Cider-making: an overview

Andrew Lea discusses some current trends in cider-making, from juicing and fermentation to sensory attributes

Stockpile of harvested cider apples (photo credit, NACM).

Definition of cider

Cider is an alcoholic drink made from apples, and is produced in a wider range of countries than is often supposed, including France, Spain, Ireland, Germany, Switzerland, South Africa, Australia and New Zealand. In North America, the unqualified term 'cider' usually refers to unfermented apple juice, but increasing quantities of 'hard' (i.e. fermented) cider are now being made in many US States and in Canada, and production there is increasing. However, the greatest production of fermented cider worldwide is still in England at around 500 M litres per annum.

Cider in all these countries is very different and so are the permitted practices and production methods. French cider (Breton and Norman) is low in alcohol and contains significant residual unfermented sugar. German cider, mostly from the Frankfurt and Trier regions, is fully fermented and very dry to an English palate. Spanish (mostly Asturian) cider is characterised by a high volatile acidity and by its foaming characteristics when served. Modern English ciders are for the most part characterised by light flavours, which arise from 'chaptalisation' with glucose syrup before fermentation to give high alcohol apple wines, which are then diluted with water and sweeteners prior to retail sale. These products are intended to compete in the lager market and are made and marketed in similar fashion. However, the UK cider industry is presently at something of a crossroads, and there is now a reviving interest in pure juice 'craft' ciders, which are positioned more in the speciality and wine sectors. Although many of these are produced by small manufacturers with only local distribution through farmers markets and similar outlets, a few are gaining national listings so that the cider shelves of major UK supermarkets are now a great deal more diverse than they were even 5 years ago.

Cider is in effect an apple wine, and good practice in wine and cider industries is similar. The world literature on cider-making is sparse. Most of it originates from the Long Ashton Research Station (LARS), near Bristol, which opened in 1903 as a cider research institute and closed just 100 years later. Our knowledge of cider chemistry and microbiology, and of the associated cider orcharding, is largely due to the research conducted at LARS during those years.

Raw materials

Apples are the primary raw material for cider-making and the traditional classification for English cider apples is shown in the Table below. There are probably around 100 UK cider cultivars still in cultivation, of which only 15 or so are current in modern intensive orchards. New lower-tannin cultivars bred by Williams and Copas in the final years at LARS are now coming into production.

Modern cider orcharding is a specialist business and plantings in recent years have tended to be on dwarf rootstocks and using intensive systems suitable for mechanical harvesting, although planting on the more widely spaced 'standard' system is returning to fashion for craft cider-making. True cider cultivars tend to have higher sugar levels than dessert apples and a more fibrous structure that makes pressing easier and juice yields higher. A further feature of cider fruit, particularly French and English bittersweets, is the relatively high concentration of polyphenols, loosely known as 'tannin'. Although modern ciders are generally lower in tannin than in the past, it still makes an important contribution to the overall mouthfeel of the beverage and prevents it becoming too insipid. The polyphenols make a major contribution to flavour, colour and 'pressability', and also have weak anti-microbial properties.

In some cases, cider fruit is also characterised by 'vintage quality', which is of particular concern to the craft producer. Vintage quality apples produce slower fermenting juices, which give generally more complex and interesting flavours to the cider than does bulk fruit. However, the vintage cultivars have generally lower yields and are often more difficult to grow.

It is rare for cider to be made of a single cultivar apple only. This is partly because the balance of sugar, acid and tannin required for a successful product is difficult to achieve, and a blend to obtain the appropriate balance is nearly always necessary. In addition, orchard cultivation considerations such as the need for cross-pollination and a

Category	Acid %	'Tannin' %	Typical bulk cultivar	Typical 'vintage' cultivar
Sharp	> 0.45	< 0.2	Bramley	Frederick
Bittersharp	> 0.45	> 0.2	Browns Apple	Kingston Black
Bittersweet	< 0.45	> 0.2	Ashton Bitter	Dabinett
Sweet	< 0.45	< 0.2	Michelin	Sweet Coppin

spread of harvesting period dictate the growing of relatively mixed orchards. Hence, fruit selection and pre-fermentation blending is regarded as a part of the traditional cider-maker's art. Apple juice concentrate (AJC) is now widely used in UK factory cider-making and is permissible also to a limited extent in France. 'Bulk' concentrates are bought on the world market, while UK bittersweet concentrates are prepared in-house for later use. This reduces the seasonal impact of fruit supply and enables factory cider-making to carry on throughout the year in a fashion similar to the brewing of beer.

