Chapter 8
Malt and Distilled Malt Vinegar

Bill Grierson

8.1 History

The origins of malt vinegar in Britain go back several hundred years. As Britain is a beer-drinking nation, the early vinegars were simply beer that had turned sour; it was left and encouraged to acetify completely, and then processed, packed and sold in the area around the local beer brewery. The area of sales covered only a few miles radius from the brewery, as this was as far as a horse could travel and return in a day.

Malt vinegar was in those days frequently referred to as 'alegar' – a combination of the words 'ale' (beer) and 'vinegar'. It was some time later that the vinegar brewers of the day had to learn how to brew their own 'barley wine', as the beer brewers had discovered the reasons for their beer going sour and had taken steps to correct the process.

8.2 Definition

There are several varieties of malt vinegar available, which include distilled, light and dark malt vinegar.

Malt vinegar is a vinegar produced, without intermediate distillation, by the process of double fermentation – alcoholic and acetous – from malted barley, with or without the addition of cereal grain, the starch of which has been converted to sugars by the natural enzymes of malted barley. It is well known that the popular vinegar of a region follows the popular beverage of that region. Thus it is the popular choice of Great Britain, the eastern USA and some areas of Europe. Malt vinegar is a pale straw-coloured liquid, with a strong acetous flavour, whereas dark malt vinegar has a dark brown colour. The dark colour is derived from the addition of barley extract or caramel to the malt vinegar.

Distilled malt vinegar is obtained by the distillation of malt vinegar (as defined above) under reduced pressure. It contains only the volatile constituents of the malt

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vinegar from which it is derived. Distilled malt vinegar is colourless and is sharper in flavour and mildly aromatic.

8.3 Raw Materials

The essential raw materials for malt vinegar production are malted barley, water and the microorganisms responsible for fermentative and oxidative transformations; yeasts and acetic acid bacteria, respectively.

8.4 Production

Barley provides sugars (maltose and glucose) for alcoholic fermentation by yeasts and the nitrogen source (amino acids) necessary to support yeast and acetic acid bacterial growth. In raw barley, substances are present as starch and proteins, both not directly metabolized by yeasts. Some initial processing steps are necessary to permit the subsequent fermentation and acetification.

8.4.1 Brewing

8.4.1.1 Milling

The first stage of the brewing process is to prepare the malted barley by milling. That means breaking open the corn in a precisely controlled fashion. This task is undertaken using a series of rollers in a malt mill (Figure 8.1). These rollers are set

Figure 8.1 Malt mill

very precisely to within one-thousandth of an inch. A double roller mill is common, but more than two sets of rollers may be present. The first set of rollers reduces the size of the grain by splitting it, preferably longitudinally, with the second set reducing the size further. A typical specification for the grain exiting the mill would be: husk 28-30%, coarse grits 60-70%, fine grits 2-4%, and flour 1-2%. This material is now known as 'grist'.

This milling can be carried out using any one of several types of mill. Double roller mills are most commonly used in the UK, but ball mills, pin disc mills or hammer mills may also be used.

8.4.1.2 Mashing

The second stage in the brewing process is to convert the grain starch to sugars in order to permit the alcoholic fermentation by yeasts. This is the function of the mashing process. The mashing vessel should be preheated by covering the perforated bottom plates with hot water and heating the remainder of the vessel by steam. The hot water is run off immediately prior to starting the mashing process. The milled grain is then initially mixed with hot water at a precisely controlled temperature by means of a Steel's masher; this consists of a set of revolving spikes that produces a thorough admixture of the grist and the hot water to a fairly thick consistency (0.019-0.023 hL of liquor per kilogram of grist) which is then allowed to flow directly into a mash tun (Figure 8.2). The temperature of the water (called the striking heat) should be approx 70 °C; this should give an initial temperature in the mash tun of around 63-66 °C. Temperature and time profiles of mashing are important parameters in the brewing process as they affect the enzyme activity and therefore the proportions of the various sugars and amino acids in the wort.

