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# Gin Manufacture

**A. C. Simpson,* B.Sc.**

**The key factors in the manufacture of gin are the spirit used, the botanical formulae and the technique of distillation. Unlike whisky, the spirit used for gin should have no indigenous flavour, the taste of the final beverage deriving entirely from the juniper, and other botanicals. The present article, dealing primarily with the manufacture of London dry gin, also points to the differences between this and gins such as Steinhager and Borovicka.**

MOST of the gin produced and drunk throughout the world is correctly described as London dry gin: the description relates to the process and not the siting of the distillery. Holland's gin, centred in the town of Schiedam in the Netherlands, is distinct in flavour and method of production. Plymouth gin comes from a unique distillery in Devon. A large quantity of gin is also made, generally for limited local markets, by various compounding and flavouring techniques. It is the manufacture of London dry gin which is specifically described in this article.

The word 'gin' is derived from the French 'genièvre', meaning juniper: it is from this plant that the principal flavouring agent is drawn. Gin is said to have been invented by the Dutchman, Franciscus de la Boe in the seventeenth century, as a specific based on the diuretic properties of juniper oil.[1] Despite a medicinal origin, gin had acquired a reputation in England a century later which was the contrary in extreme. It had become the principal agent of drunkenness among the lower classes and notorious gin shops of the period displayed such enticements as 'Drunk for 1d, dead drunk for 2d, straw for nothing'. Improvement came about with the retail licensing system and eventual concentration of distillery practice into the hands of a few large companies which developed individual strictly secret formulae. Lately the production of gin has been subject to scientific control in order to maintain uniformity in an essentially batch process.

By definition London dry gin is made from a relatively pure ethyl alcohol, flavoured by redistillation with various plant materials (botanicals) notable for their richness in essential oils. In a classification of spirits, gin is first cousin to liqueur and only distantly related to whisky and brandy, in which the flavour derives from the source of the alcohol.

Compound gin, made by the direct addition of essential oils to spirit is inferior in quality to distilled gin. The property of dryness in gin is associated with degree of flavour: a very dry gin is distilled from a low proportion of botanicals.

Gin is classified for Excise purposes as British compounded spirit which can be manufactured from immature spirit and distributed to the public without statutory age.

All spirits are defined for Excise, general trade purposes and retail in terms of percentage of proof spirit, a scale of alcoholic strength linearly proportional to per cent ethyl alcohol by volume in which proof spirit has a specific gravity of 0·92308 at 51°F.[2] On this scale, pure ethyl alcohol equals 175·35% proof; and 70% proof, the normal retail strength of spirits is equivalent to 40% by volume at normal temperature. In the parlance of the trade the former strength is 75 op (over proof) and the latter 30 up (under proof).

## Spirit

Gin production demands a supply of rectified fermentation spirit. The spirit must be clean and neutral in taste and odour and contain only traces of aldehydes, esters, fusel oils and other congeneries. The carbohydrate source of the spirit is generally grain (maize) but gin can be made from spirit of any source if it conforms to high analytical standards and is free from contaminant or congeneric odours. Spirit from molasses and, possibly, potato may therefore qualify (in Russia, spirit for vodka comes from these substrates). As the initial production of spirit is not an essential part of gin manufacture many gin distillers are not, themselves, producers of spirit.

The basic spirit is made from grain by saccharification of the mash with malted barley and distillation of the fermented mash in a patent still. The methods and materials bear a close relationship with those of the grain whisky industry. A spirit suitable for gin is obtained from Scotch grain whisky by re-rectification.

For the production of alcohol of good organoleptic quality from a fermentation spirit the fusel oils should be removed at the appropriate plate in the rectification column. Neutral alcohol is collected at the highest possible proof.

