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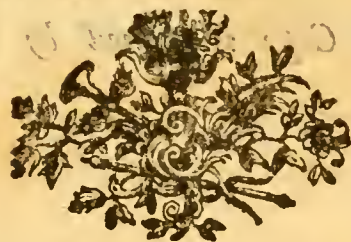




T H E
THEORY and *PRACTICE*
O F
B R E W I N G,

By MICHAEL COMBRUNE, BREWER.

Printed with Permission of the MASTER, WARDENS, and Court of
ASSISTANTS of the Worshipful Company of BREWERS.



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1817

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B R E W I N G

OF THE THREE DOWNERS

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BOOKS

OF THE

THE ONLY AUTHENTIC COPY
OF THE THREE DOWNERS
BY
BREWING

1817

T O

DOCTOR PETER SHAW

PHYSICIAN to his MAJESTY,

Fellow of the Royal COLLEGE of PHYSICIANS of LONDON,
and of the ROYAL SOCIETY.

S I R,

THE brewing of malt liquors has hitherto been conducted by such vague traditional maxims, that an attempt to establish it's practice on truer and more fixed principles, must, like every new essay, be attended with difficulties.

Your works, Sir, will be lasting monuments, not only of your great abilities, but also of your zeal for the improvement

ment of the arts, manufactures and commerce of your country. You will therefore permit me to place, under your patronage, this treatise, which, if it can boast no other merit, has that, of having been undertaken and finished by your advice and council.

Some favor, I hope, will be shewn for this distant endeavour, to imitate the laudable example you have set, and whatever be the success, I shall ever glory in the opportunity it has given me, of professing myself publicly,

S I R,

Your most obedient,

and most obliged humble Servant,

Hampstead, Middlesex,
December 15, 1761.

MICHAEL COMBRUNE.

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T H E

P R E F A C E.

THE difference that appears in the several processes of brewing, though executed with the same materials, by the same persons, and to the same intent, is generally acknowledged. The uneasiness this must occasion to those, who are charged with the directive part of the business, cannot be small: and, the more desirous they are of well executing the charge incumbent on them, the greater is their disappointment, when frustrated in their hopes. To remove this uncertainty, no method seems preferable to that of experiment, as it is that alone, which can establish this, and any other art, upon a solid foundation. But those, who have the courage, and grudge neither time nor expence, to multiply and to vary their trials, too often acquire the name of idle refiners, and, what is worse, too frequently deserve it. The operations of nature elude superficial enquiries. Where we have few or no principles for our guides, many experiments are made, which tend only to confound or deceive. Effects seen, without a sufficient knowledge of their causes, must often be neglected or viewed in an improper light; those that are remembered are seldom faithfully reported, and, for want of distinguishing the several circumstances that attend them, become the support of old prejudices, or the foundation of new ones.

Whoever is attentive to the practical part of brewing will soon be convinced, that heat, or fire, is the principal agent therein, as this

The P R E F A C E.

element used in a greater or less degree, and differently applied, is the occasion of the greatest part of the variety we perceive. 'Tis but a few years since the thermometer has been found to be an instrument sufficiently accurate for any purposes, where the measure of heat is required. And as it is the only one, with which we are enabled to examine the processes of brewing, and to account for the difference in the effects, a theory of the art founded on practice must be of later date than it.

So long since as the year 1741, I began this enquiry, and never neglected any opportunity to consult the artists of the trade, or to try such experiments as I conceived might be conducive to my purpose. It is needless, perhaps shameful, to mention their number, or to speak of the many disappointments I met with in this pursuit. At last, flattering myself with having collected the true theory, assisted and encouraged by men of abilities, I thought it fit the publick should judge whether I had succeeded in my endeavours, and in 1758 the Essay on brewing was submitted to them, either for their approbation, or that the errors therein might be pointed out. I have had no reason to repent of my temerity, since the novelty, more perhaps than the merit of this performance, has engaged the attention, I may add, the favor of some good judges. They have allowed my principles to be, at least, plausible, and their agreement with practice has since repeatedly convinced me, that they could not be far from truth.

The Essay just mentioned, revised and corrected, naturally forms the first part or theory of the present treatise. The second part is intirely practical. After giving a short idea of the whole process, I

resume its different branches in as many chapters, and endeavour to lead the practitioner by the hand, so that he may, in every part, at all times, and under a variety of circumstances, know what he is to do, and never be disappointed in his object. As hops are much more unstable in their prices than many other commodities, a rule is attempted to direct the purchasing of them. Tables shewing the lengths of all sorts of beers and ales, to be made at all the different prices expected, and the profits accruing therefrom are, for the same reasons, exhibited. Previous to any brewing, I show how to ascertain numerically the proper heat for every mash, the means to obtain such a heat, and lastly, the true quantities of water necessary for this end. Waste of fuel or of labour will, by this means, be prevented. I examine how long worts are to boil, the heat they are to arrive at in order to ferment, what quantity of yeast is necessary to forward this operation, and by what rules the artist may be enabled to brew, in coppers of any dimensions, as soon as the gauges thereof are delivered to him, every kind of malt liquor, and especially pale ales or amber, where the art may be said to be carried to its greatest height.

As much damage ensues from cellars not being attended to, a method of determining the proper stocks for them cannot be thought useless. Beers may incidentally be liable to diseases, either by neglect, by being used too soon, or by being too long kept, and there are few houses, dealing in porter, that do not experience how dearly they pay for the remedies applicable to such cases. As the servants to whom they apply for that purpose, are no ways acquainted with the proportions of the constituent parts of beers, or with the effects

resulting therefrom, it has been thought a duty to disclose this little science, that the persons concerned may relieve themselves, and to ingredients, often inefficacious, sometimes hurtful, substitute such as are wholesome, and at the same time the most conducive to their purpose.

To prevent errors is a means of rendering remedies useless, at least less expensive. As the principal view and intent of this work is to pursue the methods of obtaining fine and pellucid beers, and of brewing them so, that the whole of the fermentable parts of the malt may be extracted and the liquor become fit for use at the desired season, the expence of isinglass used for brown beers must be greatly lessened, and the train of nostrums so generally applied by coopers in great measure avoided; the beer will be possessed of all the strength it is susceptible of, the expence of over large stocks become needless, and the weight of what in the brewery is termed an hospital, by this means, removed.

In so extensive a branch of business, some benefit must accrue to the publick, from its being carried on in a just and uniform manner, and our malt liquors will better deserve the name of wine.

Boerhaave, Shaw, Macquer, and most of the great masters in chemistry are far from limiting that name to the liquors produced from the juice of the grape; they extend it to all fermented vegetable juices, which, on distillation, yield an ardent spirit, and look on the strength and faculty wine has to cherish nature, and preserve itself, to be in proportion to the quantity it possesses of this liquid generally termed spirit of wine. This, when thoroughly pure and dephlegmated, is one and the same, whatever different

vege-

The P R E F A C E.

vegetable it is produced from. Barley wines possess the same spirituous principle, which is the preservative part of the most valuable foreign wines, with a power of being brewed superior or inferior to them in quality, and the other constituent parts of beer; beside the ardent spirit just mentioned, will not, I believe, be esteemed less wholesome, than those which make up the whole of grape wine.

The reasons why Great-Britain hath not hitherto furnished foreign nations with this part of her product, but more especially her seamen, are obvious. Our mariners, when at home, do not dislike beer, either as to their palates or its effects on their constitution; but, when abroad, spirituous liquors, or new wines, often the product of an enemy's country, are substituted in lieu thereof. It is a principal duty in all commanders of ships to maintain their people in health, at the easiest expence. The disuse of beers, on these occasions, has been owing to the uncertainty of the principles by which they were brewed; the maintaining them sound, in long voyages and in hot climates, could not be sufficiently depended upon; and it was also supposed that they could not be procured at so easy a rate as wines, brandies, or rums are purchased abroad. The first of these objections the author hopes, by this work, to remove; and, were all the duties to be allowed on what would be brewed for this purpose, our seamen might be furnished with beer stronger than Spanish wine, and at a less expence, the mean prices of malt and hops being taken for seven years. It is true that, in times of peace, the seamen in his Majesty's service are not very numerous, but the number of those then employed by the merchants is very considerable. I should not have presumed to mention
this,

this, but because of the encouragement that is given to the exportation of corn and to the use of sails of British manufacture. It is computed that, in England and Wales, are brewed three millions five hundred thousand quarters of malt yearly, for which purpose upwards of one hundred and fifteen thousand weight of hops are used. The scheme here proposed might become a means of encreasing the consumption of the growth of our country, viz. of barley, to more than one hundred thousand quarters, and of hops to between fourteen and fifteen thousand weight annually.

Whether this be an object deserving the attention of the legislative power, or of the landed interest, and what might be the proper means to put it successfully in practice, are considerations which do not belong to this place; it being sufficient here to point out, how universally beneficial it is to establish the art of brewing on true and invariable principles.