At this stage the grain/water mixture, called 'goods', is allowed to stand for at least 1 hour. During this time the grain 'floats' above the false bottom of the tun and the enzymes – alpha and beta amylase, protease and beta glucanases – convert the starch to fermentable sugars. When at least an hour from the end of mashing has elapsed, we obtain a sugar solution, called 'sweet wort'. This sweet wort is run off from the bottom of the mash tun and cooled. It is not boiled, as in beer brewing. When a controlled volume has been run off, more liquor is sparged onto the grain

Figure 8.2 Mash tun

Figure 8.3 Fermenting vessels

bed at an approximate temperature of 77 °C. The amount of liquor needed can be calculated depending on the quantity of grain used per brew. It is normally split into two additions. The run-off is then continued until the requisite volume has been collected at the required gravity. This sweet wort is cooled to 25 °C as it is run off from the tun and is then transferred directly to the fermentation vessel (Figure 8.3). The spent grain is then removed from the tun and normally sold for animal feed as 'wet grains'.

8.4.1.3 Alcoholic Fermentation

When a small volume of sweet wort has been collected, brewing yeasts belonging to the species *Saccharomyces cerevisiae* are added at a pitching rate of approx 0.03% by weight to obtain a suitable starting population. The fermenting wort is maintained at a controlled temperature of 20-30 °C (Figure 8.4) by means of a circulation system, which will introduce air to the fermenter. During this fermentation process, the growth of the yeast population by about five- to six-fold occurs. Wort sugars, glucose, fructose, maltose and maltotriose are fermented by the Embden-Meyerhof-Parnas pathway to ethanol, carbon dioxide and some traces of higher alcohols, esters and aldehydes. After 2-4 days the fermentation has been completed and the circulation is closed down. Finally the fermented wort is transferred to storage via the separators.

Figure 8.4 Temperature control panel

8.4.2 Separation

At this stage in the process, the yeasts are inactive and begin to autolyse, promoting strongly reducing conditions which will hinder the acetification process. It is therefore imperative to remove the yeast cells by high-speed centrifugal separation (the normal filters used for live yeast are useless in this situation) (Figure 8.5). The 'bright wort' is stored to await acetification, and the yeast is discharged to waste. This waste yeast can be added to the wet grains from the mash tun as it goes for animal feed.

During the storage of this fermented wort the maturing process starts to take place due to the esterification of the alcohols and the acetic acid which begins to form in the stored wort.

Figure 8.5 Centrifugal separator

8.4.3 Acetification

The conversion of the alcoholic liquid produced by the above processes into 'vinegar' can be accomplished by two types of process; either by acetifiers, which give an average yield of 90-94%, or by acetators, with a yield of 93-97%.

Acetifiers are vessels designed with an open trellis-work platform constructed approximately two-thirds of the way up the vessel, on to which is packed woodwool. This material provides a suitable habitat for the *Acetobacter* species. Air enters the system below the platform and, together with the alcoholic liquid, facilitates the growth of the Acetobacter species, which convert the alcohol to acetic acid via two successive catalytic reactions of a membrane-bound alcohol dehydrogenase (ADH) and a membrane-bound aldehyde dehydrogenase (ALDH). The space below the platform houses the fermenting material, with this being continuously circulated, by way of a cooling system, into a spray mechanism above the woodwool packing, and then being allowed to trickle back to the bulk. The air is introduced into the system immediately below the platform and is drawn through the woodwool by the increased temperature of fermentation; it is allowed to exit

through the top of the vessel. This is a fairly slow process and has largely been superseded by the acetator.

8.4.4 Storage

The 'rough stock vinegar', as the liquid is called after acetification, is pumped to large storage vessels and allowed to stand for at least 3 months (Figure 8.6). At this phase we have a high level of acetic acid and a low level of alcohols, which produce esters. The concentrations and relative amounts of these compounds have a significant impact on the unique flavour and bouquet of malt vinegar. The pH of the vinegar has by this time dropped to below 3 and various polyphenols etc. will slowly drop out of solution, giving the final vinegar a much more stable character.