In North America, grain alcohol of extremely high purity and odour quality is produced in distilleries operating continuous, multi-column stills. Strict attention is paid to the conditions of fermentation, both in temperature control and sterility: the object is to maximise the yield of ethyl alcohol from a given weight of grain. The composition of the mash is regulated to secure good enzymic conversion without the formation of much fusel oil. The

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spirit produced is adequate in quality for either gin or vodka manufacture. Some grain spirit made in Britain for gin retains an odour suggestive of its origin, due to incomplete rectification and purification. Many gin distillers who are not spirit manufacturers rectify the spirit they buy before distilling it into gin.

## Botanicals

The essential botanical of gin is the berry of the European juniper tree, *Juniperus communis* L; other flavouring agents come from a number of plants including coriander, angelica, orange, cinnamon, nutmeg, cardamom, orris and others. Juniper berries, coriander seeds and angelica root are probably common factors in the composition of all London dry gins but the proportions differ from one distiller to another. The ratio of the three main flavouring agents and the inclusion of other selected botanicals are defined by the distiller's formula: an original combination which determines the character of gin. Distillers therefore do not disclose their botanical formulae.

Juniper berries[6] for the purposes of gin distillation are grown in Central Europe; the best berries come from the Chianti district of Tuscany but suitable material is also obtainable from Southern Germany and Yugoslavia. Berries from the Tyrol, Hungary and Czechoslovakia are generally utilised for local production of a juniper liqueur. At maturity the berries are smooth skinned, deep blue in colour and 5–8 mm diam. Fruiting is biennial and the ripe berries are removed by harvesters who agitate the branches of the trees causing the berries to fall upon sheets laid on the ground. The berries are winnowed and carefully dried avoiding damage and fermentation, and sorted into culinary and industrial grades. The adulteration of berries with those of other species of *Juniperus, e.g. oxycedrus*, is no longer so widespread because collection of the adulterant is no less arduous.

Juniper berries are classified and selected for gin on the basis of appearance and the physical and organoleptic properties of the extracted essential oil (1·5–3·0%). Several components of the oil have been isolated and identified;[6–8] by gas chromatographic analysis, Klein and Farrow[9] found 26·5% α-pinene, 9·0% myrcene, 8·8% sabinene and 3·8% limonene. It is to be expected that the components and the flavour of the oil will vary with locality and season: these factors are reflected in the physical properties of the oil on which the criteria of selection are based. For gin the berries should not give an oil with a predominantly terpenic odour;[10] the oxygenated compounds, in particular terpinen-4-ol, possess the aromatic flavour which characterises the best berries.

The second major botanical, the fruit of the herbaceous annual *Coriandrum sativum*,[4] is cultivated in Russia, Roumania and other East European countries, for the supply of gin distilleries and the essential oil industry. The crop is also grown in the US, North Africa and, surprisingly, in Essex, whence it is available to the English distiller after a good summer. Harvesting coriander demands judgement, for the fruit ripens sequentially and the farmer risks on the one hand an immature crop, and, on the other, shattered fruit with excessive loss of oil. It has been found that the crop contains the highest proportion of usable seed and quality of oil when the fruit on the central and first order umbels turns a chestnut colour.[11] The dried seeds (fruit) are 2–4 mm diam., number 100–130 to the gram and possess a perfumed but slightly cloying odour. Russian and English coriander seed yield 0·8–1·2% and 0·3–0·8% oil on steam distillation. As in the case of juniper berries, coriander seed is selected for gin on the physical properties of the distilled oil and organoleptic quality in dilute alcoholic solution. The main component of the oil is d-linalool (60–70%); other oxygenated compounds, geraniol, l-borneol and n-decanal are present.[4] Monoterpenic hydrocarbons occur (10–20%), principally as γ-terpinene, d-limonene and α-pinene.[12]

The dried root of *Angelica officinalis* (Hoffm) provides a third important gin botanical.[4] The plant is cultivated in the temperate climate of Europe and the distiller's requirement is met with the produce of an entirely cottage industry in the East German provinces of Thuringa and Saxony. The roots are plaited and hung up to dry: during storage changes occur in the yield and properties of the oil which becomes darker in colour, higher in specific gravity and lower in optical rotation and acquires a musk-like odour due to the predominance of high boiling lactones.

