

SCOTCH WHISKY

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SCOTCH POT STILLS FOR MALT WHISKY

The most valuable and noticeable characteristic of Scotch whisky is its smoke flavor. This flavoring principle may be readily isolated by repeated fractional distillation. Although there is some variation, the imported Scotch blended whisky is very uniform and generally lighter in congenerics, taste, and aroma than American whiskies. Domestic Scotch-type blends are still lighter in body, although not necessarily in smoke flavor, than the imported blends.

During the aging under conditions of the unheated, humid warehouses of Scotland, the proof goes down. In the higher, warmer, and dryer storage conditions of the United States, the proof goes up during storage and aging. As a general class, blended Scotch whisky is imported at about 86° proof, which is lower than many American whiskies as sold to the consumer.

Scotch grain whiskies, although distilled at high proof, are not the same as neutral spirits but are light-bodied, single whiskies distilled from corn and matured in the same manner as Scotch malt whisky. Most of the color in all domestic-type blends and imported blended Scotch whisky is due to small amounts of caramel added for uniformity of color.

On account of the general low temperature of storage, the humidity, and more particularly the long continued re-use of plain white oak cooperage, the changes which take place during aging proceed at a much slower rate than is true for American whiskies, under American conditions, stored in charred oak barrels, as shown by chemical analysis. The analysis, taste, and aroma of blended Scotchtype whisky are different from the imported blend, principally because the former is blended with grain neutral spirits and the latter with lightbodied grain whisky that has been matured the same length of time and in the same kind of cooperage as the straight Scotch malt whisky. NE of the oldest and most unique spirit beverages imported, bottled, or blended in the United States is blended Scotch whisky. It is different in character and can be easily distinguished from bourbon or rye whisky (12), rum (10), or brandy (11). The outstanding and most valuable characteristic of malt or blended whisky (Scotch) is its inimitable taste and aroma, described generally as smoky.

The most notable chemical work dealing with Scotch whiskies in particular is that of Schidrowitz and Kaye (8). They observed that the secondary products in a new spirit of any kind are obviously dependent upon the nature of the raw material and the method of manufacture. The chief points of interest in regard to Scotch pot-still whisky appeared to be the effect of the use of peat in kilning the malt and the result of the fire action in the still.

The latter effect has already been described in the fireheated copper-pot Cognac still (11). Schidrowitz and Kaye stated that the use of peat is not responsible for all the characteristics of flavor associated with Scotch whisky. They stated that although Scotch grain whiskies are distilled in a still designed for partial rectification, they are far from being silent spirits and possess considerable whisky flavor. Schidrowitz and Kave concluded that there is a wide variation in the different constituents, not only between the different classes of unblended Scotch malt whisky, but also between members of the same class. They found an increase in volatile and fixed acids and other ingredients during aging, and the type of the cask appeared to exercise considerable influence on the course of maturation. They stated that no single analytical figure denotes commercial quality, but that a certain balance of figures is more important in judging analyses, and the taste and flavor are important factors as well. The authors furnished tables of analyses for all classes of Scotch malts and Scotch grain whiskies.

Nettleton (6) stated that this best known characteristic, the peaty taste and aroma of Highland whisky, is discernible to taste and smell after 20 or more years of aging. This flavor becomes pleasanter on aging. Just as the secondary constituents distinguish whisky qualitatively and quantitatively from plain spirits, so does the peaty flavor distinguish Scotch whisky from all other whiskies.

Over a quarter of a century ago Nettleton (6) suggested the division of the constituents of whisky into three groups: alcohol (the primary constituent), acids, esters, higher alcohols, aldehydes, furfural, coloring matter and extract (the secondary constituents), and certain noncomputable ingredients which are small in quantity but exert considerable influence on the general character of the product, particularly its taste and aroma (the tertiary constituents). In the recent study of Cognac (11) it was found that these minute tertiary products formed by the slight destructive distillation of the wine lees and yeast material gave to Cognac a flavor which was different from other grape brandy. This Cognac flavor has been found even in certain fire-heated pot-still Scotch whiskies, although in less amount and somewhat overshadowed by the usual smoke or peat flavor. The vastly more important tertiary ingredient in Scotch malt and blended Scotch whisky is the peat (smoke) flavor, for without it Scotch whisky would be little different from Irish or American straight whisky in taste and aroma, except that the American whisky is influenced more or less by the charred barrel flavor.

Schidrowitz and Kaye (8) identified some of these tertiary ingredients as pyrrole, phenolic, and other bodies, and attributed their presence to the burning peat used in kilning the malt. C. S. Buchanan (7) found indications of allyl alcohol and allyl aldehyde in Highland whisky, as well as picoline, pyridine, and similar nitrogenous basic substances probably derived from the burning peat used in drying the malt.

Scotch Malt Whisky

The first step is the preparation of the malt. The cleaned and screened barley, which has been steeped in tanks until it is softened and swollen, is spread out on a malting floor where it is sprinkled to furnish adequate moisture and turned occasionally during a period of about 2 weeks. During this time the barley germinates and the diastase transforms a great deal of the starch to a fermentable sugar. After germination is completed, the malt is dried by being spread on a perforated tile or fine mesh wire floor (screen) over an open fire or furnace fed with peat alone or peat and anthracite coal or coke. Usually the peat is specially prepared and may be kept a year or more before use. The empyreumatic emanations from the smoldering peat are absorbed by the malt, are subsequently dissolved in the mash, pass over into the distillate, and impart to it the smoky flavor essential to

Scotch whisky. Some of the malt-drying kilns are made with double screen floors, the second tier about 6 feet above the first. The green malt is placed on the upper floor and let down to the lower as soon as the charge is removed. This practice, however, varies in the individual distilleries. The green malt is dried until the moisture is reduced to 2 per cent or less, care being exercised to avoid browning. To this end, the layer of malt is frequently turned during the process. Considerable quantities of prepared peat-dried malt are kept in store.



CARTING PEAT FOR SHIPMENT TO A SCOTCH WHISKY DISTILLERY

The kiln-dried malt which has absorbed a great deal, or as much as possible, of the so-called peat flavor during drying is screened thoroughly to break off the sprouts, and it is now ready for use or for storing. This malt improves in flavor on storage.

