BREWING

BREWING is the art of preparing an exhilarating or intoxicating beverage by means of a process of fermentation. In the modern acceptation of the word, brewing is the operation of preparing beer and ales from any farinaceous grain (chiefly from barley), which is first malted and ground, and its fermentable substance extracted by warm water. This infusion is evaporated by boiling, hops having been added to preserve it. The liquor is then fermented.

The art was known and practised by the Egyptians many hundred years before the Christian era, and afterwards by the Greeks, Romans, and ancient Gauls, from whom it has been handed down to us. All countries, whether civilized or savage, have, in every age, prepared an intoxicating drink of some kind. In the second book of Herodotus, written about 450 B.C., we are told that the Egyptians, being without vines, made wine from corn; but as the grape is mentioned so frequently in Scripture and elsewhere as being most abundant there, and no record exists as to the vine having been destroyed, we must conclude that the historian was only partially acquainted with the productions of that most fertile country. Pliny (*Natural History*, xxii. 82) informs us that the Egyptians made wine from corn, and gives it the name of *zythum* which in the Greek would mean drink from barley; and Hellanicus, telling of the introduction of wine at Plinthium, a city of Egypt, states: "Hence the Egyptians are thought to derive their love and use of this liquor, which they thought so necessary for human bodies, that they invented a wine made from barley." The Greeks, who derived the greater part of their civilization from the Egyptians, obtained from them also the knowledge of artificial fermentation, the art of brewing in fact, and at a very early period. We find it mentioned, for example, in the writings of Archilochus, the Parian poet and satirist, who flourished about 700 B.C., that the Greeks of his day were already acquainted with the art.

Again, we learn from Æschylus (470 B.C.), from Sophocles (420 B.C.), and Theophrastus (300 B.C.), that the Greeks employed barley wine or beer (their *zythos*) in their daily life as well as in their festive meetings. There is, in fact, little doubt that the discovery of beer and its use as an exhilarating drink were nearly as early as those of the grape itself. Xenophon, in his account of the retreat of the ten thousand Greeks, written 400 years B.C., mentions that the inhabitants of Armenia used a fermented drink made from barley. Diodorus Siculus states that the Galatians prepared a fermented beverage from barley, calling it *zythos*, like the Egyptians. By Sophocles and other Greek writers it is styled *βρῦτον*. Dioscorides mentions two kinds of beer, one he calls *ζῦθος* and the other *κοῦρμι*, but he does not describe them sufficiently to enable us to distinguish them. Both, he says, were made from barley, and similar liquors were made in Spain and Britain from wheat. In the time of Tacitus (whose treatise on the manners and customs of the Germans was written in the 1st century of the Christian era), beer was their usual beverage, and from his description, imperfect as it is, there can be no doubt that they understood the method of converting barley into malt. Pliny mentions its use in Spain (*Nat. Hist.*, xxii. 82) under the name of *celia* and *ceria*, and in Gaul under that of *cerevisia* or *cervisia*; and elsewhere (xiv. 29) he says—"The natives who inhabit the west of Europe have a liquor with which they intoxicate themselves, made from corn and water. The manner of making this liquid is somewhat different in Gaul, Spain, and other countries; and it is called by different names, but its nature and properties are everywhere the same. The people of Spain in particular brew this liquor so well that it will keep good a long time. So exquisite is the cunning of mankind in gratifying their vicious appetites, that they have thus invented a method to make water itself produce intoxication."

The *cervisia* of Pliny evidently takes its name from Ceres, the goddess of corn. Plautus calls it *Cerealis liquor*, that is, liquor used at the solemn festival of that goddess. The art of malting and use of beer are supposed to have been introduced into Britain by the Romans. That barley was known to the latter is evident from Virgil, who uses it in the plural form, *hordea*, as we do the word oats; and Pliny tells of the *hordearii gladiatores*, a kind of fencers, whose sustenance was barley. Beer and vinegar were the ordinary beverages of the soldiers under Julius Cæsar. The latter was made very strong, and was drunk diluted with water when on the march. Beer being so suitable to the climate, and so easily made by an agricultural people with plenty of corn, it was gladly welcomed, and soon became the national beverage. Previous to this, the usual drinks of the ancient Britons were water, milk, and mead (an intoxicating drink made from honey). After the expulsion of the Romans from Britain, the Saxons subdued the natives and learned from them the art of brewing.