This being the first attempt, that has been made, to reduce this art to rules and principles, the Author hopes he has a just claim to the indulgence of the public, for any errors he unwillingly may have adopted, and far from believing that there is no room left for future improvements, he recommends it to those, who, blessed with superior talents and more leisure than himself, may be inclined to try their skill in the same field, to follow closely the steps of NATURE, and not to expect ever to overtake her.

A Copy of DOCTOR SHAW'S Letter, on perusing the ESSAY beforementioned.

DEAR SIR,

I have, with pleasure and improvement, read over your manuscript; and shou'd be glad to see some other trades as justly reduced to rules as you have done that of brewing: which would not only be making a right application of philosophical knowledge, but, at the same time, accommodate human life, in many respects, wherein it is still deficient. Perhaps your example may excite some able men, to give us their respective trades, in the form of so many arts. For my own part, having long wished to see some attempts of this kind, for the good of society in general, I cannot but be particularly pleased with the nature, design, and execution of your Essay, and am,

DEAR SIR,

Your obliged Friend,

Pall-Mall, July 20,
1758.

and humble Servant,

PETER SHAW.

INTRODUCTION.

AN enquiry into the antiquity of the art of brewing would certainly be a curious, but, I fear, a very usefess research. In all probability, the inhabitants of the northern countries, soon after they settled there, found out a method of obtaining a liquor from grain, fimilar to wine, and indeed the mention of beers, or barley-wines, by some historians, who treat of the colder parts of the globe, where grapes will not ripen, seems to put this matter beyond doubt. However we have no reason to believe that they arrived at any great degree of perfection in their art; for though the brewer's company at *London* were incorporated in the year 1427, and a company of the same nature was established in *France*, many years before, yet it is certain, there was no good beer, either in *France*, or even in *England*, till much later.

The business of brewing formerly was, and now generally is, in the hands of men unacquainted with chemistry, and not conscious that their art has any relation to that science, though it is in reality a considerable branch of it. For want of a due knowledge of the elements and instruments necessary in brewing, and from never once imagining, that

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there

I N T R O D U C T I O N .

there were certain fixed and invariable principles, on which they ought to proceed, the advances the brewers made in their art could not but be slow.

In the reign of queen Elizabeth, malt began to be better made, and hops to be used ; by the addition of these, the liquor was capable of being longer kept, and acquired the advantage of being meliorated by time. The superiority of these two vegetables, over all others, for the purposes of brewing, being known and ascertained, the legislative power prohibited the use of any thing else in the composition of beer. This law was certainly of the greatest utility; by it, all sophistication was prevented, and our beers became the best in *Europe*. But still a great difference, in point of excellency, was observed in the same, but chiefly in different, places ; this was in a great measure owing to a want of principles and rules to direct the artists, according to the variations of the malt in point of dryness, or of the seasons of the year in that of heat. The same fault still subsists, the Thermometer not being more generally used, an instrument, which, as it is now brought to perfection, for the ascertaining the value of the degrees of heat, is the only one which the brewer can with certainty govern himself by.

The designs of all brewers are ; 1. To extract the fermentable parts of the malt, in the most perfect manner. 2. To add hops in such proportion, as experience teaches them will preserve and meliorate the beer. And, 3. To employ such a proportion of yeast, as is sufficient to obtain a complete fermentation.

Perhaps

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Perhaps it will be said, that these three particulars are already sufficiently understood, and that it would be a much more useful work, to publish remedies for the imperfections or diseases, that beer is naturally or accidentally subject to, and which at present are deemed incurable, such as cloudiness, &c. But if the three designs, above laid down, be executed according to the rules of chemistry, such remedies will not be wanted; for beer brewed upon true principles is, neither naturally nor accidentally, subject to cloudiness, nor to many other disorders often perceived in it. Hence it is evident, that some knowledge of chemistry is absolutely necessary to complete the brewer, as, without the informations acquired from that science, he must be unqualified to lay down rules for his practice, and to secure to himself the favor of the publick.

From true principles such a method of brewing in winter, may be deduced, that the beer shall be fit for use, at any limited period of time, and in summer, the process be carried on with more success than it generally is. I do not mean to insinuate that brewing can be better executed in summer than in winter; but only that, if necessity requires it, the operation may be performed, to a sufficient degree of perfection, and much longer than is usual, in the first of these seasons.

Before we proceed, it may be necessary, or at least convenient, to explain some few terms, and to trace the properties of fire, air and water, as far as they relate to brewing. I have not scrupled to make use of all the assistance I possibly could obtain, from the authors,


I N T R O D U C T I O N.

who have treated of these subjects; and whenever I dissent from them, it is because, to my apprehension, nature evidently does so too. The reader is likewise desired to observe, that this Essay is not designed to inform the learned in chemistry, nor do I pretend to exhaust these subjects, but only to say as much of them as is necessary for a brewer to know.





A N
E X P L A N A T I O N
O F T H E
T E C H N I C A L T E R M S.

 S the principal object of this treatise is to be useful to those concerned in the practical part of brewing, to save them the labour of any farther enquiry, it has been thought advisable to avoid, as much as possible, the terms of art, and to prefix an explanation of those that necessarily occur.

ACIDS are all those things, which taste sour, as vinegar, juice of lemons, spirit of nitre, spirit of salt, &c. and are put in a violent agitation, by being mixed with certain earths, or the ashes of vegetables. An acid enters, more or less, into the composition of all plants, and is produced by, or rather is the last effect of, fermentation. Mixed in a due proportion with an alkali, it constitutes a neutral salt, that is, a salt, wherein neither
the

An EXPLANATION

the acid nor alkali prevail. Acids are frequently termed acid salts, though generally they appear under a fluid form.

ALKALIES, or alkaline salts, are of a nature directly contrary to the acids, and generally manifest themselves by effervescing therewith: they have an urinous taste, and are produced from the ashes of vegetables, and by several other means. They, as well as testaceous and calcareous substances, are frequently made use of by coopers to absorb the acid parts of stale beer, and this they call *softning*.

AIR is a thin elastic fluid, surrounding the globe of the earth; it is absolutely necessary to the preservation, both of animal and vegetable life.

ALCOHOL is the pure spirit of wine, without the least particle of water or phlegm.

ANIMALS are organized bodies, endued with sensation and life. Minerals are said to grow and increase, plants to grow and live, but animals only to have sensation. Animal substances cannot ferment so as to produce by themselves a vinous liquor; but there may be cases, wherein some of their parts rather help than retard the act of fermentation.

ATMOSPHERE is that vast collection of air, with which the earth is surrounded to a considerable height.

ATTRACTION is an indefinite term, applicable to all actions whereby bodies tend towards one another, whether by
virtue

virtue of their weight, magnetism, electricity, or any other power. It is not therefore the cause determining some bodies to approach one another, that is expressed by the word attraction, but the effect itself. The space, through which this power extends, is called the *sphere of attraction*.

BLACKING is a technical term used by coopers, to denote sugar that is calcined, until it obtains the colour that occasions the name. From its acidity it is thought to be of some help to cloudy beers, and from its colour is in part a means of hiding the defect.

BREWING is the operation of preparing beers and ales from malt.

BOILING may thus be accounted for. The minute particles of fuel, being by fire detached from each other, and becoming themselves fire, pass through the pores of the vessel, and mix with the fluid. These, being perpetually in an active state, communicate their motion to the water: hence arises, at first, a small intestine motion, and from a continued action in the first cause, the effect is increased, and the motion of the liquor continually accelerated; by degrees, it becomes sensibly agitated, but the particles of the fire, acting chiefly on the particles, that compose the lowest surface of the water, give them an impulse upwards, by rendering them specifically lighter, so as to determine them to ascend according to the laws of equilibrium. Hence there is a constant flux of water from the bottom to the top of the vessel, and reciprocally from the
top.

An EXPLANATION

top to the bottom. This appears to be the reason why water is hot at the top sooner than at the bottom, and why an equal heat cannot be distributed through the whole. The thermometer therefore can be of little service, to determine immediately the degree of heat, especially in large vessels, on which account it is better for brewers to heat a certain quantity just to the act of boiling, and to temper it, by adding a sufficient quantity of cold water. Boiling water is incapable of receiving any increase of heat, though acted on by ever so great a fire, unless the atmosphere becomes heavier, or the vapours of the water be confined. It occasions the mercury to rise, according to Fahrenheit's scale, to 212 degrees.

CLEANSING is the act of removing the beer from the tun, where it was first fermented, into the casks.

CLOUDY is an epithet joined to such beers, as, from the violent heat which has been given to the water, with which they were brewed, are loaded with more oils, than can be attenuated by fermentation, and incorporated with the water. A muddy and grey oil is seen floating on the surface of the beer, though the body of the liquor is often transparent; this oil is frequently collected in great quantity, and exceeds the power of any known menstruum.

COHESION is that action, by which the particles of the same body adhere together, as if they were but one.

COLD is a relative term in opposition to heat. Its greatest degree is not known, and it is supposed that the colder a body is, the less is the agitation of its internal parts.

COLOUR

COLOUR; A greater or less degree of heat causes different colours in most bodies, and from a due observation of the colour of malt, we may determine what degree of heat it has been impressed with.