After grinding, the malt is mashed in large vats with the aid of stirring machinery which keeps the mass in constant motion. The mass is gradually heated but not above the point of activity of the diastase (about 140° F.) and held there for about 30 minutes until all of the starch is converted. The tun has a false bottom which is finely perforated so that when this operation is completed, the liquid part of the contents may be drawn off to the coolers and the residual spent grains separated. The hot wort is passed over coolers and run into fermentation vats called "wash-backs". The yeast (usually brewer's yeast) is added to the cooled wort and the fermentation conducted at ordinary temperatures. The fermentations are finished in 48 to 72 hours, and the beer is ready for distillation.

DISTILLATION. At all of the Scotch malt distilleries, distillation is conducted in pot stills usually heated over open fires. The principal parts of the pot still are the shoulder and head attached to a broad, round-bottomed, copper kettle with a tapering neck, which is made in various shapes and sizes. In some cases the neck passes in a horizontal position to the worm, immersed in flowing water, and the products of any condensation in this horizontal section are returned by an attached pipe to the still. There is no rectification except that given by the vapor pipe.

The stills are usually arranged in sets of three, one large wash still for making low wines (first distillate) and two smaller low-wine stills for making the high-wine feints and new whisky. On the bottom of the wash or mash stills is a scraper, usually in the form of a chain, properly fixed to revolving arms which fit the convex inner surface of the bottom of the still and prevent the depositing and burning of solid matter during distillation. The scraper is operated by a perpendicular shaft passing into the center of the still, usually with an airtight journal in the side of the shoulder. The wash still holds about 6000 gallons; the smaller low-wine stills hold from 2000 to 4000 gallons. The first distillation is carried on until all the alcohol is collected as low wines. The residue is "pot ale" and is discharged to the sewer or, where possible, collected for agricultural purposes. The spirit still is charged with low wines from the low-wines receiver and high and low feints

from the feints receiver. High feints and low feints are taken off the spirit still and run into the feints receiver. They, together with low wines, are used to charge the next run of the spirit still. The middle run off the spirit still is the malt whisky, and usually reaches a strength of approximately 137 U.S. proof. When the alcohol is all distilled over, the spent lees are drawn off and run to sewer.

Each malt distillery prepares its own barley malt, and operations vary in the less essential details with the individual distiller.





EXTERIOR OF A SCOTCH WHISKY DISTILLERY

PEAT. The smoke flavor is so characteristic and desirable in Scotch malt whisky that for years, both in this country and abroad, many attempts have been made to imitate it. So far no product has been made artificially which resembles the original natural Scotch peat flavor to any satisfactory extent. The authentic Scotch flavor found in pot-still Scotch whisky originated somewhat accidentally. When the malted barley grain was kiln-dried, the only fuel that was easily obtainable was a sort of immature coal or peat from which, when burned, a peculiar aromatic heather flavor, was obtained. The green or partially green Scotch malted barley, while slightly moist, is very absorptive, and during drying over burning peat some of this smoke flavor is taken up by the porous malted barley grain. During the process of fermentation of the Scotch barley malt mash, the flavor of peat is imparted to the mash and, being volatile, is distilled over with the finished Scotch malt distillate. In the ensuing years this flavor is carried through and appreciated to such an extent that it is unlikely any one would accept Scotch whisky without it.

There is no set peatiness in any one class of Scotch malt whisky; this property varies according to the practice of different distilleries and to the type of their trade.

The peat used for fuel in drying the green barley malt is plentiful in Scotland but is difficult to obtain in a uniform state; some grades are less "smoky" than others, in spite of the fact that the peat is carefully selected, conditioned, and graded. Some distillers in drying their malt use 25–50 per cent peat with their coke fuel for Lowland malts, 50–75 per cent peat for Highland malts, and all or nearly all peat for Islay or Campbelltown malts. This practice, however, is not general. The peat shipped to this laboratory from Scotland for experimental purposes contained 12.3 per cent water, 1.57 per cent ash (rich in iron), 0.878 per cent total nitrogen. It was very black and was filled with fine threads of vegetation roots.

The commercial Scotch whisky blends differ from one another in smoky character; some are quite strong and others may be weaker in flavor, although the matter of flavor is carefully adjusted with the use of graded malt whiskies by the skillful blender. It is significant that none of the imported blended Scotch whiskies in the United States are without this characteristic smoke flavor.

CLASSES. Four different classes of unblended Scotch malt whisky are produced in the various distilling districts of Scotland. They are Highlands, Islays, Lowlands, and Campbelltown. The Highland whiskies are much more numerous; they come from approximately seventy-five distilleries located on the mainland of Scotland which lies north of an imaginary line drawn through Dundee on the East and Greenock on the west.

The next largest class is in the Lowlands. These whiskies are made south of the imaginary line. There were eleven original distilleries, but five are closed. In or near this district the majority of the Scotch grain distilleries are also located. The Lowland malt Scotch whisky is produced on similar lines to the Highlands, although the amount of peat used in drying off the malt is generally less than in the case of the Highlands. They are lighter in body and more delicate, and the peat flavor is not so pronounced.

On the Island of Islay are ten malt distilleries with two closed. It is now generally understood that the Islays show most of the heavy peat flavor of the widely used Scotch malts. It is extensively employed by American blenders as a base for Scotch types to furnish most of the smoke flavors. With the exception of the Campbelltown malts, more peat is used in the preparation of Islay malt whiskies than any other group.

The smallest distilling district at present and the least important commercially is the Campbelltown. Campbelltown malts are from a town of that name at the southern end of the Kintyre Peninsula on the West Coast of Scotland, and was at one time famous for the number of its distilleries. The Campbelltown whisky has now fallen into disuse, and instead of over thirty distilleries there are now only two. The Campbelltown malt is usually, but not always, the heaviest of the four groups of Scotch malts in peat flavor, and its character is rather pungent. In the past they were used not so much for these characteristics as because they were thought to have a binding effect on the other constituents of a blend.