Juice preparation

Fresh cider fruit is traditionally stored for a few weeks after harvest so that all the starch converts to sugar (although nowadays amylases added to pulp can also achieve this). Apples must be sorted and washed before milling to eliminate rotten fruit and orchard debris, which have adverse effects on microbiological status and on ultimate cider quality. Modern mills are high-speed stainless steel graters, but in previous times horse-powered 'edge-runner' stone mills were used. The juice is squeezed from the milled pulp in a separate operation. Labour-intensive pack presses have traditionally been used for this but automated horizontal piston presses and/or belt presses are now standard in the larger factories.

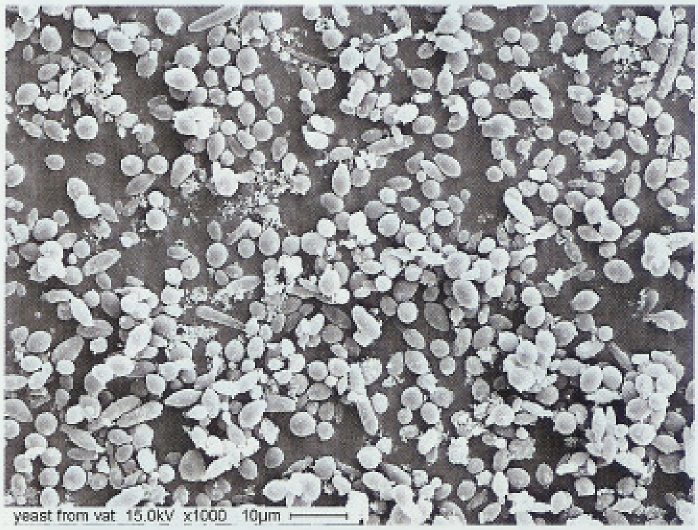
Once the juice is prepared, it is coarsely screened and run off to tanks of fibreglass, high density polythene, stainless steel or (much less commonly) wood for pre-fermentation blending and additions. In English factory cider-making, the fermentable sugar sources (juice, AJC and sugar syrups) are blended to the required level (Specific Gravity up to 1.100). Nutrients such as ammonium phosphate and thiamine are also added to ensure a complete and speedy fermentation to dryness. Broad-spectrum pectinases are used at this stage to prevent haze formation later.

Traditional pure juice ciders start at around SG 1.055 and may be fermented for weeks or even months. The traditional spontaneous pre-fermentation clarification of juice by the action of endogenous pectin methyl-esterase (PME) ('keeving') is now effectively obsolete in England but is still central to the industry in France where nitrogen flotation and added PME are used for reliability. This also has the deliberate effect of removing nutrients from the juice to ensure a very slow subsequent fermentation.

A significant adjunct in cider-making, as in white wine-making, is sulphur dioxide, primarily as an anti-microbial but also as an antioxidant. This was traditionally added by burning a 'sulphur candle' in the barrel, but is now controlled by the addition of defined levels of metabisulphite. The effectiveness of SO_2 is pH dependant since it is only the undissociated form (so-called 'molecular SO_2') which has anti-microbial properties. Hence, cider juices are usually brought below pH 3.8 by the addition of malic acid before addition of SO_2. If the original fruit is in poor condition, it may contain large amounts of 5-ketofructose or diketogluconic acid from bacterial activity, which will bind most of the added SO_2 and reduce its effectiveness.

Yeast selection

In traditional cider-making, no external source of yeast is added. However, since the apples themselves contain a mixed yeast microflora in the order of 5 $\times 10^4$ cells per gram of stored fruit, spontaneous fermentation will commence within a few hours if the temperature of the juice is above 10° C. In such a fermentation, where no yeast is added and no sulphite is used, the first few days are dominated by the non-*Saccharomyces* yeasts such as *Kloeckera apiculata*, followed by a succession to *Saccharomyces spp.* as



SEM of 'wild yeast' cider fermentation from a vat, showing a diverse yeast flora, including the characteristic 'lemon-shaped' apiculate yeasts e.g. **Kloeckera apiculata,** *in addition to* **Saccharomyces** *spp (photo credit, Jill Webb, RSSL).*

UK cider sales have doubled in the last 10 years (photo credit, NACM).

Cider apples (photo credit, Liz Copas).

the alcohol level rises and the initial colonisers die out. Nowadays, however, heavy sulphiting followed by pure culture inoculation with *Saccharomyces* wine yeasts is almost universal in the mainstream UK cider industry.