DENSITY expresses the closeness, compactness, or near approach of the parts of a body to one another: the more a body weighs in proportion to its bulk, the greater is its density. Gold is the densest body in nature, because there is none known of the same bulk, which weighs so much.

EARTH, is that fossil matter or element, whereof our globe partly consists.

EBULLITION is the boiling or bubbling of water, or any other liquor, when the fire has forced itself a passage through it. Brewers suppose water to be just beginning to boil, when they perceive a small portion of it forced from the bottom upwards in a right line, so as to disturb the surface: when the liquor is in this state, they call it, *through*, or upon the point of ebullition. The vulgar notion that the water is hotter at this term than when it boils, is without any foundation.

EFFERVESCENCE is a sudden agitation, arising in certain bodies upon mixing them together; this agitation most commonly generates heat.

ELASTICITY, or springiness, is that property of bodies, by which they restore themselves to their former figure, after any pressure or distension.

B

EXPANSION,

EXPANSION is the swelling or encrease of the bulk of bodies, from heat, or any other cause.

EXTRACT consists of the parts of a body separated from the rest, by cold or hot water, and, upon the evaporation of the fluid, remaining in the vessel.

FERMENTATION is a sensible internal motion of the particles of a mixture: by the continuance of this motion, the particles are gradually removed from their former situation, and, after some visible separation, joined together again in a different order and arrangement, so as to constitute a new compound. No liquors are capable of inebriating, except those that have been fermented.

FIXED BODIES are those, which, consisting of grosser parts, cohering by a strong attraction, and by that means less susceptible of agitation, can, neither be separated nor raised, without a strong heat, or perhaps not without fermentation.

FIRE is only known by its properties, of which the chief are to penetrate and dilate all solid and fluid bodies.

FREEZING POINT is the degree of cold, at which water begins to be formed into ice, which according to Farenheit's scale is expressed by 32.

FOXED is a technical term, used by brewers, to indicate beers in a putrid state.

GUMS,

GUMS are concreted vegetable juices, which transfuse thro' the bark of certain trees and harden upon the surface, they easily dissolve in water, and by that means distinguish themselves from balsams or resins.

HERMETICALLY SEALED is a particular way of stopping the mouth of vessels, so close, that the most subtil spirit cannot fly out, which is done by heating the neck of the bottles, till it is just ready to melt, and then with a pair of hot pinchers by twisting it close together.

HOMOGENEOUS is an appellation given to such parts or subjects, which are similar or of the same nature and properties.

ISINGLASS is a preparation from a fish called huso, somewhat bigger than the sturgeon; a solution of which in stale beer is used, to fine or precipitate other beers: it is imported from *Russia* by the *Dutch*, and from them to us.

LIGHT consists of particles of matter inconceivably small, capable of exciting in us the sensation of colours, by being reflected from every point of the surface of luminous bodies; but, notwithstanding they are so exceeding small, Sir Isaac Newton has found means to divide a single ray into seven distinct parts, viz. red, orange, yellow, green, blue, indigo, and violet.

MALT, in general, is any sort of grain, first germinated, and then dried: that generally used is made of barley, which experience has found to be the fittest for this purpose.

MEDIUM is that space, through which a body in motion passes: air is the medium, through which the bodies near the earth move; water is the medium wherein fishes live, and glass affords a medium or a free passage to light.

This term is also made use of, to express the mean of two numbers, and sometimes the middle between several quantities.

MUSTS are the unfermented juices of grapes, or of any other vegetable substances.

MENSTRUUM is any fluid, which is capable of interposing its parts between those of other bodies, and in this manner either dissolves them perfectly, or extracts some part of them.

OIL is an unctuous, inflammable substance, drawn from several animal and vegetable substances.

PRECIPITATION. If glass dissolved becomes a glutinous and heavy body; this put into malt liquors intended to be fined carries down, by its weight, all those swimming particles, which prevent its transparency; and this act is called fining, or precipitation.

RESINS, or balsams, are the oils of vegetables inspissated and combined with a proportion of the acid salts; as well as they mix with any spirituous liquor, as little are they soluble in water, but they become so, either by the intervention of gums or soaps, or by the attenuating virtue of fermentation.

Of the TECHNICAL TERMS

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SALTS are substances sharp and pungent, which readily dissolve in water, and from thence, by evaporation, crystallise and appear in a solid form. They easily unite together, and form different compounds. Thus salts, composed of acids and alkalies, partake of both, and are called neutral.

SETT: a grist of malt is by brewers said to be sett, when, instead of separating for extraction, it runs in clods, increases in heat, and coagulates. The cause of this accident is the over quantity of fire in the water applied to the first extraction. The air included in the grist, which is a principal agent in extraction, being thereby expelled, the mass remains inert, and its parts, adhering too closely together, are with difficulty separated. Though an immediate application of more cold water to the grist is the only remedy, yet in general, as the cohesion is speedy and strong, it seldom takes effect. New malts, which have not yet lost the heat they received from the kiln, are most apt to lead the brewer into this error.

SUGAR or saccharine salts, are properly those, that come from the sugar canes; many plants, fruits and grains give sweet juices reducible to the same form, and supposed to be acids smoothed over with oils; all vegetable sweets are capable of fermenting spontaneously when crude; if boiled, they require an addition of yeast to make them perform that act. Malt, or its extracts, have all the properties of saccharine salts.

SULPHUR.

SULPHUR. Though by sulphur is commonly understood the mineral substance called brimstone, yet in chemistry it is frequently used to signify in general any oily substance, inflammable by fire, and, without some saline addition, indissoluble in water.

SOAP OR SAPONACEOUS JUICES. Common soap is made of oil mixed with alkaline salts: this mixture causes a froth on being agitated in water. The oils of vegetables are, in some degree, mixed with their salts; and, according to the nature of these salts, appear either resinous or saponaceous, that is, soluble or indissoluble in water. Sugar is a kind of soap, rendering oil miscible with water; and therefore all the bodies, from which saccharine salts may be extracted, are truly saponaceous.

VEGETABLE is a term applied to plants, considered as capable of growth, having vessels and parts for this purpose, but generally supposed to have no sensation.

VINEGAR is an acid penetrating liquor, prepared from wine, beer, cyder, or a must, which has been fermented as far as it was capable.

VITRIOL is, in general, a metalline substance combined with the strongest acid salt known. This acid, being separated from the metal, differs in nothing from that which is extracted from alum, and from brimstone. It is improperly called spirit of vitriol,
when

when diluted with water, and, with as little propriety, oil, when free from it. This is commonly used in the brewery, in order to precipitate or fine brown beers, that are stubborn or nearly cloudy. Twelve ounces of this oil is a quantity many times put into a single butt of beer, though the use thereof had much better be wholly banished from the trade.

VOLATILE BODIES are those, which, either from their smallness or their form, do not cohere very strongly together, and being most susceptible of those agitations, which keep liquors in a fluid state, are most easily separated and rarified into vapour, with a gentle heat, and on the contrary condensed and brought down with cold.

WINE is a brisk, agreeable, spirituous, fluid cordial, drawn from fermented vegetable bodies. In this sense beers and ales may be called, and really are, barley wines.

WORTS are the unfermented extracts of malt.

YEAST is both the flowers and lees of a fermented wort, the former of these being elastic air enveloped in a subject less strong and less consistent than the latter.





PRINCIPLES

OF THE

THEORY of BREWING.



SECTION I.

Of FIRE.

ALTHOUGH fire is the chief cause, and principle of almost every change in bodies; and though persons untaught in chemistry imagine, that they understand its nature, yet certain it is, that there is nothing more incomprehensible, or that eludes so much our nicest research. The senses are very inadequate judges of it; the eye may be deceived and suppose no fire, in a bar of iron, because it does not appear red, though at the same time it may contain enough to generate pain: the touch is equally unfaithful, for a body containing numberless particles of heat, will feel cold, if it is much more so than ourselves.

The great and fundamental difference among philofophers, in refpect to the nature of fire, is, whether it be originally fuch, formed by the Creator himfelf at the beginning of things; or whether it be mechanically producible in bodies, by fome alteration produced in the particles thereof. It is certain, that heat may be generated in any body by attrition; but whether it exifted there before, or was caufed immediately by the motion, is a matter of no great import to the art of brewing; for the effects, with which we are alone concerned, are the fame.

Fire expands all bodies, both folid and fluid. If an iron rod, juft capable of paffing through a ring of the fame metal, is heated red-hot, it will be encreafed in length, and fo much fwelled as not to be able to pafs through the ring, as before *: if a fluid is put into a bellied glafs, with a long flender neck, and properly marked, the fluid, by being heated, will manifefly rife to a confiderable height.

The expansion of fluids, by heat, is different, in different fluids; with fome exceptions, it may be faid to be in proportion to their density. Pure rain water, gradually heated to ebullition, is expanded one 84th part of its bulk, fo that 85 gallons of

* There is a very fingular exception in regard to iron itfelf in this refpect. It is only a certain degree of heat that expands this metal; (and that much lefs than any other either more or lefs denfe;) when melted, it

occupies a lefs fpace than when in a folid form. This ought to caution us againft general rules, by which nature appears by no means to be bound. See *Mem. de l'Acad. des Scienc.* p. 273.

boiling

boiling water will, when cold, measure no more than 84; and 85 gallons of boiling wort will not yield so much, because worts contain many oily particles, which, though less dense than water, have the property of being more expansible: hence we see the reason why a copper, containing a given number of barrels of boiling wort, will not produce the same number of barrels of beer when cold.