Scotch Grain Whisky

Most of the Scotch grain whisky is made in or near the Lowlands in the district bounded by the Firth of Forth on the east and Firth of Clyde on the west. In the production of these spirits imported Indian corn from Argentina, the United States, and elsewhere, is the principal ingredient of the mash and usually the only ingredient except the barley malt; the latter is used in excess of the quantity required to convert all of the starch to sugar in order to enhance the flavor. Unmalted barley, rye, and oats are rarely used. Oats have been utilized in small quantities (about 2 per cent) in the yeast mash to furnish nitrogen and for the value of the husks as filtering media. The malt used in the corn mash is made by the modern drum malting and drying methods similar to those in the United States. The barley for Scotch grain whisky is not dried over peat fires and hence does not have a smoky flavor. Although the use of home-grown barley is encouraged and even preferred, the supply is now inadequate, and a great deal of it is imported from California, India, Africa, Canada, and other countries both for the production of malt whisky and of Scotch grain whisky.

All the established distillers of Scotch grain whisky use the old-fashioned type of Coffey continuous still, which is generally supposed to give the best type of Scotch grain whisky. The Coffey still is composed of two columnsa rectifier and an analyzer. The cool wash travels down through the rectifier column in a long, winding, continuous, completely sealed tube approximately 6000 feet long where it becomes heated. It then passes to the head of the analyzer column and pours down through the perforated plates of that column in a zigzag fashion. Steam enters the bottom of the analyzer, ascends, meets the downpouring heated wash, and frees it of alcoholic vapors. The balance of the wash is drawn from the bottom of the analyzer, cooled, and settled, the residue being used as cattle food. The alcoholic vapors start their return journey by ascending the analyzer and passing from its head to the bottom of the rectifier. Here they again ascend and are condensed by the cool wash, descending in the continuous winding tube mentioned above. The condensed vapor pours through the perforated plates of the rectifier. Most of the congenerics find their way to the lower part of the rectifier and are drawn off. The condensed vapors, freed of a large portion of congenerics, pass off at the spirit plate near the head of the rectifier and are run through a cooling worm to a receiver. The whisky thus condensed contains from 90 to 94 per cent alcohol by volume. The two-column Coffey stills have a capacity of about 10,000 gallons of wash per hour.

One or two Scotch grain distilleries have been experimenting with a different type of still, such as the 4-column continuous still, which runs about 180 final U. S. proof. The character of this product is about the same as the Coffey still distillate.

Although Scotch grain whisky is much lighter in body than Scotch malt whisky, containing only about 25 per cent of whisky congeneric substances, it is by no means the same in character as grain spirits intended for gin, as grain or molasses alcohol, or as neutral spirits used for industrial or pharmaceutical purposes. Scotch grain spirits still retains enough of the congeners of fermentation to give it a light whisky bouquet and flavor. It is generally considered a light-bodied whisky distilled from corn. Analysis shows it to be as light in body as the lightest whiskies found on the American market. It is rarely used for beverage purposes unblended, and apparently none of it is sold as such in the United States. Scotch grain whisky is stored in the same sort of wood, in the same manner, at the same proof, and for the same length of time as the malt whisky. It is used abundantly for mixing with malt whisky to produce the blended Scotch whisky met in commerce. It is cheaper to produce being usually sold commercially off the still without aging at about one-half to three-quarters as much as new Scotch malt pot-still whisky. The manufacture of Scotch grain whisky is conducted under the same excise supervision and regulations as is Scotch malt whisky. Every part of the distillation process of both malt and grain is controlled and checked by excise officers, whose lock and seal are kept on every valve and other opening where whisky might be surreptitiously withdrawn. It is possible for the excise officials to follow each package of spirits from the time it is made until it is delivered for domestic consumption or for export. Although only eight Scotch grain distilleries are in operation, their output is necessarily larger than the total pot-still output because these spirits are used to blend with the product of the present eighty-two Scotch malt distilleries in the ratio of about one part of malt whisky to two parts of Scotch grain whisky.

Aging of Malt and Grain Whiskies

Scotch grain whisky is usually filled into casks for aging at 11 over proof British, which is equivalent to about 127 U. S. proof. In Great Britain, proof spirit is 49.3 per cent ethanol by weight or 57 per cent by volume at 62° F. In the United States, proof spirit is 42.489 per cent ethanol by weight and 50 per cent by volume at 60° F.; 100 British proof equals 114.6 U. S. proof. When whisky is 100 U. S. proof, it is 12.9 per cent under proof British.

Scotch malt whisky is aged at the same proof strength as Scotch grain whisky. As far as can be determined, American white oak is always used. Both Scotch malt whisky and Scotch grain whisky are aged in casks of 100 to 120, 55 to 65, or 28 to 36 Imperial gallons. The barrels containing Scotch malt whisky shipped to rectifiers in this country are much heavier and more rugged than our whisky or brandy barrels. The latter weigh 80–90 pounds, and the Scotch barrels (casks) weigh about 158 pounds net and contain approximately 83 U. S. gallons. Both re-used sherry, re-used Scotch whisky, or plain casks are utilized.

Owing to the use of long re-used cooperage, which seems to be preferred, generally very little coloring matter is extracted from the wooden cask by the malt whisky or the grain whisky, and this natural wood color will range from the slightest amber to pale amber. Although the depth of color in unblended Scotch malts and grain whisky due to storing in wood reach an unusual depth for Scotch whisky of 13.7 in the half-inch cell of the Lovibond tintometer, most of them have an average color of less than 3, since the Scotch grain whisky takes up as much wood color as the malts. This may be expected since it was entered at the same proof, for the same period, into the same sort of cooperage.

Occasionally, however, a sample of unblended Scotch malt whisky without caramel coloring will contain a fair amount of natural color, probably due to newer or new barrels. Eightyear aging in new barrels tends to cover or interfere with the more delicate burning-peat flavor. Aging in the American sense of extracting wood flavor and developing acids, esters, solids, and color progresses slowly in ordinary Scotch cooperage. The evidence presented before the Royal Commission (7) showed very little change, according to analyses during storage of four pot-still whiskies aging in the usual long re-used wooden casks, even after 7 years. After the first year all the differences were practically within the limit of experimental error, except the proof which went steadily and substantially downward in all cases. The changes taking place in the casks during storing or aging, such as the increase in congenerics, are much less than in the cooperage used in the United States for whisky (12), rum (10), or brandy (11), which include new charred, plain, and once or more re-used barrels of both kinds. Charred barrels are not used for aging Scotch whisky.