Dr H. J. Mann tells us that the Kaffre races of South Africa have made for ages, and still make, a fermented drink of beer from the seed of the millet (*Sorghum vulgare*), which is first subjected to a malting process in all essential particulars identical with our own. The seed is first induced to germinate by covering it in a warm place with moistened mats of grass, and the sprouting is then stopped by the application of heat. After simmering for some time in hot water, the malted grain is set aside to ferment in the sun—fragments of a dried succulent plant having been stirred in to play the part of yeast and start the fermentation. The scum which rises to the surface during the fermentation is skimmed away from time to time by ladles made of grass stems spread out and loosely woven together at the bowl. When the fermentation is complete the beer is poured through a mat strainer, shaped and tasselled very much like an inverted night-cap, into the store vessel, which is made of thickly and firmly woven grass. The natives of Nubia, Abyssinia, and other parts of Africa also make an intoxicating drink of great power called bousa, from the flour of the teff (*Poa abyssinica*), and from the durrha or millet (*Sorghum vulgare*), much esteemed by the natives, and perferred by many to palm or date wine, the common intoxicating drink in tropical countries. According to Mungo Park, the natives of Africa also make a beverage from the seed of the spiked or eared soft-grass (*Holcus spicatus*). The Russian drink kvass or quass, a thick, sour beverage, not unlike bousa, is made of barley and rye flour, mixed with water and fermented. Formerly, the spruce-fir, birch, maple, and ash trees were tapped, and their juice used in England,—the first two, indeed, till within the last fifty years. Koumiss, the drink of the Tatar race, is the fermented milk of their mares. The Chinese beverage, sam-shee, is made from rice. This is not only intoxicating, but, like absinthe, peculiarly mischievous in its permanent effects. In South America a favourite drink is palque, the fermented juice of the Amercian aloe (*Agave americana*). Guarapo is the juice of the sugar-cane, which, when fermented, forms the common drink of the negro races, who also prepare a drink from rice and honey. Where beer has once been introduced, however, it has generally become the national beverage, and is now in universal use in the northern and temperate parts of Europe and Asia.

Beer used formerly to be made in England from wheat; but this beverage was not so well flavoured as if prepared from barley-malt, nor did it keep long. It was esteemed in Germany and Denmark, and was called by the Germans *Mumme*, and by the Danes *mom*. The German *Weiss-bier* is made from wheat-malt, with a small portion of barley-malt added.

We are informed by William of Malmesbury that, in the reign of Henry II., the English were greatly addicted to drinking. The monasteries were remarkable for the strength and purity of their ales, brewed from malt prepared by the monks with great care and skill. The waters of Burton-on-Trent began to be famous in the 13th century. The secret of their being so especially adapted for brewing was first discovered by some monks, who held land in the adjacent neighbourhood of Wetmore. There is a document still extant, dated 1295, in which it is stated that Matilda, daughter of Nicholas de Shoben, had re-leased to the abbot and convent of Burton-on-Trent certain tenements within and without the town; for which re-lease they granted her, daily for life, two white loaves from the monastery, two gallons of conventual beer, and one penny, besides seven gallons of beer for the men. The abbots of Burton must also have made their own malt, for it was a common covenant in leases of mills belonging to the abbey, that the malt of the lords of the manor, both spiritual and temporal, should be ground free of charge. Mary Queen of Scots, in the midst of her troubles, seems not to have been altogether insensible to the attractions of English beer, for when she was confined in Tutbury Castle, Walsingham her secretary asked, "At what place near Tutbury beer may be provided for her majestie's use?" to which Sir Ralph Sadler, governor of the castle, made reply, "Beer may be had at Burton, three miles off." Plot, in his *Natural History of Staffordshire*, written 200 years ago, refers to the peculiar properties possessed by the Burton waters, from which, he says, "by an art well known in this country good ale is made, in the management of which they have a knack of fining it in three days to that degree that it shall not only be potable, but is clear and palatable as one could desire any drink of this kind to be." In 1630 Burton beer began to be known in London, being sold at "ye Peacocke," in Gray's Inn Lane, and, according to the *Spectator*, was in great demand amongst the visitors at Vauxhall. In 1585 Stow relates that there were 26 brewers in the city of London, the suburbs, and Westminster,—13 being English and 13 foreigners,—who brewed 648,960 barrels of beer, of which they exported 26,400 barrels to Embden, the Low Countries, and Dieppe. In 1643 the first excise was imposed on beer. In William III.'s reign, the brewer sold his nut-brown ale at 16s. per barrel, and his small beer from the same grains for 6s. per barrel.