Bodies are weakened or loosened in their texture by fire: the hardest, by an increased degree of heat, will liquify and run; and vegetables are resolved and separated by it into their constituent parts. It must be owned that vegetables seem at first, on being exposed to the fire, to become rigid or stiff; but this is owing to the evaporation of the aqueous particles, which prevented a closer adhesion of the solid matter. It is only in this manner that fire strengthens some bodies that were before weak.

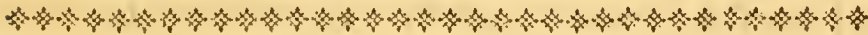
That the texture of bodies should be loosened by fire, seems a consequence of expansion; for a body cannot be expanded but by its particles receding farther from one another; and if these be not able to regain the situation they had when cold, the body will remain looser in its texture, than before it suffered the action of fire. This is the case of barley when malted.

Fire may be conveyed through most bodies, as air, water, ashes, sand, &c. The effect seems to be different according to the different conveyances. A difference appears between boiling and roasting, yet they answer the same purpose, that

of preserving the subject; and this, in proportion to the degree of heat it has suffered. Malts, the more they are dried, the longer are they capable of maintaining themselves in a sound state, and the liquor brewed with them will, in proportion to their dryness, keep the longer sound. The hotter the water is applied to malt, provided its heat doth not exceed the highest extracting degree, the more durable and sounder will the extract be.


The last consideration of fire or heat, that relates to brewing, is the knowledge of its different degrees, and how to regulate them. Till of late, chemists, and all others, were much to seek in this respect; they distinguished more or less fire in a very vague and indeterminate manner, as the first, second, third, and fourth degree of heat, meaning no precise heat, or heat measured by any standard; but, by the invention of the thermometer, we are enabled to regulate our fires with the utmost precision. Thermometers are formed on different scales; and therefore when any degree of heat is mentioned, in order to avoid confusion, the scale made use of should be indicated. I have constantly used Fahrenheit's, as it is the most perfect and the most generally received. According to this instrument, 32 degrees is the freezing point, or where water first begins to harden into ice; from 32 to 90 degrees are the limits of vegetation, according to the different plants that receive those or the intermediate heats. The 40th degree is marked by Boerhaave as the first fermentable heat, and the 80th as the last: 47 degrees I have found to be generally the
 medium

medium heat of London throughout the year in the shade; 98 degrees is said to be that of our bodies when in health, as from 105 to 112 are its degrees when in a fever. At 175 degrees the purest and highest-rectified spirits of wine boil, and at this degree I have found well grown malts to charr, at 212 degrees water boils, at 600 degrees quicksilver and oil of vitriol. Gold, silver, iron, and most other metals in fusion exceed this heat; greater still than any of these is the heat in the focus of the burning lens of Tschirnhausen, or of the concave mirror made by Vilette; they are said to volatilise metals and vitrify bricks. Thus far experiments have reached; but how much more, or how much less, the power of this element extends, will probably be for ever unknown.



SECTION II.

Of AIR.

 ONE of the operations, either of nature or art, can be carried on without the action or assistance of air. It is a principal agent in fermentation; and therefore brewers ought to be well acquainted at least with its principal properties and powers.

By air we mean a fluid, scarcely perceptible to our senses, and discovering itself only by the resistance it makes to bodies. We find it every where incumbent on the surface of the globe,
rising

The THEORY of BREWING.

rising to a considerable height, and commonly known by the name of atmosphere. The weight of air is to that of water as 1 to 850, and its gravitating force equal to that of a column of water of 33 feet high; so that an area of one foot square receives, from air, a pressure equal to 2080 pounds weight.

Elasticity is a property belonging to only one of the four elements, namely, air, and it varies in proportion to the compressing weights. We scarcely find this element, (any more than the others,) in a pure state: one thousandth part of common air, says Boerhaave, consists of aqueous, spirituous, oily, saline, and other particles scattered through it. These are not, or but little compressible, and in general prevent fermentation: consequently where the air is purest, fermentation is best carried on. The same author suspects, that the ultimate particles of air cohere together, so as not easily to insinuate themselves into the smallest pores, either of solids or fluids. Hence those acquainted with brewing easily account, why very hot water, which forces strong and pinguious particles from malt, forms at the same time extracts unfavourable for fermentation, as oils are an obstruction to the free entrance of air; and from an analogous reason, why in weak extracts fermentation is so much accelerated, that the whole soon becomes sour.

Air, like other bodies, is expanded and rarified by heat, and exerts its elasticity in proportion to the number of degrees of fire it has received; the hotter therefore the season is, the more active and violent will the fermentation be.

Air

Air abounds with water, and is perpetually penetrating and insinuating itself into every thing capable of receiving it. Its weight, or gravitating force, must necessarily produce numberless effects. The water contained in the air is rendered more active by its motion; hence the saline, gummous and saponaceous particles it meets with are loosened in their texture, and, in some degree, dissolved. As principles like these are the chief constituent parts of malt, the reason is obvious why those that are old, or have lain a proper time exposed to the influence of the air, dissolve more readily, or, in other words, yield a more copious extract than others.

All bodies in a passive state, remaining a sufficient time in the same place, become of the same degree of heat with the air itself. On this account the water, lying in the backs used by brewers, is nearly of the same degree of heat as the thermometer shews the open air in the shade to be. When this instrument indicates a cold below the freezing point, or 32 degrees, if the water does not then become ice, the reason is, because it has not been exposed long enough to be thoroughly affected by such a cold. For water does not immediately assume the same degree of temperature with the air, principally on account of its density, also from its being pumped out of deep and hot wells, from its being kept in motion, and from many other incidents. Under these circumstances, no great error can arise to estimate its heat equal to 33 degrees.

Air

Air is not easily expelled from bodies, either solid or fluid. Water requires two hours boiling to be discharged of the greatest part of its air. That it may be thus expelled by heat appears from this; water, if boiled the space abovementioned, instead of having any air bubbles when it is froze, as ice commonly has, becomes a solid mass like crystal.

As air joined to water contributes so powerfully to render that fluid more active, that water which has endured fire the least time, provided it be hot enough, will make the strongest extracts.

Worts or masts, as they contain great quantities of salts and oils, require a greater degree of heat to make them boil: consequently more air is expelled from boiling worts, than from boiling water in the same time; and as air doth not instantaneously re-enter those bodies, when cold, they would never ferment of themselves. Were it not for the substitute of yeast, to supply the deficiency of air lost by boiling, they would fox or putrify, for want of that internal elastic air, which is absolutely necessary to fermentation.

Though there is air in every fluid, it differs in quantity in different fluids; so that no rule can be laid down for the quantity of air, which worts should contain. Probably the quantity, sufficient to saturate one sort, will not be an adequate proportion for another.


Air in this manner encompasses, is in contact with, confines, and compresses all bodies. It insinuates itself into their penetrable passages, exerts all its power either on solids, or fluids, and finding in bodies some elements to which it has a tendency, unites with them. By its weight and perpetual motion, it strongly agitates those parts of the bodies in which it is contained, rubs, and intermixes them intimately together. By disuniting some, and joining others, it produces very singular effects, not easily accomplished by any other means. That this element has such surprising powers is evident from the following experiment. “ Fermentable parts duly prepared and disposed in the vacuum of Mr. Boyle’s air-pump will not ferment, though acted upon by a proper heat; but, discharging their air, remain unchanged.





S E C T I O N III.

Of WATER.


 A S water is perpetually an object of our senses, and made use of for most of the purposes of life, it might be imagined that the nature of this element was perfectly understood: but they who have enquired into it with the greatest care, find it very difficult to form a right notion of it. One reason of this difficulty is, that water is not easily separated from other bodies, or other bodies from water. Hartshorn, by being long dried, resists a file more than iron; yet, on distillation it yields much water. I have already observed, that air is intimately mixed, with, and possibly never intirely separated from it, but in a *vacuum*; how is it possible then ever to obtain water perfectly pure?

In its most perfect state, we understand it to be a liquor very fluid, inodorous, insipid, pellucid, and colourless, which, in a certain degree of cold, freezes into a brittle, hard, glassy ice.

Lightness is reckoned a perfection in water, that, which weighs less being in general the purest. Hence the great difficulty of determining the standard weight it should have. Fountain, river, or well waters, by their admixture with saline, earthy, sulphureous, and vitriolic substances, are rendered much heavier

heavier than in their natural state; on the other hand an increase of heat, or an addition of air, by varying the expansion, diminishes the weight of water. A pint of rain-water, supposed to be the purest, is said to weigh 15 ounces, 1 drachm, and 50 grains; but for the reasons just now mentioned, this must differ in proportion as the seasons of the year do from each other.