The pot-still Scotch malt whisky, as well as Scotch grain whisky, is usually aged in long re-used packages in which the development of secondary constituents are exceedingly slow, less in 12 years than in a year in new charred white oak barrels or 2 years in new plain white oak barrels.

Warehouses in Scotland are constructed and secured according to the regulations of British customs and excise, and no marked differentiation is made between Scotch grain whisky and Scotch malt whisky. To a great extent these warehouses have earthen floors with wooden runners passing along them. As a general rule, the proof strength goes down in about equal ratio to the loss of bulk by evaporation. On the average this works out, as between strength and bulk, at about the allowance granted by British Customs and Excise authorities; the percentages can be roughly reckoned at twice the number of years plus 2. In practically all cases the proof goes down in Scotch warehouses, none of which are heated; therefore, there is a loss in proof, owing to the high humidity of the atmosphere. After aging, the Scotch malts and grain whiskies are about 120° U.S. proof.



STILL HOUSE IN A DISTILLERY

Since the proof of Scotch malt whisky and grain whisky is the same when put into casks entering the warehouses for maturation, the final proof of both is about the same after 4 or 8 years of aging. The Scotch grain whiskies which are aged and used for blending have a fair percentage of congenerics when new, and steadily become fuller and pleasanter in flavor during maturation. This is the case with all whisky and other potable spirits. The loss in Scotch storage is approximately 8 per cent in 3 years.

Blending and Coloring

Blending of Scotch whiskies includes the mixing or combination of "single" or self-aged malt whiskies with Scotch grain whisky of the same age. The product of twenty or more malt distilleries may be blended with the mixed product of several grain distilleries. One popular brand is known to be a blend of forty to fifty malts with four or more grains. After thorough blending by the aid of mechanical stirrers or compressed air devices, the Scotch is filled into well re-used cooperage, butts, casks or half casks, which may or may not have been rinsed out and drained with sherry wine, and further aged for 6 months to 1 year or more. This last process is referred to as marrying. Loss in volume, rents, taxes, insurance, wages, interest, maintenance, and management all contribute to the increase in cost and add value to both grain and malt whisky during storage.

Scotch malt (single) whisky, before blending, aside from its smoke flavor, has something of the character of the oldfashioned fire-heated pot-still whisky, once extensively made in the United States. The fact that the Scotch malt whisky is distilled twice and sometimes three times, usually with the elimination of some heads and tails, tends to make it lighter, but it still has the body of an American straight rye or bourbon whisky although rather on the lighter side. Under the British Customs and Excise Regulations, it is permissible to add 1 pint of coloring matter in the fluid state to every 80 proof (British) gallon of whisky. The maximum coloring matter added cannot exceed 0.15 per cent. Special care is taken that the color be entirely composed of caramel from pure cane sugar. Color can be added at any time provided it does not exceed the regulation quantity. Scotch whisky obtains some of its color from the cask during the maturation process. The use of the caramel is largely for the purpose of getting uniformity in color, so that this does not vary from time to time in the different bottlings.

Domestically Bottled Scotch Blends, Types, etc.

Besides the bottled blended Scotch whisky which is imported into the United States in large quantities, a relatively small amount of blended Scotch whisky is imported in casks by bottlers and rectifiers who bottle it under their own brands without change.

Domestic blended Scotch-type whisky is prepared by United States rectifiers who import Scotch malt whisky in the original casks in which it was stored, duly supported with a certificate of age, and blend it with United States neutral grain alcohol (neutral spirits) or a light-bodied whisky. At this stage the rectifier will also add the necessary caramel to bring the type up to a uniform standard color and will add any natural permitted substance he deems necessary to improve its quality.

A blended Scotch-type whisky is essentially a mixture of not less than 20 per cent of Scotch malt whisky, made in Scotland and aged not less than 3 years, with neutral spirits or a light-bodied whisky. As far as can be determined, all of the Scotch malt whisky as well as the blended Scotch whisky bottled in Scotland and brought to this country at present is actually 4 years old. In order to take advantage of the

After blending with

grain whisky, it gen-

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few exceptions, the

lightest in body of

all the commercial

whiskies and is

usually the oldest

whisky on the

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of age is from 4 to 12

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malt whiskies im-

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United States with-

out the addition of

Scotch grain whisky

are unusual; only

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(Table IC). In

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of single malt whisky

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malts or grain

whisky. The con-

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blended Scotch

grain whisky is still

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	Proof	Total Acids	Volatile Acids	Esters	Higher Alcohols	Solids	Aldehydes	Furfural	Color in Half-In. Cell	pН	Age
				Grams/1	00 liters (not cal A. 23 Older S	amples, 193	4-35				Years
Average Maximum Minimum	87.2 87.9 85.2	$21.0 \\ 33.6 \\ 16.8$	$16.6 \\ 25.2 \\ 12.0$	$20.6 \\ 28.6 \\ 16.7$	$ 49.2 \\ 88.0 \\ 35.2 $	$ \begin{array}{r} 140 \\ 206 \\ 102 \end{array} $	$\begin{smallmatrix} 5.6\\10.3\\2.4\end{smallmatrix}$	$0.7 \\ 1.6 \\ 0.4$	$9.6 \\ 13.0 \\ 7.5$	$4.23 \\ 4.48 \\ 4.00$	
				B. 74 /	Authentic Samp	les Analyze	d Aug., 1939				
Average Maximum Minimum		$21.4 \\ 34.8 \\ 8.4$	$ \begin{array}{r} 16.6 \\ 28.8 \\ 6.0 \end{array} $	$19.5 \\ 29.0 \\ 13.2$	$63.9 \\ 114.0 \\ 42.2$	$ \begin{array}{r} 141 \\ 216 \\ 88 \end{array} $	6.0 9.2 1.5	$0.7 \\ 1.5 \\ 0.3$	$\substack{8.2\\12.0\\4.0}$	$4.38 \\ 4.78 \\ 4.10$	10 17 86
C. Samples	Representir	ng All of the	All-Malt Unb	lended (with	Scotch Grain Sp or Wholesale at	oirits) Scotch nd Retail Tr	whisky Import	ed from Scotl	and in 1939–40) in Con	nmercial Bottles
$ 112 \\ 116 $	$\begin{array}{c}92.4\\86.7\end{array}$	$\begin{smallmatrix}25.2\\26.4\end{smallmatrix}$	$\begin{smallmatrix}21.6\\24.0\end{smallmatrix}$	26.4 29.0	129 117	114 132	5.9 7.9	$1.5 \\ 1.2$	4.0	4.68	12 No age given