Craft cider-makers do not necessarily follow suit on yeast inoculation and often prefer some element of the natural microflora to remain. The judicious use of low-level SO_2 can help to eliminate the most troublesome yeast and bacteria while still allowing a more diverse population to develop than is available from a single added monoculture. In France, the need for a mixed microflora is regarded as axiomatic for reasons of flavour complexity. Modern French factory cider-making is still based on traditional procedures, and care is taken to ensure a cool slow fermentation over several months, so that significant residual sugar remains in the final product. English factory practice is almost completely the opposite, a rapid and complete fermentation to 12% alcohol in as little as one week being a desirable objective.

The malo-lactic fermentation

Traditional ciders are very frequently subject to a malo-lactic fermentation. The major desirable organism responsible for this change is the bacterium *Leuconostoc oenos*, although other *Lactobacillus* species may also be present. It is favoured by a lack of sulphiting during fermentation and storage, and by a certain amount of nutrient release from yeast autolysis when the cider stands unracked on its lees. In French and Spanish cider-making, where the primary fermentation is very slow, the malo-lactic change may occur concurrently with the yeast fermentation, whereas in UK cider-making, it is most likely to occur once the yeast fermentation has finished and the cider is in bulk store.

The most obvious external feature of the malo-lactic change is the decarboxylation of malic to lactic acid and the consequent evolution of gas. The acidity therefore falls and the flavour becomes rounded and more complex. In traditional stored cider in the UK, this takes place in Spring as the weather warms up and the trees blossom, thereby giving rise to the belief that the trees and the cider are somehow working in sympathy! In modern UK factory cider-making, the malo-lactic fermentation is generally regarded as a nuisance because of the loss of acid and is not encouraged, but it is normally welcomed by craft cider-makers and indeed may even be deliberately induced by the inoculation of commercial (winemaking) bacterial cultures. Old oak 'maturation' vats have been shown to retain the bacteria within the pores of the wood and hence provide an immediate inoculum for each new filling of cider.

Storage and packaging

Once yeast fermentation is complete, ciders are racked from the yeast lees for storage. In some English factories, racking and clarification takes place as soon as possible for virtually immediate blending and packaging without any maturation. In others, the ciders remain on their lees for several weeks and are racked into inert tanks or oak vats for a maturation period of several months. During this time a malo-lactic fermentation may or may not be encouraged; if considered desirable, no sulphur dioxide must be added during storage or the bacteria will be inhibited. At any rate, air is the enemy of cider and must be rigorously excluded during storage.

Initial clarification may be performed by the natural settling of a flocculating yeast, by centrifugation, by 'fining' with gelatin or chitosan, or by a combination of all three, before blending. Craft cider-makers generally perform less post-fermentation blending than do the major producers. In a large factory, high alcohol 'base ciders' will be blended according to the cider-maker's requirements. Water will be added to these bases to give the correct alcoholic strength for retail sale (3.5-8.5%), together with additions of sugar and artificial sweeteners, malic or other acids, permitted food colours, preservatives and carbonation. Generally, UK regulations permit for cider all those operations or additives which are allowed by EU 'horizontal' food law. In France and Germany, specific 'vertical' legislation applies to cider and is much more restrictive.

Final filtration may take place just before and after blending. Typically, powder filters or coarse disposable sheets are used to produce a bright product, followed by near-sterile sheet or membrane filtration (0.5 µm) to remove all yeasts and most bacteria. Cross-flow membrane filtration systems have become a popular and efficient alternative in recent years. Most ciders are then pasteurised and/or carbonated into the final pack. In some cases, in-bottle or tunnel pasteurisation of glass bottles or cans is still used. With the widespread use of PET bottles by many producers, HTST treatment in a flow-through pasteuriser and chiller is required followed by near-aseptic filling conditions. For mainstream pub sales, cider is filled into pressure-dispense kegs as is beer.

There is a certain market for 'naturally-conditioned' ciders in kegs or small plastic barrels. These are generally produced from fully fermented dry ciders, to which an additional charge of sugar and yeast has then been added. The product is of course somewhat cloudy but may remain in good condition for many weeks due to the slow continued fermentation. Traditional bottled cider in the UK up to the mid-20th Century was naturally conditioned in the bottle and retained a slight yeast deposit (as much French *'artisanal'* cider does now), but due to its variability and the danger of exploding bottles it was gradually replaced by force-carbonation. It is now known that the traditional system was invented in the Forest of Dean in the 1640s, some 50 years or so before being adopted for sparkling wine in the Champagne area of France! True *'methode traditionelle'* ciders, prepared by secondary fermentation in bottle followed by disgorging the yeast from the neck, are expensive to produce but the style is now being revived by a number of craft cider-makers in the UK. Many small producers sell their ciders bottled in the style of dry table wines and without any overt carbonation at all. Fully dry ciders are not to everyone's taste, but the addition of sugar for sweetening means running the risk of an uncontrolled and potentially dangerous secondary fermentation in the bottle unless pasteurisation is used. Preservatives such as sorbate are permitted in cider but cannot be solely relied upon for total effectiveness.

