is used to add character or simply achieve consistency of quality. I hope this short article also provides some wider background to the nature of caramel and its manufacture.