Other ingredients in gin formulae vary with distillery practice and are generally included in lower proportions, often only a few ounces in a charge of several hundred pounds. Common minor ingredients are: sweet orange peel (*Citrus sinensis* L.); bitter orange peel (*Citrus aurantium* L.); lemon peel (*Citrus limon* L.); cinnamon bark (*Cinnamomum zeylanicum* Nees); cassia bark (*Cinnamomum cassia* Nees); cardamom seeds (*Elettaria cardamomum* Maton); nutmeg (*Myristica fragrans* Houtt); orris root (*Iris pallida* Lam); and liquorice root (*Glycyrrhiza spp.*).

Small quantities of these botanicals may have a considerable effect on the flavour of the gin, being rich in oils of highly odorous composition. Orange oil[3] is 90% d-limonene and cinnamon bark and cassia bark oils[4] contain 60–70% and 70–95% cinnamic aldehyde. Other gin botanicals have been reported; aniseed, caraway seed, fennel seed, calamus root, geranium leaves, grains of paradise, turpentine and cubeb berries.[13,14]

Many of the botanical ingredients described lose important quantitative and qualitative fractions of their oil on storage. Juniper berries stored a year for gin suffer a reduction of 20% in oil content and between 15 and 30% in moisture.[10] Coriander seeds lose absolutely 0·18–1·5% oil on prolonged storage at –14°C and 30% total oil in a year when stored in large hermetically sealed containers.[15] Citrus oils undergo autocatalytic oxidation when the peel is exposed to light and moisture.[3] Decorticated cardamom seeds lose 30% oil in eight months.[5] Stored botanicals are liable to insect infestation. Careful storage of botanicals by the distiller is necessary if he is to produce a consistently flavoured gin or avoid the evaporation of his flavouring material into the atmosphere. Ideally the botanicals are stored under temperature and humidity controlled conditions.

## Distillation

The botanicals are proportioned according to formula and loaded into the still. A specified quantity of spirit, reduced to a strength of 80–100% proof is added (the exact strength depends on individual practice) and gin is collected as a definite fraction of the distillate. In

Britain, gin distilleries and rectifying premises are not bonded but the stills are secured by Excise lock and distillation of a set volumetric charge only is permitted. In North America, gin distilleries can be operated under bond.

The shape and design of the gin still and the manner of distillation constitute the third important factor in the manufacture of gin. The dimensions of the still relative to the volume and strength of the charge, the supply of steam to the jacket and cooling water to the head, determine the reflux ratio and hence the composition of the distillate. For a still of given reflux ratio and charge of specific composition the distiller modifies the product by selection of the middle cut of the distillate and also sometimes by a second distillation. Gin stills are built to exact specification by experts; and vary in capacity from a few hundred to several thousand gallons, measured to the level of the man-door in the pot of the still. The construction is always in copper and usually in the form of a simple pot still with tapering head which curves at the highest point into the downward sloping lyne arm (Fig. 1). The head may be expanded into a bulbous shape immediately above the pot. In some distilleries still heads are equipped with water jackets through which cold water is circulated during distillation; at another distillery a system of return flow conducts a preliminary condensate of higher boiling volatiles back to the pot of the still. All these features promote reflux in the course of distillation. The distillate is conveyed through a tubular condenser and is piped to inspection chambers for continuous measurement of alcoholic strength by means of in-line hydrometers; thence it passes to collection vessels. Stills are heated with steam generally applied to the jacketed base but some stills function with internal steam coils. Gauges for steam pressure, temperature of the liquid contents of the still, temperature of the distillate vapour and the condenser water are centralised in the modern distillery in a control panel.