Another property of water, which it has in common with other liquors, is its fluidity, which is so great that a very small degree of heat, above the freezing point, makes it evaporate. Few brewers, I believe, have examined how great a proportion of the quantity of water, used in brewing, is lost by evaporation. The purer it is, the more readily it evaporates. Sea-water, which is supposed to contain one fortieth part of salt, more forcibly resists the power of fire, and wastes much less, than that which is pure. Notwithstanding this, as fire ultimately divides most, if not all, bodies, and separates the dense parts from the rare, a strong continued ebullition may be a means of freeing, in some measure, the must from impurities, if any such were in the water.

The ultimate particles of this element, Boerhaave believed to be much less than those of air, as water passes through the pores and interstices of wood, which never transmit the least elastic air; nor is there, says he, any known fluid, (fire excepted, which forces itself through every subject,) whose parts are more penetrating than those of water. Yet as water is not

an universal diffolver, there are vessels which will contain it, though they will let pass even the thick fyrup of sugar, for sugar makes its way by dissolving the tenacious and oily substance of the wood; which water cannot do.

Water, when fully saturated by fire, is said to boil, and by the impulse of that element, comes under a strong ebullition. Just before this violent agitation takes place, I have already observed, that it occupies one eighty fifth more space than when cold: so that a brewer who would be exact, when he intends to reduce his liquor to a certain degree of heat, must allow for this expansion, abating therefrom the quantity of steam exhaled.

As water, by boiling, may be said to be filled or saturated with as much fire as it can contain, so may it be with any other substance capable of being dissolved in it. But though it will dissolve only a given quantity of any particular substance, it may at the same time take in a certain proportion of some other. Four ounces of pure rain water will melt but one ounce of common salt, and after taking this as the utmost of its quantity, it will still receive two scruples of another kind of salt, viz. nitre. In the same manner the strongest extract of malt is still capable of receiving the properties belonging to the hops: but in a limited proportion. This appears from the thin bitter pellicle, that often swims on the surface of the first wort of brown beers, which commonly are overcharged with hops, by putting the whole quantity of them at first therein; the water not being capable of suspending all that the heat dissolves, it

no sooner cools but these parts rise on the top. This may serve as a hint to prevent this error, by suffering the first wort to have no more hops boiled therein than what it can sustain; and as this must be different in proportion to the heat of the extracts and quantity of water used, two or three experiments are necessary to indicate the due proportion for the several sorts of drink. This however should always be extended to the utmost; for the first wort, from its nature and constituent parts, stands most in need of the preservative quality imparted by the hops.

Water acts very differently, as a menstruum, according to the quantity of fire it contains: consequently its heat is a point of the utmost importance with regard to brewing, and must be properly varied according to the dryness and nature of the malt; as it is applied either in the first or last mashes, and in proportion also to the time the beer is intended to be kept. These ends can, in my opinion, be obtained to a degree of numerical certitude.

Nutrition cannot be carried on without water, though likely water itself is not the matter of nourishment, but only the vehicle.

Water is as necessary to fermentation as heat or air. The farmer, who stacks his hay or corn before it is thoroughly dried, soon experiences the terrible effects of too much moisture, or water, residing therein: all vegetables therefore intended to be long kept, ought to be well dried. The brewer should carefully

fully avoid purchasing hops that are slack bagged, or kept in a moist place, or malt that has been sprinkled with water soon after it was taken from the kiln. By means of the moisture, a fermentation begins, which, for want of a sufficient quantity of air, is soon stopped; but the heat thereby generated remaining, every seed begins to grow, and forms a moss which dies, and leaves a putrid musty taste behind, always prevailing, more or less, in beer made from such grain.

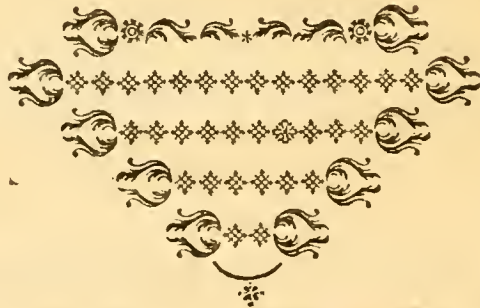
That water is by no means an universal solvent, as some people have believed, has been already observed. It certainly does not act as such on metals, gems, stones, and many other substances: it is not in itself capable of dissolving oils, but is miscible with highly rectified spirits of wine, or alcohol, which is the purest vegetable oil in nature. All saponaceous bodies, whether artificial or natural, fixed or volatile, readily melt therein; and as many parts of the malt are dissoluble in it, they must either be, or become by heat, of the nature of soap, that is, equally miscible with oils and water.

When a saponaceous substance is dissolved in water, it lathers, froths, and bears a head; hence, in extracts of malt, we find these signs in the underback. Weak and slack liquors, which contain the salts of the malt without a sufficient quantity of the oils, yield no froth, and generally let part of the grist fall undissolved in a whitish flour. Somewhat like this happens, when the water for the extract is over-heated, for then as more oils are extracted than are sufficient to ballance the salts, the extract
comes

comes down as before, with little or no froth or head, but without depositing any flour in the underback. Should the heat of the water be increased beyond this last mentioned degree, so as to impede the action of the air necessary to extract with, that error would take place which is termed by brewers *setting the goods*: instead of a good extract, the whole runs into inseparable clods or lumps, from whence the grist is seldom or never recovered.

This might be a proper place to observe the difference between rain, spring, river, and pond waters; but as the art of brewing is very little affected by the difference of waters, if they be equally soft, but rather depends on the due regulation of heat, and as soft waters are found in most places where brewing is necessary, it is evident, that any sort of beer or ale may be brewed with equal success, where malt and hops can be procured proper for the respective purposes. If hitherto prejudices and interest have appropriated to some places a reputation for particular sort of drinks, it has arose from hence: the principles of the art being totally unknown, the event depended on experience only, and lucky combinations were more frequent where the greatest practice was. Thus for want of knowing the true reason of the different properties observed in the several drinks, the cause of their excellencies or defects was ignorantly attributed to the water made use of, and the inhabitants of particular places soon found an advantage, in availing themselves of this local reputation. But just and true principles, followed by as just a practice, must render

render the art more universal, and add dignity to the profession, by establishing the merit of our barley wines on knowledge, not on prejudice. This truth would appear in a stronger light, were I to extend the observations farther on this element; but as the subject of water has been fully treated of by Boerhaave, Shaw, and Hales, it would be tedious to add any thing more upon it.



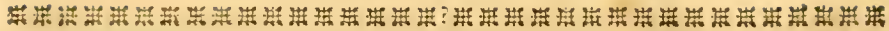


S E C T I O N IV.

Of EARTH.

REGULARITY requires that some notice should be taken of this element. The great writer on chemistry, so often mentioned, defines it to be a simple, hard, friable, fossil body, fixed in the fire, but not melting in it, nor dissoluble in water, air, alcohol or oil. These are the characters of pure earth, which, no more than any of the other elements, comes within our reach, free from admixture. Though it is one of the component parts of all vegetables, yet as designedly it is never made use of in brewing, except sometimes for the purpose of precipitation, it is unnecessary to say any thing more upon it: whoever desires to be farther informed concerning its properties may consult all, or any of the authors before-mentioned.





SECTION V.

Of the THERMOMETER.

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 HIS instrument is designed for measuring the increase or decrease of heat. By doing it numerically, it fixes in our minds the quantity of fire, which any body is at any time impregnated with. If different bodies are brought together, though each possesses a different degree of heat, it teaches us to discover what degree of heat they will arrive at when thoroughly mixed, supposing effervescence to produce no alteration in their heat.

The inventor of this admirable instrument is not certainly known, though the merit of the discovery has been ascribed to several great men, of different nations, in order to do them, and their countries honour. It came to us from Italy, about the beginning of the sixteenth century. The first inventors were far from bringing this instrument to its present degree of perfection. As it was not then hermetically sealed, the contained fluid was, at the same time, influenced by the weight of the air, and by the expansion of heat. The academy of Florence added this improvement to their thermometers, which soon made them more generally received; but as the highest degree of heat of the instrument, constructed by the Florentine gentlemen, was fixed by the action of the strongest rays of the sun in their country, this vague determination, varying in almost every place, and the want of a fixed and universal scale, rendered all the observations, made with such thermometers, of little use to us.

Boyle

Boyle, Halley, Newton, and several other great men thought this instrument highly worthy of their attention. They endeavoured to fix two invariable points, to reckon from, and by means of these, to establish a proper division. Monsieur Amontons is said to have first made use of the degree of boiling water, for graduating his mercurial thermometers. Fahrenheit indeed found, that the pressure of the air in its greatest latitude, would cause a variation of six degrees in that point, he therefore concluded, that a thermometer made at the time when the air is in its middle state, might be sufficiently exact for almost every purpose. Long before this degree of heat, viz. that of boiling water was perfectly settled, many means were proposed to determine another. The degree of temperature in a deep cave or cellar, where no external air could reach, was imagined by many, a proper one; but what that degree truly was, and whether it was fixed and universal, was found too difficult to be determined. At last the freezing point of water was thought of, and though some doubts arose with Dr. Halley, and others, whether water constantly froze at the same degree of cold, Dr. Martine has since, by several experiments, proved this to be beyond all doubt, and this degree is now received for as fixed a point, as that of boiling water.