Figure 8.6 Storage tanks of malt vinegar after acetification

8.4.5 Clarification

The vinegar at this stage needs to be filtered bright; this process may be carried out in different ways. Ultra-high-speed centrifuges are available with which to remove any particulate matter and produce a bright, straw-coloured liquid, which is fairly stable.

Plate and frame filtration is an alternative method of clarifying the rough vinegar. This process consists of mixing filter powder, usually diatomaceous earth, with the vinegar, which is then pumped through the filter, with the powder building up a fine filter bed on the plates and with the frames filling with powder, giving a depth of filter bed to enhance the clarity of the vinegar. Membrane filters may also be employed to produce the required clarity.

8.4.6 Making up

This is the stage where the vinegar is 'made up' to whatever strength and colour is required for sale to customers (Figure 8.7). For bottled vinegar the normal strength

Figure 8.7 Making-up vessels

is 5% of total acidity and the colour is amber; water is therefore added to adjust the strength to this level, and colour is added to give the required degree of colour. The colour may be caramel or barley extract. This is also the stage when flavours may be added to produce special vinegars. The flavours are normally essential oils of the herb or fruit desired. It is also possible to utilize synthetic flavours at this stage.

8.4.7 Final Filtration and Packaging

The finished vinegar is normally filtered using sheet filters packed with clarifying grades of sheet (Figure 8.8) and passed directly to a heat exchanger for hot filling, or to a pasteurizer for bulk supplies. Bottled vinegar is hot-filled at 60 °C directly into the bottle. This ensures a sterile product, as all the machine components are sterilized by the hot vinegar on its way into the bottle.

The completed bottles are stacked on pallets and allowed to cool naturally; they are then forwarded to storage areas to await delivery to the customer. Vinegars for the catering trade are also packed at this stage and would consist of 5-, 10- or 25-litre packs.

Vinegars for the bulk trade are taken direct from the make-up vessels through clarifying sheet filters (or cartridge filters) to a pasteurizer, and they are then filled

Figure 8.8 Sheet filters

into the final containers for delivery to manufacturing customers. These bulk containers can be barrels, intermediate bulk containers (1000 L), or road tankers.

8.4.8 Distribution

Vinegar distribution is carried out by the normal schedules of road and rail transport to its required destinations – bottled vinegar on pallets and bulk vinegars either on pallets or palletized IBC's. Road tankers take higher-strength vinegars direct to other manufacturers for the production of pickles, sauces and similar products.

8.5 Distilled Malt Vinegar

After acetification and before the maturation storage, vinegar is passed direct to the distillation plant (Figure 8.9) for the production of distilled malt vinegar. The distillation plant consists of a steam-heated pan in which the vinegar is vaporized and then passed through a water-cooled condenser, all under high vacuum. The final product is a completely clear water-like liquid, containing only the volatile constituents of the original malt vinegar.

The distilled malt vinegar is sometimes referred to as 'white' vinegar and is approximately 0.2% weaker than the starting vinegar, as the fixed acid derived from the malt is non-volatile and remains behind in the still pan. This thick brown, residual, acidic liquid is on occasion sold for the production of flavouring for snack foods such as potato crisps.

Figure 8.9 Vinegar distillation plant

8.6 Vinegar Powder

A version of 'dried vinegar' can also be made. This powder is produced by initially mixing malt vinegar of at least 10% acidity with malto-dextrin powder, using a high sheer mixer. Malto-dextrin makes it easier to powderize the liquid. The resultant fairly viscous liquid is then fed into a conical spray-drying unit using an inlet

temperature of 190 °C and an outlet temperature of 98 °C. The air supply is at ambient temperature and the atomizer speed is approx 11,000 rpm using a curved vein atomizer.

The resultant product is a pale-coloured powder used in many 'dry mixes', such as sweet-and-sour recipes, soups and many other ready-meals.

Testing of the final powders consists of acidity levels and a measure of occupational density. This is a measure of the weight of powder per volume and is usually expressed in grams per litre.

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