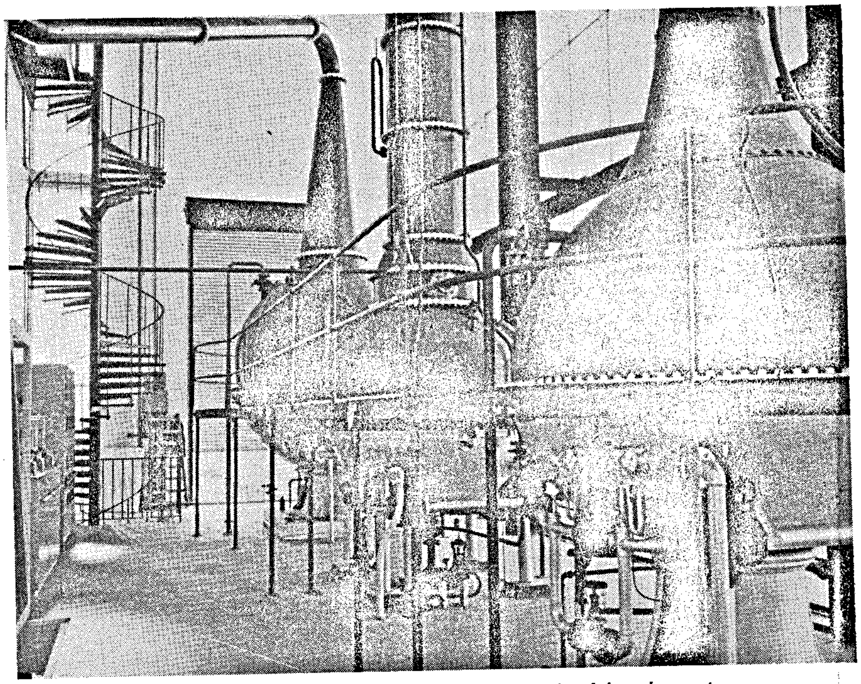

*Fig. 1. Two gin stills with rectifying still for feints in centre*

In operation the still is brought to boiling and the first few gallons of distillate rejected: this fraction is termed heads. Collection point for the middle cut of the distillate may be determined by an arbitrary quantity of heads, by the temperature in the column or by the appearance of the distillate. As the still charge is depleted of alcohol the steam pressure is raised to maintain distillation rate and when the strength of the distillate falls to a predetermined value the still is struck and the distillate diverted into the second collection vessel. The still must now be exhausted of alcohol (tails) before the residue may be discharged. Combined heads and tails are called feints. The middle fraction of the distillate is gin, with a mean strength of 30–50 op. Still residues may be discharged to sewer after sedimentation and appropriate treatment. Feints are rectified in a special still with high reflux ratio and the recovered spirit is added in constant proportion to the gin still charge. Feints may also be cleaned up by treatment with charcoal or potassium permanganate.

Alternative systems of distillation are sometimes adopted. In one variation the botanicals are placed in a mesh tray above the liquid surface in the still. Volatile oils are extracted by heat and by contact with refluxing liquid but the botanicals do not undergo the maceration which occurs in the action of boiling. Some gin stills have been operated under reduced pressure.

In order to equalise the slight differences which result in the product of successive distillations in spite of the application of rigorous quality control methods, gin should be blended in large holding tanks before transference to the bottling warehouse. Gin is diluted with distilled or demineralised water to bottling strength which in Britain is generally 70% proof. Water, free of dissolved solids, is used because otherwise the calcium and magnesium salts of hard water are precipitated, giving sediments and chalky incrustations in the bottles.[16] Gin is a colourless liquid and is often marketed in clear glass bottles. In order to attain the clarity demanded, gin is filtered (polished) before bottling, usually with cellulose-asbestos sheets in plate and frame filters or where throughput is large, with a filter-aid such as kieselguhr. Gin requires no period of laying down or maturation for improvement. The flavour derives entirely from the essential oils of the botanicals which are present in the condensate of the still. With gin the maxim might be 'the earlier drunk the better', for essential oils in dilute solutions tend to oxidise slowly with a detrimental effect on the flavour of the gin.