These two degrees being thus determined, the next business was the division of the intermediate space on some scale, that could be generally received. Though there seemed to be no difficulty in this, philosophers of different countries have not been uniform in their determinations, and that which is used

in the thermometer now the most common, and in other respects the most perfect, is far from being the simplest.

The liquid wherewith thermometers were to be filled, became the object of another enquiry. Sir Isaac Newton employed, for this purpose, linseed oil: but this being an unctuous body, is apt to adhere to the sides of the glass, and when suddenly affected by cold, for want of the parts which thus stick to the sides, does not shew the true degree.

Tinged water was employed by others; but this freezing, when Fahrenheit's thermometer points 32 degrees, and boiling, when it rises to 212, was, from thence, incapable of denoting any more intense cold or heat.

Spirit of wine, which endures much cold without stagnating, was next made use of; but this liquor being susceptible of no greater degree of heat, than that, which in Fahrenheit's scale is expressed by 175, was not capable of being used, where boiling water was concerned.

At last the properest fluid, to answer every purpose, was found to be mercury. This has never been known to freeze*, and will not boil under a heat of 600 degrees; besides, it is free from every inconveniency attending other liquors.

As the instrument is entirely founded on this, that heat or fire expands all bodies, as cold condenses them, there was a necessity of employing a fluid easy to be dilated. A

* I ate'y indeed by such intense cold, mates, mercury is said to have been as can only be procured with the stagnated or fixed. greatest art, and in the coldest cli- quan-

quantity of it is seated in one part or reservoir. This being expanded by heat, is pushed forward into a fine tube, or capillary cylinder, so small, that the motion of the fluid in it is speedy and perceptible. Some thermometers have been constructed with their reservoir composed of a larger cylinder : now they are generally made globular. The smaller the bulb is, the sooner it is heated through, and the finer and smaller the tube is, the greater will be the length of it, and the more distinct the degrees. It is scarcely possible that any glass cylinder, so very small, should be perfectly regular ; the quicksilver, during the expansion, passing through some parts of the tube wider than others, the degrees will be shorter in the first case, and longer in the latter. If the divisions therefore are made equal between the boiling and freezing points, a thermometer consisting of such a tube cannot be true. To rectify this inconveniency, the ingenious Mr. Bird of London, puts into the tube about the length of an inch of mercury ; and measuring, with a pair of compasses, the exact length of this body of quicksilver in one place, he moves it from one end to the other, carefully observing, in the several places, how much it increases or diminishes in length, and thereby ascertains where, and how much, the degrees are to be varied. By this contrivance his thermometers are perfectly accurate, and exceed all that were ever made before.

I shall not trouble my reader with the number of calculations that have been made, to express the quantity of particles

cles of the liquor contained in the bulb, in order to determine how much it is dilated: this Dr. Martine seems to think a more curious than useful enquiry. It is sufficient for our purpose to know, how the best thermometers ought to be constructed: they who have leisure and inclination, may be agreeably entertained by the author last cited.

By observing the rise of the mercury in the thermometer, during any given time, as, for instance, during the time of the day, we ascertain the degree and value of the heat of every part of the day, and may hereafter nearly fix the medium of the whole time. By repeated experiments, it appears, that the medium heat of any day is usually indicated at eight o'clock in the morning, if the instrument is placed in the shade, in a northern situation, and out of the reach of any accidental heat.

Though water is not so readily affected as air by heat and cold, yet as all bodies, that are long exposed in the same place, become of the same degree of heat with the air itself, no great error can arise from estimating water, in general, to be of the same heat as the air, at eight o'clock in the morning, in the shade.

The thermometer teaches us, that the heat of boiling water is equal to 212 degrees, and by calculation we may know what quantity of cold water is necessary to bring it to any degree we choose; so that though the instrument cannot be used in large vessels, where the water is heating,
yet

yet, by the power of numbers, the heat may be ascertained with the greatest accuracy. The rule is this: multiply 212, the heat of boiling water, by the number of barrels of water thus heated, (suppose 22) and the number of barrels of cold water to be added to the former, (suppose 10,) by the heat of the air at eight o'clock, (suppose 50,) add these two products together, and divide by the sum of the barrels, the quotient shews the degree of heat of the water, mixed together.

212 heat of boiling water	50 deg. heat of air at 8.
22 barrel to be made to boil	10 barrels of cold water
<hr style="width: 50px; margin-left: 0;"/>	<hr style="width: 50px; margin-left: 0;"/>
424	500
424	
<hr style="width: 50px; margin-left: 0;"/>	
22 4664	
10 500	
<hr style="width: 50px; margin-left: 0;"/>	
sum 32) 5164 (161 + $\frac{1}{3}$ degrees, will be the heat of the water,	
of barrels 32 when mixed together.	
<hr style="width: 50px; margin-left: 0;"/>	
196	
192	
<hr style="width: 50px; margin-left: 0;"/>	
44	
32	
<hr style="width: 50px; margin-left: 0;"/>	
12	

The calculation may be extended to three or more bodies, provided they be brought to the same denomination. Suppose 32 barrels of water to be used where there is a grift

grift of 20 quarters of malt, if these 20 quarters of malt are of a volume or bulk equal to 11 barrels of water, and the malt by having lain exposed to the air, is of the same degree of heat with the air, in order to know the heat of the mash, the calculation must be thus continued.

$$\begin{array}{r}
 161\frac{1}{7} \quad 161\frac{1}{7} \text{ heat of water} \quad 50 \text{ degrees of heat of malt.} \\
 \quad \quad \quad 32 \text{ barrels of water} \quad 11 \text{ barrels, volume of malt.} \\
 \hline
 \quad \quad \quad 333 \quad \quad \quad 550 \\
 \quad \quad \quad 483 \\
 \hline
 32 \text{ water} \quad 5163 \\
 11 \text{ malt} \quad \quad 550 \\
 \hline
 43 \quad) \quad 5713 \quad (\quad 132 \text{ degrees, which will be the heat of} \\
 \quad \quad \quad 43 \quad \quad \quad \text{the mash.} \\
 \hline
 \quad \quad \quad 141 \\
 \quad \quad \quad 129 \\
 \hline
 \quad \quad \quad 123 \\
 \quad \quad \quad 86 \\
 \hline
 \quad \quad \quad 37
 \end{array}$$

We shall meet hereafter with some incidents, which occasion a difference in the calculation, but it will be time enough to mention them in the practical part.

The thermometer by shewing the different degrees of heat of each part of the year, informs us at the same time, how necessary it is, that the extracts of small beer should carry

vary in proportion to such heats, as also what quantity of hops ought to be used at different times; how much yeast is requisite, at each stated season, to carry on a due fermentation; and what variation is to be made in the length of time, that worts ought to boil. Indeed without this knowledge, beers, though brewed in their due season, cannot be regularly fermented, and whenever they prove good, so often may it be said, that fortune was on the brewer's side.

Beers are deposited in cellars, to prevent their being affected by the variations of heat and cold in the external air. By means of the thermometer, may be determined the heat of these cellars, the temper the liquor is to be kept in, and whether it will sooner or later come forward.

The brewing season, and the reason why such a season is fittest for brewing, can only be discovered by this instrument. It points out likewise our chance for success, sometimes in the hottest months.

As all vegetable fermentation is carried on in heats, between some settled points, we are, by this instrument, taught to put our worts together at such a temperature, that they shall neither be evaporated by too great a heat, nor retarded by too much cold.

If curiosity should lead us so far, we might likewise determine, by it, the particular strength of each wort, or of every mash; for if water boils at 212 degrees, oil at 600,
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and worts be a composition of water, oil and salt, the more the heat of a boiling wort exceeds that of boiling water, the more oils and salts must it contain, or the stronger is the wort.

A given quantity of hops, boiled in a given quantity of water, must have a similar effect, consequently the intrinsic value of this vegetable may, in the same manner, be ascertained.

The more the malts are dried, the more do they alter in color, from a white to a light yellow, next to an amber, farther on to a brown, until at last the color becomes speckled with black; in which state we frequently see it. If more fire or heat is continued, the grain will at last charr, and become intirely black. By observing the degrees of heat necessary to produce these alterations, we may, by the mere inspection of the malt, know with what degree of fire it has been dried; and fixing upon that which best suits our purpose direct, with the greatest accuracy, the heat of the first mash, a thing of the utmost consequence to the right management of the process of brewing.

If I had not already said enough to convince the brewer of the utility of this instrument, how curious he ought to be in the choice, and how well acquainted with the use of it, I would tell him, that the heat gained by the effervescing of malt is to be determined by it alone; that the
heat


heat lost by mashing, by the water in its passage from the copper to the tun, or by the extract coming down into the underback, can be found by no other means; and above all, that there is no other way to know with certainty the heat of every extraction.