At the present day the brewing trade has reached vast proportions in Great Britain. It would appear that its extent has now attained the *maximum;* the quantity produced for export is likely to decline, as most of the colonies are beginning to make their own. The pale ale of Tasmania deserves particular notice; the climate being specially favourable to hop-growing and malting, that colony not only produces its home-supply, but carries on an export trade with Australia. According to the report to Messrs Bass by Professor Leone Levi, the number of persons employed in and depending on the British liquor trade is 1,500,000, and the capital invested in it amounts to £117,000,000. There are 5000 maltsters, 34 000 licensed brewers, 6000 dealers in ales, and 139,000 publicans. These pay nearly £8,000,000 a year for permission to make and sell the popular drink. The quantity of beer brewed in 1869 was 25,542,664 barrels, of which 521,272 barrels were exported; whilst in 1874 the exports were 573,957 barrels, of the declared value of £2,508,883. It has been estimated that Barclay & Perkins (successors to Thrale, Johnson's friend) have £1,500,000 sunk in their trade. Bass, the largest brewer in the world, pays license on 1,000,000 barrels, and there are eighteen other brewers who pay duty on 200,000 barrels. From the excise official returns we find the annual consumption per head of the population is

In England, 2 bushels of malt, ½ gallon of spirits.
,, Scotland, ⅛ ,, ,, 1½ ,, ,,
,, Ireland, ⅛ ,, ,, ⅛ ,, ,,

The first essay known to us on the subject of brewing is by Basil Valentine. Boerhaave says of this treatise that it is both accurate and elegant. In 1573 H. Knaust published a work in five volumes at Erfurt, with the quaint title, *On the Divine Noble Gift, the Philosophical, highly Dear, and Wondrous Art to Brew Beer*. In the year 1585 Thaddeus Hagecius ab Hayck (a Bohemian), published a treatise entitled *De Cerevisia, ejusque conficiendi ratione, natura, viribus, et facultatibus*. This small work of fifty pages gives a very clear and accurate description of the process of brewing. To Mr Combrune, a London brewer in the earlier part of the 18th century, we are indebted for the proofs he gave of the value of the thermometer in brewing. In other respects his work entitled *The Theory and Practice of Brewing*, is of no particular value at the present day, though it was very useful at the time in advancing the art, and ran through several editions. Previous to his time brewers had looked upon the thermometer as a scientific toy, and "rule of thumb" was the order of the day. In the year 1784 Mr Richardson of Hull brought out his *Theoretic Hints on Brewing Malt Liquor*, and *Statistical Estimates of the Materials of Brewing, showing the use of the Saccharometer*. These works would be beneficial but for the absurd mystery with which the author invests the whole subject. It was he who first brought publicly to the notice of brewers the value of the saccharometer, an improvement of his own on the hydrometer, or water guage, invented by Martin, the Fleet Street mathematician. Mr Baverstock purchased one of these in 1768, and in 1770 received a certificate of the value of his instrument from Mr Thrale, the celebrated brewer in Southwark, who had tested it. It was not, however, till 1785 that Mr Baverstock published his *Hydrometrical Observations and Experiments in the Breweries;* so that Mr Richardson has the merit of bringing his improved hydrometer, which he christened saccharometer, first to the notice of the trade. By this instrument the brewer is enabled to ascertain the amount of saccharine or fermentable matter in the wort, and thus to take advantage of a particularly good sample of malt, or to compensate for a bad one, so as to procure an uniform strength. Malt varies in quality according to season, the skill of the maltster, and other circumstances. Samples of barley raised from the same seed, and grown in adjoining fields, will produce malt widely different, although this is not discovered till it has been in the mash tun. The quantity of malt which suffices for a particular "length" to-day may fall far short of affording the same quantity of ale to morrow, and *vice versa*. In either case the saccharometer is essential, as it enables the brewer to make his ales one standard strength. The instrument is also of great service in regulating the fermentations.

Mr Richardson's saccharometer was constructed on the principle that 36 gallons (one barrel) of water weighs 360 lb, and if that quantity of water were converted into wort

and again weighed the difference would show the weight of fermentable matter extracted from the malt. His instrument, therefore, was graduated so as to show one degree for each pound that a barrel of wort weighed more than a barrel of water. He does not, however, allow for the displacement of a certain quantity of water by the saccharine matter dissolved in it; consequently, his instrument is not quite correct. The saccharometer of Dring and Fage and that of Long, which are both on the same principle as Richardson's, are adjusted so as to allow for this inaccuracy; for example, if a gallon of sugar, weighing 16 lb, be added to 35 gallons of water (together making one barrel imperial measure), their instruments show in this infusion, at 60° Fahr., the excess above that of distilled water, which, in this instance, is 6 lb gravity; thus we have a barrel of wort, weighing 366 lb, composed of water 35 gallons, and saccharine matter 16 lb. The Excise make their calculations by Allan and Bate's instruments, which are constructed on the principle of indicating the specific gravity of the wort,—that of distilled water, which is the standard of weight by which all substances have to be compared, being reckoned 1000. It is, however, easy to change the reckoning of the one to the other. Should we wish to reduce the specific gravity indicated by Allan's or Bate's instruments, we have only to divide the specific gravity by 2·77; or if we wish to convert the indication of Dring and Fage's scale into specific gravities we multiply by the same factor.