reciprocal trade agreement reducing the duty to half the former rate, the whole of it as imported must not be less than 4 years old.

Generally more Scotch malt whisky is used in the imported blends than in the domestic Scotch types. The usual amount of malt whisky in the imported Scotch blends is from 30 to 50 per cent, in the domestic types 20 to 30 per cent. Usually the American blended Scotch types have for their bases carefully selected, richly peat-smoke-flavored Islay or Highland malt whisky, and the finished types often have as much smoky character as the imported product. The Islay malts are more often used for Scotch types than the lighter flavored Highland or Lowland malts.

One of the most obvious differences between the two kinds of Scotch whisky is that the imported Scotch blend contains a considerably higher portion of higher alcohols and more of other congenerics than American-blended Scotch types. This may be accounted for in large measure by the fact that the blending material (aged Scotch grain whisky) in Scotland has a considerable proportion of higher alcohols and other congenerics and is not the same in character as the neutral spirits used domestically. The Scotch-type blends all contain caramel coloring, as do all the imported blends. Of sixty-eight samples of domestic types analyzed, about half contained solids in solution other than caramel. Among the other ingredients used as blending material were sherry, prune, and other blenders, sugars, sherry wine, grape and other brandy, honey, glycerol, extract from oak chips, fruit extracts, and other ingredients commonly used in blending and rectifying whisky. If more than 2.5 per cent of any of which contain less than 20 per cent of imported Scotch malt whisky. In one or more of this type of domestic blends, as little as 5 per cent Scotch malt whisky has been found, the rest of the fluid being diluted neutral spirits. Owing to the elastic flavoring properties of the Scotch malt, this sort of Scotch mixture may have a light peat smoke flavor. Under the regulation of the Federal Alcohol Administration, it may not be called a "blended Scotch type whisky".

A small amount of imported, well-aged, Scotch malt whisky is used by some blenders in the United States as one of the ingredients in some of the more expensive blended whiskies. If more than 2.5 per cent by volume is used, it is so stated on the label (9).

Fractionation

Composites of 1 to 5 liters each were made up of Scotch malt whiskies and imported blended Scotch whiskies, and several lots were fractionated in glass pot stills, using glass columns packed with glass helices. The first runnings contained small amounts of aldehydes (chiefly acetaldehyde) and ethyl acetate. The middle ethyl alcohol portions were quite pure; the later ones and the cuts taken between 78° and 85° C. contained noticeable quantities of higher esters, principally amyl acetate with distinguishable traces of amyl valerate. The fractions up to 85° C. had none of the smoky or creosotic odor or taste characteristic of the original Scotch whiskies. However, between 85° and 100° C., particularly between 93° and 97° C., the smoky odor and taste were strongly evident. The still residues contained practically all of the water, caramel, and wood extract, but were devoid

these ingredients is used, it must be so stated on the label (9).

The alcohol proof of domestic blends (types) varies over wider limits than the imported blends. Most of them are below 86 U. S. proof, with the lowest limit 80 and the average 85. The imported blends rarely fall below 85 or over 88, and the average is about 87.

To a small extent rectifiers in the United States also manufacture blends



MALTING FLOOR IN A MALT DISTILLERY

of smoke flavor. Portions of the aqueousresidues were distilled to dryness without the temperature rising above 100° C. and without further evolution of the Scotch characteristics. The later alcohol fractions and those taken between 79° and 100° C. were redistilled from a small all-glass pot still through a 91-cm. (3foot) column of 1.27cm. (0.5-inch) diameter, packed with single-turn glass

			TA	BLE II.	ANALYSES O	F SCOTCH	I-TYPE WHI	SKIES				
	Proof	Total Acids	Volatile Acids	Esters ——Gram	Higher Alcohols s/100 liters (n	Solids ot calcd. to	Aldehydes proof)	Furfural	Ash	Color in Half-In. Cell	pH	Age Years
			A.	Blended S	Scotch-Type V	Vhisky Ma	de in U.S. in	1939ª				
Average Maximum Minimum	85.3 88.2 80.2	$\substack{12.1\\26.4\\2.4}$	8.8 20.4 1.2	$8.9 \\ 19.4 \\ 4.4$	$26.2 \\ 45.8 \\ 12.3$	$286 \\ 1394 \\ 54$	$2.2 \\ 4.7 \\ 1.0$	0.4 1.8 Trace	$\begin{smallmatrix} 7\\16\\0\end{smallmatrix}$	$7.3 \\ 10.5 \\ 3.5$	$4.81 \\ 6.22 \\ 4.00$	$\begin{array}{c}10\\15\\6\end{array}$
		<i>B</i> . I	mported Sco	tch Malt WI	hisky to Be U	sed in Dor	nestic Blended	Scotch-Typ	e Whisky	yb		
Average Maximum Minimum	$ \begin{array}{r} 111.2 \\ 123.2 \\ 84.5 \end{array} $	50.0 78.0 31.2	$39.3 \\ 68.4 \\ 21.6$	$41.1 \\ 60.7 \\ 17.6$	$129.7 \\ 190.1 \\ 84.5$	$210 \\ 485 \\ 64$	$9.2 \\ 15.5 \\ 1.6$	$1.9 \\ 4.0 \\ 1.0$	$\begin{smallmatrix}&9\\20\\0\end{smallmatrix}$	$\begin{smallmatrix}10.6\\20.0\\3.0\end{smallmatrix}$	$4.30 \\ 4.60 \\ 3.83$	$\begin{array}{c}11\\18\\6\end{array}$
and the second second		C. Con	parison of S	cotch Malt	Whiskies and	Blended S	cotch-Type W	hiskies Made	from T	hem		
Av. 10 malt whiskies Av. 10 blends	$\substack{112.2\\86.2}$	$42.5 \\ 11.6$	35.5 8.3	36.3 8.9	$\substack{134.4\\28.9}$	189 349	8.5 2.1	$1.9 \\ 0.5$	$10 \\ 6$	$9.7 \\ 7.3$	$\substack{4.41\\4.74}$	10 10
^a All samples e Highland malts,	xamined we	re colored	with caramel celltowns.	. The amou	nt of Scotch n traces of cara	nalt used in mel, and 7	h the seventy b 7 contained no	lends was 20- caramel.	30%. N	Mostly Islay malt:	s were us	sed, som