I know very well, that good beer was made before the thermometer was known, and still is, by many, who are entirely ignorant of it; but this, if not wholly the effect of chance, cannot be said to be very distant from it. They who carry on this process, unassisted by principles and the use of the thermometer, cannot but confess, that they are frequently unsuccessful, whereas did they carefully and with knowledge apply this instrument, they certainly never would be disappointed. It is equally true, that the brewing art has, for a long space of time, been governed by tradition alone, and this but ill conveyed; if lucky combinations have, sometimes flattered the best practitioners, faulty drinks have as often made them feel the want of certain and well established principles. It is just as absurd for a brewer to refuse the use of the thermometer, as it would be for an architect to throw away his rule, as unserviceable, because the first house, probably, was built without one.



SECTION VI.

Of the VINE, *its* FRUITS *and* JUICES.

T is now time to consider more distinctly the object we have in view, and the properest means to attain it.

Any fermented liquor, that in distillation yields an inflammable spirit miscible with water, may be called wine, whatever vegetable matter it is produced from. Now as beer and ales contain a spirit exactly answerable to this definition, brewing may justly be called the art of making wines from corn. Those indeed, which are the produce of the grape, have a particular claim to that name, either because they are probably the most ancient and the most universal, or that a great part of their previous preparation is owing to the care of nature itself. By observing the agents she employs, and the circumstances under which she acts, we shall find ourselves enabled to follow her steps, and to imitate her operations.

Most grapes contain juices, which, when fermented, become in time as light and pellucid as water, and are possessed of fine spirituous parts sufficient to cherish, comfort, and even inebriate. But these properties of vinosity are not
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observed equally in the fruits of all vines; some of them are found less, others not at all proper for this purpose. It is therefore necessary to examine some circumstances attending the formation and ripening of those grapes, whose juices produce the finest liquors of that kind.

All grapes, when they first bud forth, are austere and sour. Whether this is the effect of the autumnal remaining sap, or of the new raised vernal one, is neither very easy nor very material to determine. This however plainly appears, that the juice, in that state, consists of little else than an acid combined with a tasteless water. When the fruit is ripe, it becomes full of a rich, sweet, and highly flavoured juice. The color, consistency, and saccharine taste of that juice show, that, by the power of heat, a considerable quantity of oil has been raised, and that the originally acid salts are now so changed as to possess the properties of those, which are called saponaceous, or lixivial.

In England, grapes are probably produced under the least heat they can be raised by. They discover themselves in their first shape, about June, when the medium between the heat of the sun's beams, and that of the night, is from 58 to 60 degrees in Fahrenheit's thermometer. This therefore is the degree of heat, by which the acid salts are produced or introduced into the grape.

The highest degrees of heat, in the countries, where grapes come to perfect maturity, have been observed to be
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in various parts of Italy, Spain and Greece 100, and at Montpellier 88, in the shade, to which, according to Dr. Lining's observations, 20 degrees must be added for the effect of the sun's beams. The greatest heat then in Italy will amount to 120 degrees, and in the south of France to 108. These approach nearly to the heats ever observed in the hottest climates, which in Afracan, Syria, Senegal, and Carolina were from 124 to 126.

Those countries, where the heat is the greatest, produce in general the richest fruits, that is the most impregnated with sweet, thick and oily juices. We are told that, among the Tokay wine-hills, that one which directly fronts the south, and is the most exposed to the sun, produces the sweetest and richest grapes. It is called the *sugar-hill*, and the delicious wines extracted from this particular spot, are all deposited in the cellars of the Imperial family. Those grapes, as well as some in the Canaries, and in other places, which, by being suffered to remain the longest on the tree, with their stems half cut through, have their juices highly concentrated, produce that species of sweet oily and balmy wines, which, from that operation, are called *sack*, from the French word *sec* or *dry*.

In all distillations, water and acid salts rise first. A more considerable degree of fire is required for the elevation of oils, and a still greater one for that of those lixivial salts, which render those oils miscible with water. Nature puts
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this process before our eyes, in the formation and maturation of grapes, and it is by the imitation of what she does, that the inhabitants of different countries improve the advantages both of their soil and of their air.

In order to illustrate the doctrine, that grapes are endued with various properties, in proportion to the heat of the air, which they have been exposed to, let us remember what Boerhaave has observed, that in very hot weather, the oleous corpuscles of the earth are carried up into the air, and descending again, render the showers and dews in summer very different from the pure snow in winter. The first are acrid and disposed to froth, the last is transparent and insipid. Hence summer rain, or rain falling in hot weather, is always fruitful, whereas that in cold weather is scarcely so at all. In winter the air abounds with acid parts, neither smoothed by oils or rarefied by heat, cold being the condensing power, as heat is the opener of nature. In summer, the air dilating itself, penetrates every where, and gives to the rain a disposition to froth, occasioned by the admixture of oleous and aerial particles. Thus the acid salts, previously existing in the grapes, and necessary to their preservation, are neutralized by heat, covered or blended with oil, and changed by both in a saccharine form. Now in proportion as these acids are more or less sharp, and counterbalanced by a greater or lesser quantity of oils, the juices of the grapes approach more or less to the state of perfection, which fermentation requires.

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There are indeed many places, as Jamaica, Barbadoes, &c. where neither the lowest or highest degree of heat, proper for the production of grapes, is observed, and in which the vines cannot be cultivated with advantage. By comparing the heat of those places with that in Italy and Montpellier, it appears, that this defect is not owing to the excessive heats of these countries, but to their constancy and uniformity; the temperature of the air never being so low as the degree necessary for the first production of the fruit. Whenever the cultivation of the vine is attempted in these countries, the grapes on their first appearance are shaded and screened from the beams of the sun, which, in their infancy, they are not able to bear.

Hence we learn, that nature employs lesser heats to form than to ripen the juices of this fruit, or to bestow on them a power of maintaining themselves, for some time, in a sound state. We have investigated the lowest degrees of heat, in which grapes are produced, and nearly the highest they ever receive to ripen them. Let us call the first the *germinating* degrees, and the last those of *maturation*. If 50 or 60 be the lowest of the one, and 124 or 126 the highest of the other, and if a certain power of acids is necessary for the germination of the grapes, which must be counterbalanced by an equal power of oils raised by the heat of the sun for their maturation, then the medium of these two numbers, or 92, may be said to be a degree, at which this fruit cannot possibly be produced, and inferior to that by
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which it is maturated. At Panama the lowest degree of heat is 72, to which 20 being added, for the sun's beams, the sum will be 92, and consequently no grapes can grow there, except the vines be placed in the shade.

If we recollect that we can scarcely make wine, which will preserve itself, of grapes produced in England, we shall be induced to think, that the reason of this defect is the want of the high degrees of heat. Our sun seldom raises the thermometer to 100 degrees, and that but for a short continuance. Our medium heat is far inferior to 92, and hence we see, at several distant terms in summer, new germinated grapes, but seldom any perfectly ripe. These observations, the use of which in brewing will hereafter appear, likewise point out to us, what part of our plantations are fit to produce this fruit, and to what degree of perfection.

A perfect fermentation is the aim of the wine-maker, and this cannot be obtained, but with juices, whose parts may be intimately blended and united, that is according to our definition, that are perfectly saponaceous. Wines, that have that quality, will ferment of themselves, become spontaneously bright and pellucid, and keep sound a due time. The wines of France, Spain and the Madeiras possess more or less of these properties, in proportion to the heats, which the grapes of these countries sustain in their several stages of growth, and some wines, which come from

the East-Indies can scarcely ever be made transparent by art, nature having being too lavish of its heat, at the time of their first formation.

The nature of the soil proper for the vine might, in another work, be a very useful enquiry. It will be sufficient here barely to hint at the effect, which lixivial soils produce in musts. The Portugueze, when they discovered the Island of Madeira in 1420, set fire to the forests, with which it was totally covered. It continued to burn for the space of seven years, after which the land was found extremely fruitful, and yielding such wines, as, still at present, we have from thence, in greater plenty. It is very difficult to fine these wines, and, though the climate of this island is more temperate than that of the Canaries, the wines are obliged to be carried to the Indies and the warmer parts of the globe, to be purged, shook, and attenuated, before they can arrive to an equal degree of fineness with other wines; though, were the Portugueze acquainted with what may be termed the artificial method of exciting periodical fermentation, much or the whole of this trouble might be avoided. Hence we see, that soils impregnated with alkaline salts will produce musts able to support themselves longer, and to resist acidity more, than other soils, under the same degree of heat.

Grapes have the same constituent parts as other vegetables. The difference between them, as to their tastes and properties,

properties, consists, in the parts being mixed in different proportions. This arises, either from their absorbent vessels more readily attracting some juices than others, or from their preparing them otherwise, under different heats and in different soils.

We find, says Dr. Hales, by the chemical analysis of vegetables, that their substance is composed of sulphur, volatile salts, water, and earth, which principles are endued with mutual attracting powers. There enters likewise in the composition a large portion of air, which has a wonderful property of attracting in a fixed, or of repelling in an elastic, state, with a power superior to vast compressing forces. It is by the infinite combinations, actions and reactions of these principles, that all the operations in animal and vegetable bodies are effected.