Barley is the seed of several species of *Hordeum*, and belongs to the tribe of grasses, called by botanists *Graminaceæ*. It has been cultivated from the earliest times. The species most used for malting purposes are the long-eared or two-rowed barley (*Hordeum distichum*), and the *Hordeum hexastichon*, commonly called bere or bigg. This, in consequence of its being more hardy and ripening more rapidly, is cultivated in Scotland and Ireland. The variety of the two-rowed most in repute is the Chevalier. This was introduced early in the present century by the rector of Stonham, in Suffolk, after whom it was named, and was the result of careful cultivation. Mr Chevalier saw some fine specimens of two-eared barley growing on a manure heap, had them saved, and cultivated them for several years, selecting only the soundest and largest seeds, until the Chévalier barley became famous and commanded large prices. The land in Great Britain suitable to the growth of the finest grain for malting is limited;—the most favourable districts being Suffolk, Norfolk, and parts of Essex and Herts. It is, of course, cultivated in all other counties, but not to the same extent. From the *Agricultural Returns of Great Britain*, presented to Parliament, we find that in the year 1870, there were 2,600,000 acres under barley, which, if taken together, would form a block ⅛th larger than the counties of Suffolk and Norfolk. Taking the average yield at 32 bushels per acre, the total is 83,000,000 bushels, or more than 10,000,000 quarters. Of this, 50,000,000 bushels were converted into malt, and 4,000,000 used by the distillers. Farmers find by experience that some land is not fit for the growth of this cereal, and maltsters that if it is grown on certain soils it will not make good malt. Light calcareous or friable gravelly dry soil is the best. Rich loamy soil produces an excellent crop, and sandy soil, when well manured, answers; but cold clayey land, even when well drained, will not produce the best malting barley. It is a most precarious crop, requires but little moisture, and a wet season is fatal to it. When it is in full ear rain, or even heavy dew, will break the stalk, and if wet continues for two or three days the ears on the ground begin to grow, get stained, and become quite unfit for malting. It should remain in the stack at least a month to season. If "got up" damp, it is liable to generate excessive heat, in which case the growing power of the germ is destroyed, and the grain rendered useless for malting purposes. Good barley should have a thin, clean, wrinkled husk, closely adhering to a plump well-fed kernel, which, when broken, appears white and sweet, with a germ full, and of a pale yellow colour. It is of all cereals the best adapted for malting, containing as it does more starch and far less gluten than other grain, and about 7 per cent. of ready-formed grape-sugar. Its specific gravity is from 1·280 to 1·333, that of malt 1·200. A bushel of barley weighs between 53 lb and 58 lb, depending on climate, soil, and harvest; the same quantity of bere or bigg weighs from 47 lb to 51 lb. It cannot well be too heavy, as it gives a corresponding gravity to the malt, providing it be mellow, thin-skinned, and not steely. The cuticle, or husk, forms nearly ⅓th of the weight of barley, and between ¼th and ⅕th in bigg. According to Einhoff, 1000 parts of barley meal contain 720 of starch, 100 of water, 68 of fibrous or ligneous matter, 56 of sugar, 50 of mucilage, 36·6 of gluten, 12·3 of vegetable matter, and 2·5 of phosphate of lime. Hermbstädt gives the following percentages as the mean of ten analyses of barley made by him:—

Water	10·48
Husk	11·59
Gluten	4·91
Albumen	0·35
Starch	60·50
Sugar	4·66
Gum	4·50
Oil	0·35
Soluble phosphates, &c.	0·36
Loss	2·30
	100·00

Great care must be taken when buying for malting, for sometimes the grain is doctored by kiln-bleaching or dried at too great a heat. Several samples, too, may be mixed, in which case they will not grow regularly, as heavier barley generally requires to be longer in steep. Corns broken by the drum of the thrashing-machine being set too close spoil a sample; those cut into sections will not germinate, but in warm weather putrefy, as is evident from their blue-grey and mouldy appearance, and offensive smell whilst germinating. A good buyer will, by the use of a skilful hand, estimate very closely the weight per bushel in bulk; his eye will tell him if the grain has been cut before being ripe, in which case there will be a variety in the colour of the barley-corns, some being bright, and some a dead greyish yellow. In consequence of being sown in spring, and not undergoing the equalizing tendency of winter, barley is of all grain the most liable to ripen in a patchy manner, and not come to perfection simultaneously. The buyer has also to judge if it has been heated or "mow-burnt" while lying in the field after being cut, or in the stack; this it is apt to do in showery weather, or when the crop of clover, which is generally sown with or soon after the barley, is luxuriant. In this case the grain is apt to sprout, and as the process of malting is as near as can be a natural vegetation, barley once sprouted is useless to the maltster.