helices. By distilling slowly, practically all the ethyl alcohol was removed as such, and the remainder was cleared with the esters between 78° and 83° C. The distillation temperature jumped sharply from 83° to 93° C. The fractions between 93° and 97° C. separated into two layers. The Scotch odor and taste were very strong in these fractions and, in sharply decreasing order, in those fractions up to and including the first few drops at 100° C. On further fractionation the aqueous layer which separated from the 93-97° C. portion consisted of a small amount of amyl alcohol (1.5 per cent) containing Scotch flavor, a small amount of ethyl alcohol, and a comparatively large quantity of water. All of the smoke flavor of the original 20 liters of Scotch malt and blends were concentrated in 10 cc. of an immiscible liquid containing 55 per cent amyl alcohol. This portion had powerful Scotch flavoring properties which were unimpaired from its multiple fractionations.

Analyses

The methods for samples analyzed were substantially those of the A. O. A. C. (1) and those described in previous work (10, 11, 12). The methods for acid determinations were modified by Beyer for the A. O. A. C. The method of methanol determination described by Valaer (11) was further improved by Beyer (2).

TOTAL ACIDS. Neutralize 250 cc. of boiled distilled water in a porcelain evaporating dish (19 cm. is a convenient size), add 25 cc. of sample, and titrate with 0.1 N solution, using 2 cc. phenolphthalein indicator solution.

FIXED ACIDS. Evaporate 25-50 cc. of sample to dryness in a platinum dish on a steam bath and dry 1 hour in an oven at 100° C. Dissolve and transfer the residue with several portions of neutral alcohol of approximately the same proof as the sample, using 25-50 cc. in all, to a porcelain dish containing 250 cc. of neutralized boiled distilled water. Titrate with 0.1 N sodium hydroxide in a 10-cc. buret graduated in 0.05 cc. and the same amount of indicator as above.

VOLATILE ACIDS are calculated as total acids minus fixed acids. ALDEHYDES. The method for aldehydes described by Valaer (11) was made more sensitive by adding small pieces of silicon carbide in the distilling flask to ensure even boiling, and by using a delivery tube immersed in 100 cc. of boiled distilled water during distilling.

Table I gives the analyses of seventy-four samples (B) of regularly imported blended Scotch whiskies and two samples (C) of imported Scotch malt whisky, unblended with Scotch grain whisky; all were in typical commercial bottles and were imported into the United States from Scotland during the summer of 1939. This list of Scotch whisky includes practically all of the regularly imported blends and malts that are now being sent to the United States. In general, the blends are uniform, usually varying more in peat or smoke flavor than in congenerics. Each sample has a distinct and un-

mistakable flavor of peat smoke. All this Scotch whisky has a low acid and ester content as compared with rye or bourbon whisky made in the United States which was aged even for a short time in a charred barrel. The total acid content of this Scotch whisky is about equal to or only a little in excess of the ester content. The volatile acids are usually a little less than the esters. In general, the heavier the body of the Scotch blend, which is usually accompanied by a larger percentage of higher alcohols, the more pronounced is the Scotch peat flavor; this indicates in a measure that a larger proportion of Scotch malt distillate is present, and there are few exceptions to this rule. One of the most reliable chemical figures for judging the amount of Scotch malt whisky in the blend is the higher alcohol determination. It may seem surprising that there is so little acid development during the long aging of Scotch malt whisky and grain whisky. For instance, four or more samples which were aged from 4 to 8 years had a total acid content of only 8 to 14 grams per 100 liters. This could happen only in barrels that had been used over and over for many years and aged in damp unheated warehouses.

Although Table I shows the analyses of practically all of the regularly imported Scotch whisky, ten brands represent about 90 per cent of that received. It is these more extensively advertised brands that are more often subject to counterfeiting, refilling, and substitution. The principal purpose of this article is to furnish information that will assist in preventing and detecting these forms of fraud and adulteration.

Table IB shows that the average analyses of the imported blends of 1939-40 are the same as those taken from original imported shipments five or more years ago (Table IA). Some of the original brands imported have not changed in character over long periods. Table IIA shows the analyses of domestic blended Scotch types obtained from the premises of United States rectifiers or purchased in the open market. Among them is a comparatively wide variation, particularly as to proof and solids content. Table IIB gives the analyses of the Scotch malt whiskies imported to be used to produce domestic blended Scotch types. Most of these (about 75 per cent) were colored with caramel abroad and in a few instances reduced in proof there. Although some of the malts may be single whiskies, they are for the most part probably combinations of malts mixed to fill the barrels and to meet the requirements of a strong-flavored, heavy-body malt whisky suitable for producing domestic-type whiskies with a smoky flavor. In general, they are heavier in body and flavor than the unblended malts of Table III. Their higher average solids content and color are accounted for by the caramel used. Table III shows the single malts that were removed from the original aging casks. They were