## Analysis and quality control

The difference in flavour between well known brands of gin is distinctive even to the untutored palate. In order to maintain that distinction the distiller seeks to reproduce from one distillation to the next and from one year to another, a gin which is uniform in flavour. This is the aim of all producers of blended and compounded spirits but in the case of gin the process is more amenable to control. The whisky blender chooses from a wide range of finished whiskies, whereas the gin distiller selects his raw materials and adapts his process to suit them. In the past, distillery organisation was based exclusively on the distiller's palate and practical experience: today laboratory analysis and panel tasting play an important part.

The factors which determine the flavour in a bottle of gin have been described: spirit, botanical formula and technique of distillation. The distillation is a matter of control on the spot, with the still operator making adjustments in steam pressure and water flow from observations of the strength and rate of flow of the distillate. Modern distilleries utilise automatic steam valves, flowmeters and other mechanical devices to obtain a precise control and the time of the entirely automated gin distillery approaches.

Botanicals and spirit were in the past selected wholly on organoleptic evidence and, while this method remains paramount in importance, it is necessarily supplemented by laboratory analysis. Control by tasting in the food industry has undergone a major rethinking in the last 10–15 years and the new methods are finding their way into traditionalist strongholds. In the US the standardisation of quality in distilleries through the use of taste panels numbering 20–30 persons is a widely employed technique.[17] Panelists are members of the distillery staff selected by test and they examine apparently similar samples daily in difference tests of the triangular or duo-trio type. Differences between the samples examined are expressed in statistical terms. Gin is amenable to this method of organoleptic examination because the accepted standard sample, properly stored, remains in good representative condition for a number of weeks. Panel tasting can be applied to finished gins as a test of uniformity, to spirit to check that it is up to standard and to dilute alcoholic solution of essential oils extracted from botanicals.

Analysis of spirit has been restricted mainly to chemical methods: esters (expressed as ethyl acetate) by direct saponification; aldehydes (as acetaldehyde) using Schiff's reagent; and fusel oil by the Komarowsky reaction. These methods give acceptable, meaningful results at intermediate and high levels of congeneries but approach the limit of accuracy when applied to the highly rectified spirits required for gin. It has been reported that the 'fusel oil value' of rectified spirits measured by the Komarowsky reaction is not necessarily an accurate measure of higher alcohol content but is a useful index of spirit quality.[18] Another widely used empirical measure of spirit quality is the permanganate time test which estimates the content of reducing substances by the rapidity with which a standard solution of potassium permanganate in contact with the spirit is decolorised. Ultra-violet spectrophotometry has been applied with some success to spirit analysis and provides a rapid instrumental assessment of inherent quality.[19] In Table 1 an analysis of a number of spirits used or proposed for use in gin distillation is presented together with a ranking of organoleptic quality by a small taste panel.

**Table 1. Comparative analysis of spirits**

| Spirit | ΔT* (mins) | Fusel oil† mg/l | Absorbance at 220mμ | Taste‡ panel rating |
|---|---|---|---|---|
| Grain (British) .. .. | 47 | 1·5 | 0·030 | 15 |
| ,, (British) .. .. | 49 | 4·2 | 0·110 | 6§ |
| ,, (Irish) .. .. | 43 | 9·1 | 0·002 | 3= |
| ,, (USA) .. .. | 50 | 1·7 | 0·010 | 2 |
| Molasses (British .. | 37 | — | 0·013 | 1 |
| ,, (Austrian) .. | 62 | 1·3 | 0·020 | 3= |
| ,, (Middle East) | <10 sec | 17·3 | 0·250 | 7§ |

(*) = permanganate time test at 15°C; (†) = AOAC method; (‡) = five membered panel ($p = 0.001$); (§) = not suitable for gin without further purification.