Cider flavour

As with any beverage, the flavour of cider is a combination of taste and aroma. Traditional English and French ciders made from bittersweet fruit have been distinguished by relatively high levels of bitterness and astringency due to the polyphenolic procyanidins ('tannin'), although nowadays these heavily tannic flavours are much less in demand. Acidity is corrected by blending or by the addition of food grade acids from external sources. Sweetness may be provided by sugar or by a variety of non-nutritive synthetic sweeteners. Carbonation levels and serving temperature can also have a considerable impact on the perception of cider flavour.

The volatile aroma of cider is in the most part qualitatively identical to that of all other fermented beverages and derives to a large extent from the yeast utilising well-known biosynthetic pathways. Ciders have traditionally been regarded as high in 'fusel alcohols', particularly 2-phenyl ethanol, which has often been attributed to their low nutrient status. It is also known that higher fusel levels are generated from cloudy rather than clear juice fermentations, and these factors may be contributory to the 'hangover-generating' properties of rough 'scrumpy' ciders! Work at LARS over a number of years listed several hundred compounds as contributors to cider aroma. Some of these arise from non-volatile glycosidic precursors which are hydrolysed by enzymic action when the fruit is disrupted. Therefore, the high levels of 2-phenyl ethanol and its esters in ciders may not only derive *de novo* from yeast synthesis or de-amination of phenylalanine (both routes are known), but also from the presence of a glycosidically-bound form in the fruit, which is liberated and cleaved during fermentation.

One of the most interesting and perhaps unique volatile components of cider is the dioxolane, which results from the condensation of acetaldehyde (a normal fermentation metabolite) with octane-1,3,-diol. The diol itself is an unusual alcohol, which is known to be restricted almost entirely to apples and is present in a glycosidically-bound form. The resultant dioxolane has a characteristically green and 'cidery' note and results specifically from the action of alcoholic fermentation on apples and in no other way.

A particular group of flavours described as 'spicy' and 'phenolic' derives principally from the malo-lactic fermentation in bittersweet ciders. These are typified by ethyl phenol and ethyl catechol, which arise from hydrolysis, decarboxylation and reduction of certain phenolic acids in the fruit. Although these volatile phenols are not unique to cider, being found in whiskies too, they are distinctive contributors at low levels to the characteristic 'spicy-bittersweet' aromas of well-made traditional ciders from the West Country or Normandy.

Further reading and information

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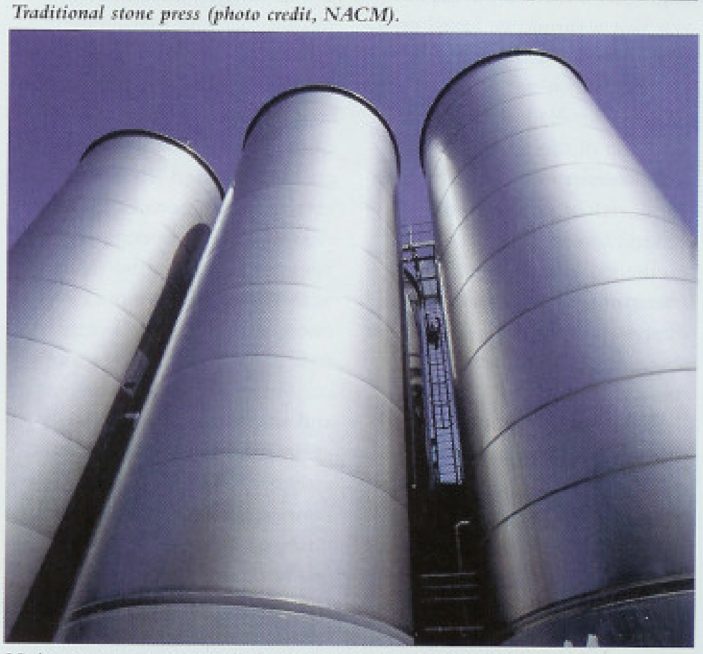
Traditional stone press (photo credit, NACM).



Modern temperature controlled stainless steel vats (photo credit, NACM).