Samples Averaged	Proof	Total Acids	Volatile Acids	Esters	Higher Alcohols	Solids	Aldehydes	Furfural	Color in Half-In. Cell	Approx. Age
				-Grams/100	0 liters (calcd.	to 100° pr	oof)			Years
			Samples 7	Taken for F	Experiment N	Iay, 1939				
2 Lowland malts 2 Lowland malts 3 Islay malts 1 Islay malts 1 Scotch grain 2 Scotch grains 3 Scotch grains 1 Campbelltown malt 6 Highland malts	$\begin{array}{c} 112.7\\ 121.6\\ 114.2\\ 123.1\\ 121.1\\ 122.4\\ 123.5\\ 111.5\\ 119.6\\ 122.1\\ \end{array}$	$17.1 \\ 10.8 \\ 22.4 \\ 12.3 \\ 15.8 \\ 10.7 \\ 8.1 \\ 23.6 \\ 30.4 \\ 24.9 \\ 17.1 \\ 24.9 \\ 10.1 \\ 1$	$14.6 \\ 9.4 \\ 18.7 \\ 11.0 \\ 9.9 \\ 7.4 \\ 4.8 \\ 22.6 \\ 21.3 \\ 21.1 \\$	$\begin{array}{c} 31.5\\ 28.4\\ 24.6\\ 20.6\\ 16.0\\ 10.4\\ 12.5\\ 37.1\\ 38.4\\ 33.7 \end{array}$	$110.5 \\ 100.0 \\ 105.6 \\ 138.1 \\ 26.1 \\ 30.8 \\ 45.5 \\ 116.7 \\ 117.5 \\ 111.1 $	$\begin{array}{r} 36.7\\ 13.9\\ 44.4\\ 43.9\\ 132\\ 47.3\\ 70.4\\ 62.7\\ 89\\ 111\end{array}$	3.7 4.5 6.4 5.1 4.9 4.8 4.8 7.9 5.5 5.2	$1.8 \\ 1.5 \\ 1.8 \\ 1.0 \\ 0.12 \\ 0.20 \\ 1.8 \\ 1.9 \\ 1.4$	3.3 1.3 2.7 2.3 3.0 3.0 2.8 1.5 6.2 3.7	8 4 9,5 8 13.2 8 4
			Samples '	Faken for I	Experiment I	Dec., 1939				
4 Lowland malts 5 Islay malts 6 Scotch grains 1 Campbelltown malt 13 Highland malts 23 Scotch malts (all kinds) 2 neutral spirits from molasses	$122.3 \\ 117.7 \\ 122.5 \\ 122.0 \\ 120.0 \\ 120.0 \\ 192.7$	$\begin{array}{c} 13.8\\ 16.7\\ 14.0\\ 14.3\\ 32.9\\ 25.2\\ 0.6\end{array}$	$ \begin{array}{c} 11.8\\ 14.5\\ 8.7\\ 12.6\\ 26.1\\ 20.4\\ 0.6 \end{array} $	29.923.911.622.439.033.71.6	99.198.528.3109.696.697.73.5	26.832.253.641.884.460.50.5	$5.2 \\ 5.1 \\ 3.6 \\ 8.0 \\ 6.5 \\ 5.9 \\ 0.4$	1.3 1.3 Trace 1.1 1.5 1.4 0	1.6 1.8 3.8 1.8 5.3 3.8 0	4-8 4-8 4-8 4 6 (Av.)
^a No caramel coloring.	and the sta	au 16 1	epen app	No. Car	A Really	ing the sta	ar willing	an aber		and a second second
and the provide served the serve	TABLE IV	7. ANAL	LYSES OF R	EGULARL	Y IMPORTEI	o Irish V	VHISKY ^a , 193	5–1940	an internet	CALL STOR

TABLE III. ANALYSES OF AUTHENTIC UNBLENDED SCOTCH MALT AND GRAIN WHISKIES^a FURNISHED BY THE WHISKY ASSOCIATION

Serial No.	Proof	Total Acids	Volatile Acids	Esters	Higher Alcohols	Solids	Aldehydes	Furfural	Color in Half-In. Cell	pH	Age	Туре
				-Grams/10	00 liters (not	calcd. to p	roof)				Years	
$54502 \\ 54589 \\ 54590 \\ 54595 \\ 95846$	91.2 91.0 85.8 86.8 91.2	$24 \\ 16.8 \\ 16.8 \\ 19.2 \\ 38.4$	$22.8 \\ 10.8 \\ 14.4 \\ 15.6 \\ 27.6$	$23.8 \\ 20.2 \\ 18.5 \\ 22.0 \\ 28.2$	$153 \\ 145 \\ 154 \\ 73 \\ 155$	$114 \\ 122 \\ 192 \\ 222 \\ 138$	$3.2 \\ 7.2 \\ 4.8 \\ 5.6 \\ 14.9$	2.0 2.0 1.6 1.0 8.0	$ \begin{array}{c} 6b \\ 6.5^{c} \\ 10.0^{c} \\ 8.5^{c} \\ 6.0^{b} \end{array} $	$\begin{array}{r} 4.37 \\ 4.67 \\ 4.25 \\ 4.60 \\ 4.33 \end{array}$	$ \begin{array}{r} 7 \\ 10 \\ 10 \\ 9 \\ 15 \end{array} $	Pot still Pot still Pot still Pot still + grain Pot still
				-Grams/10	00 liters (calc	l. to 100°	proof)					
3067 3063 3064 3062 3065	$\begin{array}{r} 124.7 \\ 118.8 \\ 120.0 \\ 127.2 \\ 134.9 \end{array}$	$22.1 \\ 21.6 \\ 19.6 \\ 14.2 \\ 16.2$	$20.4 \\ 15.6 \\ 14.2 \\ 12.0 \\ 13.1$	$\begin{array}{r} 40.6\\ 21.9\\ 18.7\\ 19.3\\ 20.9 \end{array}$	$172 \\ 225 \\ 235 \\ 33.2 \\ 28.7$	$24 \\ 83 \\ 113 \\ 28.8 \\ 46.7$	9.6 9.1 7.2 5.3 5.7	2.2 5.0 3.3 0 Trace	$1.7b \\ 6.7c \\ 4.8b \\ 2.4b \\ 3.2b$	$\begin{array}{r} 4.58 \\ 4.48 \\ 5.06 \\ 4.57 \\ 4.56 \end{array}$	8 8 8 8 8	North of Ireland pot still Pot still North of Ireland grain ^d North of Ireland grain ^d
3065 ^a Samples f	134.9 urnished	16.2 by the 1	13.1 Whisky Ass	20.9 ociation (28.7 London), tal	46.7 cen direct	5.7 ly from aging	Trace casks, suppo	3.2 ^b orted by ceri	4.56 tificate o	8 of origin.	North of Ireland graind