In the examination of gin botanicals for purchase or at intervals in storage, only juniper, coriander and angelica are likely to be subjected to a detailed laboratory analysis. The other botanicals would be distilled on pilot scale both individually and as ingredients in the formula and compared by taste against accepted standard. The essential oils of juniper berries, coriander seeds and angelica root are isolated from the plant material by steam distillation[20] and are measured volumetrically and for refractive index. The range of refractive index of the oil of juniper berries suitable for gin has been reported as 1·4840–1·4870.[10] Lower values are indicative of a high content of low boiling terpenes which is undesirable in gin. Coriander and angelica oils should show refractive indices between 1·463–1·471 and 1·476–1·488.[4] Ultra-violet absorption provides a rapid and valuable check of oil composition: juniper oil absorbs strongly in the region 220–240 mμ which is coincident in wavelength with a plateau in the absorption spectrum of terpinen-4-ol, an important constituent. Dilutions of juniper oil in 70° proof alcohol demonstrate an obedience of Beer's Law at 225 mμ. Coriander oil begins to absorb at wavelengths less than 220 mμ but useful data are obtained if stray light factors are considered. Dilutions of the oil in alcohol are checked by taste against standard samples. Moisture content of botanicals is determined by Dean and Starke tube.

Analysis of gin botanicals enables the distiller to base the flavouring formula of his gin upon the definite properties of the batch in current use. Lots of berries or seeds with high and low oil contents may be blended together to give an appropriate intermediate level and a new season's crop rich in oil can be phased into production with the least disturbance of the flavour characteristics of the gin. Purchase of botanicals each year from a range of samples supplied by the broker is made selectively on the basis of oil and moisture content, and composition and flavour of the oil in comparison with current stocks.

The finished gin is too dilute in oil to allow chemical analysis but control by tasting is supplemented by measurements of ultra-violet absorption. No published work exists on the application of gas chromatography to gin analysis but even with the most sensitive equipment, some preparation and extraction of sample is anticipated.

## Other gins

Holland's gin possesses a heavy, full-bodied flavour which derives not from the botanicals used in the gin distillation but from the original spirit; the gin character comes

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pressed and the basicity of the amino groups increased. Elution with dilute alkali gives a relatively pure lysine concentrate from which lysine monohydrochloride is obtained by acidification to pH 4·0 and concentration. The pure product can be obtained by recrystallisation. This procedure is in principle employed in the process of the Kyowa company (Fig.5).

### Chemical synthesis

Lysine was first synthesised by Fischer and Weigert in 1902 by the condensation of diethyl malonate with $\gamma$-chlorobutyronitrile.[56] By the reaction of the condensation product with ethyl nitrite in the presence of sodium ethoxide these authors obtained the intermediate ethyl ester of $\alpha$-oximino-5-cyanovaleric acid which finally led to lysine after reduction with sodium in ethanol and hydrolysis. Numerous synthetic procedures described in the last fifty years have been used for the preparation of labelled lysine samples. We may mention an older procedure described by von Braun.[57] Lysine was obtained by a six-step synthesis from benzoylpiperidine via benzoyl-$\varepsilon$-aminocaproic acid. This intermediate was also involved in several other syntheses of lysine suggested later. The most interesting of these is the procedure of Eck and Marvel who synthesised lysine from cyclohexanone via caprolactam.[58] This last substance finally became a suitable starting material for the large-scale production of lysine by an improved procedure which was originally described by Brenner and Rickenbacher.[59] Their synthesis is rather unique since it leads to L-lysine.[60-61]

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# Gin Manufacture

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essentially from juniper berries but is overlaid with whisky-like congeneries. A mash containing up to 30% malt is fermented and distilled in a pot still with low rectification. The distillation may be repeated several times but the final spirit (moutwijn) does not show the neutral characteristics demanded for London dry gin. Originally the botanicals were added to the fermented mash for distillation

Steinhager (Germany and Austria) or Borovicka (Hungary) is the distilled product of crushed fermented juniper berries.[21] It is twice distilled to a final alcohol strength of 70–85% proof. The stillage is an important source of oil of juniper.

Old Tom is a gin sweetened after distillation to approximately 3% w/v sugar. It is uncommon now in the English market but is still exported. Sloe gins, lemon and orange flavoured gins are made by steeping finished gin in the fruit or peel.


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