Malting.—The word malt has been variously derived from roots that have respectively the meanings of grinding, soaking, and rotting. The last derivation, corresponding to the *humor ex hordeo corruptus* of Tacitus (*Germ.* 23), is the most probable. Malting consists in steeping the grain in water to supply moisture enough to cause it to germinate, and when the growth is sufficiently advanced, stopping it by drying the grain on a kiln. Before explaining the process of malting we must describe the construction of the seed, and see the chemical changes that take place. A grain of barley is composed of several parts—the inner and outer husks, the cotyledon, the corcule (which includes the plumule or future stem and the rostel), the investing membrane and the scar or eye, through which the seed is nourished during the process. The hard white part is termed, botanically, albumen. This is the cotyledon, and forms the chief part of the seed, supplying the germ with food during the first few days of its existence. With the germ, which begins to exist within an hour of being put in steep, springs also into existence the principle termed diastase. This name (from διάστημι, to separate) was given it by MM. Payen and Persoz, who made numerous experiments with it.

According to Muspratt, diastase may be obtained by making a paste of malted grain at a temperature of 76°, allowing it to stand for a few minutes, and then pressing out the liquor, which is afterwards filtered and heated in a water bath at 170°. At this temperature a portion of the foreign nitrogenous matter coagulates, which is afterwards separated by filtration. The clear filtrate, which contains tolerably pure diastase, is evaporated at a low temperature to dryness. Diastase is not only soluble itself, but has the power of dissolving starch, and converting it into soluble gum, to which is given the name dextrin, and finally into grape sugar, so called because, on analysis, it closely resembles the sugar which naturally exists in the grape. So powerful is diastase, that one part will convert 2000 parts of starch into grape-sugar. This operation will be noticed below under the head of mashing. It is on account of this wonderful power of diastase to convert starch into saccharine matter, that distillers use one part of malt in mashing to five parts of raw grain. The next part of the seed that comes under notice is the corcule, which is the embryo of the future plant. This germ, feeding on the sugar formed from the starch of the cotyledon by the action of diastase, grows upwards and downwards,—the upward growth being the plumule or "acrospire," the downward the radicle or future root. Acetic acid (vinegar), which does not exist in raw grain in a free state, is now also formed; this assists the diastase in its action.

The maltster's object is to obtain as much saccharine matter as possible, with the smallest loss of substance, by converting the starch of the barley into sugar, and thus preparing it for the brewery, where it is changed by fermentation into alcohol. Chemically, starch and sugar are composed of the same elements, carbon, oxygen, and hydrogen; but their atoms are differently arranged,—the mean results of the analyses of Berzelius, Gay-Lussac, and Thenard, giving $\frac{17}{100}$ths of a grain of carbon more in starch than in sugar, whilst sugar contains $\frac{25}{100}$ths of a grain more of oxygen and $\frac{8}{100}$ths less of hydrogen than starch.

The duty on malt forms an important item in the revenue, and stringent laws have been made to enable the excise to levy the duty, and prevent the maltster from defrauding. It may be remarked, however, that although those rules were relaxed or abolished, the process of manufacture would be carried on as it is now. The duty was first raised in the reign of Charles I. on the following scale:—English malt, 4s. 4d.; Scotch barley-malt, 3s. 8½d.; Scotch bigg-malt, 3s. per bushel, but 2s. of this was a war-tax, and the whole was soon repealed. In 1697 a tax was again imposed (to enable William III. to carry on war with France) of 6¾d. per bushel. The rate has been frequently changed, and has ranged between 7d. and 4s. 5¾d. in England, and 7d. and 3s. 9¾d. in Scotland. For this and much other information we are indebted to a useful little work on malting published by W. R. Loftus. The present rate of duty on malt made from barley is 2s. 7d. per bushel, and 5 per cent. additional, making in all 2s. 8⅓d.; and on malt from bere or bigg, when made for consumption in Scotland or Ireland, 2s., and 5 per cent. additional; when the latter is imported into England the higher duty is charged. The 5 per cent. additional was imposed in 1840 on all exciseable articles, except spirits.

Table showing Quantity of Malt made in Great Britain during the years 1871 *to* 1874, *and the amount of Duty levied:*—

	Year.	No. of Bushels.	Duty Levied.
England—			
From Barley.	1871	46,318,153	£6,281,899
	1872	51,511,682	6,986,273
	1873	52,873,839	7,171,014
	1874	53,661,020	7,277,775
Scotland—			
From Barley.	1871	2,768,187	375,435
	1872	2,956,040	400,913
	1873	3,171,582	430,146
	1874	2,819,612	382,410
From Bigg...	1871	37,843	3,973
	1872	23,636	2,482
	1873	26,931	2,828
	1874	20,600	2,163
Ireland—			
From Barley.	1871	2,929,282	397,284
	1872	2,715,412	368,278
	1873	3,365,624	456,463
	1874	3,221,329	436,893
From Bigg...	1871	7,545	792
	1872	7,014	737
	1873	nil.	nil.
	1874	...	...