^a Samples furnished by the Whisky Association (London), taken directly from aging casks, supported by certificate of origin b No caramel.

c Caramel.

d The Irish grain whiskies both have a light whisky character.

sent to the United States for experimental and research purposes, accompanied by certificates of age and authenticity issued by the British Customs and Excise. Table III indicates that the older malts have more congenerics than the younger malts of the same class, owing to concentration, as would be expected. Some variation in the groups of malts and between individuals of the same group is indicated. The burnt peat flavor varies in the same manner. All of these differences, however, are made uniform by the extensive mixing and blending by the Scotch blenders.

The lower furfural content in blended Scotch-type whisky indicates the use of less malt whisky. Very little furfural is extracted from the long re-used Scotch cooperage; this would lead us to conclude that practically all the furfural present is due to the fire heating of the pot still. The grain whisky aged in the same sort of cooperage but steam-distilled contains only the small traces that are extracted from the old cooperage. The Irish whisky of Table IV, all fire-heated pot-still samples, with less tails removed than in the case of Scotch malts, usually has a relatively larger portion of furfural; this is almost comparable to the United States pot-still rums (10) and pot-still apple brandy (11) aged in new charred barrels, which are also a source of furfural. Furfural comes off towards the end of the distillation of whisky.

The esters are generally low in all kinds of Scotch whisky, particularly the blends, and seem to play a less important role than in rum, brandy, or American whisky. Fractionation showed that most of the esters of Scotch whiskies were ethyl acetate, with only a small portion of higher esters, depending principally on the amount of malt whisky present. The usual delicate flavoring effect of the esters is overshadowed by the peat smoke flavor.

Comparison of the various distilled spirit products of Scotland shows that pot-still malt whisky is the heaviest in flavor and body, the blends are next (about halfway between the malts and the Scotch grain whisky), and the grain whiskies are halfway between the blends and the grain alcohol. The latter is usually produced for gin and has very little character. A still purer alcohol is the industrial product distilled from molasses; it is Britain's purest commercial alcohol and is about the same in character as United States pure industrial spirit. Malt whisky, similar to Scotch malt whisky, distilled in imported Scotch pot stills is beginning to be made in the United States from all-malted barley dried over burning Canadian peat. Light grain whisky is being produced at the time to be aged for the same number of years to blend with the peat dried malt whisky. This blend will be called "blended Scotch-type whisky".

Irish Whisky

In 1937-38 fourteen distilleries were making pot-still whisky in Ireland, and three of them used all-malted barley. The next important ingredient is unmalted barley, and in much smaller amounts rye, wheat, and oats are also used. No peat is utilized in drying the malt; hence there is no smoke flavor. One grain distillery utilizes corn as the principal ingredient of the mash.

The mashing, fermenting, and distilling are conducted in about the same manner as in Scotland, except that the pot stills are larger and, although mostly fire-heated, may also be reinforced with steam coils. Irish whisky is distilled three times, and the whisky is stored at a higher proof (132–135 U. S.) than Scotch whisky. The cooperage is about the same as in Scotland. It is bonded at 25 over proof British. Scotch is bonded at 11 over proof British. Irish whisky is usually sold to the trade unblended with grain whisky. Table IV gives analyses of Irish whiskies which have been imported in the last few years. Four of the samples are all pot-still whisky, and sample 54595 is blended with about 50 per cent Irish grain whisky.

Because of the material used, method of distillation, and other factors, Irish whisky has a character of its own and can be readily distinguished by taste and aroma from Scotch and American whiskies.

Conclusions

- 1. The best single index for judging the amount of Scotch malt used in a Scotch blend or type is the fusel oil content.
- 2. As far as can be determined, there is no naturally occurring methanol in Scotch malt, grain whisky, blended Scotch whisky, or Scotch type blended with United States neutral spirits.
- 3. There is no record of charred barrels being used for storing Scotch whisky.
- 4. It is possible with practice to judge the amount of peat flavor in Scotch blends and types by the taste and aroma in order to supplement the chemical analysis of any sample in question.
- 5. Domestic types vary over wider limits of proof, acids, esters, solids, and color than imported blends, and are generally lower in all these values.
- 6. The furfural determination, which is generally of less importance in ordinary whisky analysis, is helpful in judging the amount of malt used in a blend or type. It is an ingredient not easy to supply artificially; although some is extracted from the wood, most of it is due to fire heating in the pot still.
- 7. In the Scotch type the malt used must furnish all whisky character, taste, and aroma, except that supplied in some cases by blending agents.
- Although the four classes of Scotch malts vary in peat 8. flavor, there is not much difference in their chemical analysis. Their higher alcohol content ranks in the same order as their flavor.
- Although true whiskies, the Scotch malts, Scotch 9. grains, blends, and types are distinctly different from rye, bourbon, or other kinds of whisky.
- The Irish whiskies are generally heavier in body than 10. any of the unblended Scotch malts and are much heavier than any Scotch blends or types. The flavor is characteristic.

Acknowledgment

Credit should be given Loren Burritt for assistance in analytical work, G. K. Hamil for fractionation and analytical assistance, Harry L. Lourie for procuring numerous authentic imported samples, the Whisky Association (London) for furnishing unblended malt and grain whiskies and other samples, James M. Doran for information concerning practice and processes in Scotland and Ireland, Edward Wootton for assistance in preparing and correcting details of the manuscript, and W. V. Linder, Paul W. Simonds, Richard L. Ryan, and other officials of the Bureau of Internal Revenue for assistance and cooperation.

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