Malting consists of four processes,—steeping, couching, flooring, and kiln-drying.

Steeping is performed in a large cistern of stone, or more usually brick, covered with cement, into which the barley (properly screened, to remove the small useless grains) is shot from the store-chamber above. It is then levelled and covered with water to the depth of 5 or 6 inches, all floating kernels and refuse being skimmed off. This process is necessary for the germination of the seed not only in a chemical but also in a mechanical point of view. The seed is so hard and compact, and the husk so firmly bound to the kernel, that it would be impossible for the tender germ to make its way through it; the steeping imparts vitality to the germ, and also assists it in making its way through the husk. The grain now swells about one fifth in bulk and one-half in weight from the moisture absorbed; or more precisely, 100 lb of barley would weigh, after steeping, 147 lb, and 100 bushels measure would increase to 122. By law it has to be kept at least forty hours under water, and fifty if the grain is to be sprinkled before the twelfth day. This time must depend on the kind of barley used, the soil on which it was grown, the heat of the weather, and the hardness or softness of the water in which it is steeped. More time is required in cold than in hot weather. Scotch barley requires more time, but bigg less. Fifty hours steeping will generally suffice, but sometimes seventy is necessary. The rule is—if a barleycorn, held lengthwise between the finger and thumb, breaks down into a pulpy, mealy state, the process is complete; whereas, if the farina exudes in the form of a milky paste, it is over-steeped. In warm weather the steep-water acquires an odour from matter dissolved out of the barley skin; and, in consequence of a slight fermentation caused by the organic matter in the water acting on the decayed grain, the water becomes acescent or putrid. The steep-water should then be changed. This the maltster is allowed to do once during each wetting, upon giving due notice to the Excise. Whilst the barley is in steep it is guaged by the excise officers, to prevent fraud, and to calculate the duty to be paid. Wide planks are placed across the cistern to enable them to take the "dip,"—sufficient light, and headroom of at least 48 inches, being provided. Numerous experiments show that 81½ bushels of good dry barley will, after forty-eight hours steep, swell to exactly 100 bushels. An allowance is therefore made of 18½ per cent. on the grain found in the

cistern or couch frame, but the duty is charged on the greatest amount found, whether in the couch or on the floor or kiln. When the operation of steeping is complete the water is drained off in about half an hour by means of a gutter laid below the level of the cistern from end to end, with a proper fall, and covered with perforated iron plates. The perforated plates being movable, the gutter is easily cleaned and the plates replaced. The law requires that every cistern shall be permanently constructed with the sides and ends straight, and at right angles to each other, for facility of measurement; the depth must not exceed 40 inches in any part; the bottom must be even, with a fall of not more than half an inch per foot for drainage. No cistern can be used under a penalty of £100 until a certificate in writing from the supervisor has been obtained, stating that he has surveyed the utensil, and that it is constructed according to the requirements of law.

Couching.—The couch-frame is formed like the cistern, with the exception that the fourth side may be made of movable planks at least 2 inches in thickness. Before the year 1827 it was lawful to construct the couch-frame entirely of movable boards; and couches made before that date may still be used by obtaining permission from the Board of Inland Revenue. Into this frame the grain is now thrown with wooden shovels. It must not be compressed in any way, under heavy penalties, and must not exceed 30 inches in depth. If the excise officer has any suspicion that the grain has been trodden down, he may order it to be thrown back into the cistern and levelled. The officer will then gauge it again. If he finds that the quantity has increased more than 5 or 6 per cent. according to the length of time the grain has been emptied from the cistern, any such increase over and above the 5 or 6 per cent. will be deemed conclusive evidence that the grain has been trodden or forced together. A penalty of £100 is then incurred; and a like sum for maltsters or their men refusing to return the grain to the cistern. After twenty hours the maltster is at liberty to move the grain on to the floors; but, in cold weather, when sufficient heat to forward germination has not generated, it is left two days, and even longer; but if left too long, the grain becomes sour. After sufficient time has elapsed, in order to prevent the heat rising too rapidly, and to equalize it through the whole body of grain, it is thrown forward on to the floors.

Flooring.—Here the grain must be kept level, with the edges straight to make it easy for the officers to gauge, which is done several times to prevent the introduction of uncharged grain. This operation of gauging requires great care, as, in large houses, a mistake of the tenth of an inch would make a difference of between 20 and 30 bushels to the maltster. On the floors an allowance of one-half is made for the rootlets; this is generally quite sufficient. Each steeping is called a "floor" or piece, and must be laid in succession according to age, the most recent next the couch, and the oldest next the kiln. Maltsters may have six floors, including grain in the couch and on the kiln, in operation at one time. Germination now progresses; the plumule, or stem begins to grow under the husk from the same end as the root, but instead of piercing the husk, turns round and proceeds under it to the other end of the grain. This would develop into the green leaf were its progress not stopped. Maltsters vary as to the length it is advisable to let the acrospire attain; some like it not much more than half up the back of the grain, others like it $\frac{3}{4}$ths or even $\frac{7}{8}$ths of its length, because it is practically found that a friability of the starchy matter takes place *pari passu* with the length of the plumule. Unless the floors are worked with great skill and regularity, however, some are apt to protrude when carried to the latter extent. This shows an exhausted condition within. Malsters who sell by *weight* work the acrospire no higher than is absolutely necessary; the higher it is worked the less starch and the more sugar is produced, and a corresponding loss in weight ensues. The maltster who sells by *measure*, however, likes to have the acrospire as high as he can, to increase the bulk of his malt. The writer's experience is that ales fine better, and keep better, when brewed from malt well worked up. In large mash tuns, where the heat can be maintained, it is not of so much importance; but in small tuns, where less than twenty quarters are mashed, if the "spire" is up $\frac{4}{5}$ths of the grain, so much the better, so long as it is uniform. The temperature on the floor rises to between 50° and 60°; the fibrils of the radicle, the "chick," as it is technically called, shoot from the tip of every corn. The middle of the floor being the warmest starts soonest; so, after a few hours, the grain is turned or stirred, so as to bring all to a similar state of forwardness. At this point comes the critical test of the maltster's skill; no fixed rules can be laid down; he must be guided by experience and circumstances. He has to consider the quality and growth of the barley,—whether it came off light or heavy soil,—the kind of malt intended to be made,—the temperature and peculiarities of his particular malting. His principal object is to get the grain to work, and to work regularly, to accomplish which, and to check the too rapid growth of the rootlets, the grain must be turned several times daily, the interior being always brought to the surface by the shovels of the workmen. The grain is spread more thinly each time, the depth of it, originally 14 or 15 inches, being thus gradually lessened to 3 or 4 This brings it to the middle of the process; it is then thickened as gradually as it was diminished until it is thrown on the kiln. The grain now emits an agreeable odour, something like apples; and if the hand be thrust into the corn it is found wet enough to damp it; this is called sweating. The "chick" develops into several short bushy rootlets. As the acrospire grows the constituents undergo a great change; the gluten and mucilage almost disappear; the grain becomes white, mealy, and sweet; carbonic acid is produced; air is absorbed, almost as by animals in breathing; and, consequently, air is necessary to the germination of the grain. It loses during this part of the process from $1\frac{1}{2}$ to 3 per cent. in weight.

There can be no doubt that it is of importance to the maltster that the law allows him to sprinkle water over the "pieces" on the floor; this may be done at the expiration of ninety hours after removal from the steep, provided such grain has been kept under water fifty hours. Sprinkling is generally commenced on the fifth or sixth day, notice having been given to the Excise twenty-four hours before. If in steep less than fifty hours it may not be sprinkled till the expiration of twelve days. Sprinkling is used most by maltsters who sell by measure, and therefore want to increase the bulk of their malt; but there are seasons when it would be difficult to make good malt unless moisture were thus supplied, to make up the water lost during sweating. Too much light is detrimental, as appears from the fact that grain under the influence of uninterrupted light is inferior, unless the sky-light be covered with a coating of blue, which admits the actinic rays, and excludes the calorific and light rays, which hinder germination. Shutters on the sliding principle are the best for regulating both light and heat. Great care has to be taken not to damage the grain by turning, especially when it is spread thin. To obviate the necessity of turning as much as possible an insrument like a narrow shovel, called a plough, is used, which brings the grains underneath to the surface, and into contact with the cold air, so keeping the germination

regular. Grain is required by law to be kept at least 168 hours on the floors, but maltsters may keep it there as much longer as they like. Barley throws out five rootlets, the middle one being the strongest; and if the young floor has been neglected, this will shoot out three times the length of the others and turn up at the end like an awl. When the grain has germinated sufficiently, its growth is arrested by placing it on the kiln, the object being to drive off superfluous moisture and insure the keeping qualities of the malt.

Kiln-drying.—The kiln is a chamber of which the floor should be made of woven-wire or sheet-iron, or of perforated tiles. The perforations are necessary to give admission to the hot air, and also to allow the detached rootlets to fall through. The kiln should have a sufficient area to allow the whole of one steeping to be dried at once, at a depth of 8 or 10 inches; by which means the malt is more regular than when dried in two or three lots, as the portion left on the floor will grow, notwithstanding the maltster's efforts to prevent it. The opening at the top of the kiln is covered with a cowl or cupola, which answers the double purpose of excluding rain and allowing the escape of the steam. The furnaces are placed under the floor, nearly in the central line, and the hot air passing through the perforations dries the malt, while the steam is carried off through the vent in the roof. An iron or stone plate, 4 or 5 feet square, called the "disperser," is placed over each fire to disperse the heat and prevent the malt immediately above from taking fire. The heat at first should not exceed 90°; if higher it produces a hardening or vitrifaction of the starchy matter or dextrin, and also heightens the colour of the malt; whereas, if the malt be freed from moisture at a low temperature it may afterwards be exposed to a high heat without gaining colour. The moisture being disposed of, the heat may be gradually raised to from 125° to 135° for India pale ale malt, and to 170° or 180° for ordinary pale malt,—the difference in the kinds of malt being the amount of heat to which they are subjected on the kiln. During the process the fires should never be allowed to go out, as the smell of a green fire imparts an unpleasant flavour. During the last few hours in particular there should be a bright, clear fire for finishing off the malt, otherwise the beer will not get bright. It will thus be seen that the process of kiln-drying is very important. Dr Ure's remarks on it are pregnant with meaning. He says, "The operation of kiln-drying is not confined to the mere expulsion of the moisture from the germinated seeds, but it serves to convert into sugar a portion of the starch which remains unchanged, and that in a two-fold way. This is, first, by the action of the gluten upon the fecula at an elevated temperature, as also by the species of roasting which the starch undergoes, and which renders it of a gummy nature. If we dry one portion of the malt in a naturally dry atmosphere, and another on a moderately warm kiln, the former will yield less saccharine matter than the latter. Moreover, the kiln-dried malt has a peculiar agreeable and faintly burnt taste,—probably from a small portion of the empyreumatic oil formed in the husk, which not only imparts its flavour to the beer, but also contributes to its preservation." Kiln-drying takes from one to four days, according to the depth of malt and amount of heat used. The fire being kept always burning, great care is needed to prevent its breaking out in the night; it is therefore made up the last thing and then "banked up," that is, covered with a quantity of the ashes which fall through the bars. For ordinary pale malt, about three hours before it is thrown off the kiln the heat is raised from 150° to 180°, and during this process it requires turning two or three times, and is thrown off the kiln in a hot state. The rootlets are readily detached from the malt by the turning on the kiln, and the treading of the men in their list slippers; they are finally separated by screening, and are the best criterion of the colour of the malt, showing at once the amount of heat used. These malt "combs" or "cummings," as they are called, are valuable food for cattle in winter; and the fine ones which fall through the kiln-floor on the disperser, mixed with the dust from the fire, are said to be almost equal to Peruvian guano as a top dressing for turnips.

Malt continues to swell, by absorbing moisture from the atmosphere, for nearly three months, the time varying according to the dampness of the air. Malt in store is said to be mellowing. The increase by measure of malt over dry barley, called the "outcast," is from 3 to 8 per cent.; in bigg the increase scarcely amounts to 1 per cent. During the process of malting barley loses one-fifth of its weight; in other words, 100 lb of barley converted into pale malt weighs on an average 80 lb: but as barley when kiln-dried loses 12 per cent. of moisture, the actual loss is reckoned at only 8 per cent. The late Professor Thomson thus accounted for it:—

Soluble matter carried off by steep-water	1·5
Carbonic acid formed and given off during germination	3·0
Roots	3·0
Waste (bruised and lost grains)	0·5
	8·0

Dr R. D. Thomson, who made various experiments on malt for the purpose of ascertaining its feeding and fattening properties, states the loss sustained to be

Water	6·00
Saline matter	0·48
Organic ,,	12·52
	19·00

Bigg sustains a greater loss than barley, amounting to 7 per cent. more. The great similarity which chemical analysis shows to exist between barley and malt, proves that malting is only the beginning of the process by which saccharine matter in solution is obtained. A glance at Stein's analysis of the two will show this:—

	Barley.	Malt.
Soluble albuminous compounds	1·258	1·985
Insoluble ,, ,,	10·928	9·771
Husk	19·854	18·817
Dextrin	6·500	8·232
Fatty matter	3·556	3·379
Inorganic matter	2·421	2·291
Extractive matter	0·896	4·654
Starch	54·282	50·871
Loss	·305	...
	100·000	100·000

The following is the composition of barley and malt, as given by Oudemans:—

	Barley.	Malt.		
	Air-dried.	Air-dried.	Kiln-dried Pale.	Kiln-dried Amber.
Produce of torrification	0·0	0·0	7·8	14·0
Dextrin	5·6	8·0	6·6	10·2
Starch	67·0	58·5	58·5	47·6
Sugar	0·0	0·5	0·7	0·9
Cellulose	9·6	14·4	10·8	11·5
Albuminous substances	12·1	13·6	10·5	10·5
Fatty ,,	2·6	2·2	2·4	2·6
Ash, &c.,	3·1	3·2	2·7	2·7
	100·0	100·0	100·0	100·0

Albuminous compounds in barley and malt (Oudemans)—