Boerhaave, who is somewhat more particular with regard to the constituent parts of vegetables, says, that they contain an oil mixed with a salt in form of a sapo, and that a saponaceous juice arises from the mixture of water with the former.

We have seen, from the nature of the composition of the grapes, that they have all the necessary principles to form a sapo. They abound with elastic air, water, oils, acid and neutral salts, and even lixivial and saponaceous juices. The air contained in the interstices of fluids is more

in quantity than is commonly apprehended, for Sir Isaac Newton has proved that water has forty times more pores than solid parts; and the proportion is likely not very different in vegetable juices. But their viscidty prevents the expansion of this inclosed air, and being enveloped by the covering of the fruit, it lies inactive, till it is moved by some foreign cause. In this forced state, it causes no visible motion, nor are the principles, thus confined, either subjected to any apparent impressions of the external atmosphere, or so intimately mixed as when the juices of the fruit are expressed. But as a perfect mixture of these principles is necessary for the formation of a sapo, it is clear, that a free communication of the external air with that contained in the interstices of the liquor is required for that purpose. By what means this is effected, what alterations it produces, or in general, in what manner the juices of the grapes become wine, must be the subject of our next enquiry.

The process of a perfect fermentation is undoubtedly the same, (where the due proportions of the constituent part, forming the must are exactly kept,) whatever vegetable juices it is excited in. For this reason, we will observe the progress of this act in beers and ales, these being subjects we are more accustomed to, and where the characters are most distinct, in order to apply what may be learned from thence to our chief object, the business of the brewer.



S E C T I O N VII.

Of F E R M E N T A T I O N in general.

F E R M E N T A T I O N is that act, by which oils, and earth, naturally tenacious, are brought to such a degree of fluidity, as to be equally suspended in an homogeneous, pellucid fluid; which, by a due proportion of the different principles, is preserved from precipitation and evaporation. According to Boerhaave, a less heat than forty degrees leaves the mass in an inert state, and the particles fall to the bottom in proportion to their gravity; a greater heat than eighty degrees disperses them too much, and leaves the residuum a rancid, acrimonious, putrid mass.

It is certainly very difficult, if not totally impossible, to discover the true and adequate cause of fermentation. But, by tracing its several stages, circumstances and effects, we may perhaps find out the agents and means employed by nature to produce this singular change; a degree of knowledge, which, if not sufficient to satisfy philosophical curiosity, may be so to answer our practical purposes.

The must, when just pressed from the grapes, is a liquid composed of neutral and lixivial salts, oils of different spissitude, water, earth, and elastic air. These are irregularly ranged, and if I may be permitted the expression, compose a chaos of wine. Soon after the liquor is settled, a number of air bubbles arise,
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and at first adhere to the sides of the containing vessel: their magnitude encreases as they augment in number, till at last they cover the whole surface of the must.

It has been long suspected, and if I mistake not, demonstrated, that an acid, of which all others are but so many different species, is universally dispersed through, and continually circulating in the air; and that this is one of nature's principal agents in maturing and resolving of bodies. Musts, like other bodies, being porous, the circulating acids very powerfully introduce themselves therein by the pressure of the atmosphere, in proportion as the pores are more or less expanded by the heat they are exposed to. The particles of acids are supposed by Newton to be endued with a great attractive force, in which their activity consists. By this force, they rush towards other bodies, put the fluid in motion, excite heat, and violently separate some particles in such manner as to generate or expel air, and consequently bubbles.

From hence it appears that, as soon as the acid particles of the air are admitted into the must, they act on the oils, and excite a motion somewhat like the effervescence generated, when acids and oils come in contact, though in a less degree. This motion is the cause of a heat, by which the included elastic air, being rarefied, occasions the bubbles to ascend towards the surface. These, by the power of attraction, are drawn to the sides of the vessel; at first they are small and few, but increase, both in number and magnitude,

tude, as the effect of the air encreases, till, at last, they spread over the whole surface. The first stage then of vegetable fermentation shews itself to be the motion, by which part of the elastic air is freed from the must. It may, perhaps, be proper to observe, that all musts, which ferment spontaneously, contain for this purpose a large proportion of elastic air.

Bubbles still continue to rise after the must is entirely covered with them; and a body of bladders is formed, called by the brewers, the *head of the drink*; which, by retaining the internal heat excited by motion, accelerates the fermentation. As the number of bubbles encrease, the head rises in height, but the oils of the must being as yet of different spissitudes, such which are least tenacious emit their air soon than the others, and their aerial bubbles, being more strongly rarefied by the fermenting heat, rise on the surface higher than the rest. From hence, and from the constituent parts of the must not being intimately mixed, the head takes an uneven and irregular shape, and appears like a beautiful piece of rock work: After this, it requires some time, and it is by degrees, that the particles dispose themselves in their due order, which, when effected, the interposition of the water keeps not only the saline, oily and spirituous parts, but also the mucilaginous and earthy ones, within their respective sphere of attraction. The head becomes more level, heterogenous bodies, as dirt, straw, corks, &c. are now buoyed on the surface, and should be skimmed

med of, left, when the liquor becomes more light and spirituous, they should subside. As the heat increases, and the air bubbles grow larger, some, not formed of parts so strong as the others, which generally are the first, burst and strengthen the rest; the internal heat is hereby better retained in the fermenting liquor, and fermentation carried on to a farther degree. The particles of the must become more pungent and spirituous, because more fine and more active; some of the most volatile ones fly off; hence, that subtle and dangerous vapor, called *Gas*, which extinguishes flame and suffocates animals. Those bubbles, which were formed of oils more tenacious than the rest, and are rendered more dense by their admixture with earth, though they strongly envelope much elastic air, subside by their weight, and form the lees. The wine, by these several acts, being more and more attenuated, is at last unable to support, on its surface, the weight of such a quantity of froth, rendered more dense by the repeated explosions of the air bubbles. At this period, lest the liquor should be fouled by the falling in of the froth, it is put in vessels having only a small aperture, where it continues to ferment, with a slower and less perceptible motion, even when the bung hole of the cask is stopped. It is sufficient for this, that the communication with the atmosphere be not intirely interrupted. The alteration caused in the liquor, by the pressure of the external air, from the very first of its fermenting, not only occasions the particles of the must, to form themselves in their
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due order, but also, by the weight and action of that element, grinds and reduces them into smaller parts. From hence, they more intimately blend with each other, the wine becomes of an equal and even taste, and if the must was perfectly saponaceous, it will continue to ferment, until, from the constituent parts being disposed and ranged in right lines, a fine and pellucid fluid be produced.

That this operation subsists, even after the liquor becomes fine, is evident; for every fretting is a continuance of fermentation, though often almost imperceptible. Thus, as the component parts of the liquor are continually reduced to a less volume, the oils become more attenuated, and less capable of retaining elastic air. As these frettings are often repeated, it is impossible to determine, by any rule, the exact state in which wine should be, in order to be perfect for use. It would seem however, that the more minutely the parts are reduced, the more their pungency will appear, and the easier their passage be in the human frame. Both wines and beers, when new, possess more elastic air, than when meliorated by age; to be wholesome, they must be possessed of the whole of the fermentable principles. For these reasons, beers and ales, when substituted to wines in common, and more especially when given to the sick, should always be brewed from entire malt: for the last extracts, possessing but the inferior virtues of the grain, have by so much less the power to become light, spirituous and transparent.

Wines never totally remain inactive ; fermentation in some degree continues, and in time the oils, by being greatly attenuated, volatilize, and fly off. In proportion as this circumstance takes place, the latent acids of the liquor show themselves, the wine becomes sour, and in this state is termed vinegar.

It's last stage or termination is, when the remaining active principles, which the vinegar possessed, being evaporated in the air, a pellicle forms itself on the surface of the liquor, and dust and seeds, which always float in the atmosphere, depositing themselves thereon, strengthen this film into a crust, on which grow moss, and many other small plants. These vegetables, together with the air, exhaust the watery parts. No signs of fermentable principles then remain ; but, like the rest of created beings, all the virtues being lost, what is left is a substance resembling common earth.

Upon the whole, then, it appears, that a liquor fit for fermentation ought to be composed of water, acids smoothed over with oils, or saccharine salts, and a certain portion of elastic air ; that the heat of the air the liquor is fermented in, must be in proportion to the density of it's oils ; and lastly that the pores are to be expanded by slow degrees, lest the air, by being admitted too hastily, or too quickly, should cause an effervescence rather than a fermentation, and occasion the whole to become sour. Wines therefore fermented in countries, where the autumn is hot, require their oils to be more
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pinguious, than where the season is cooler. For the same reason, beers are best made, when the air is at forty degrees of heat, or below the first fermentable point, because the brewer can, in that case, put his wort to work, at a heat of his own chusing, which will not be augmented by that of the air; on the contrary, when, by it's internal motion, the heat is increased, it will again be abated and regulated by the cold of the medium.

As the acids are to be blunted by the oils of the must, if the first are conveyed in a greater proportion, the must ought to be charged with a larger quantity of the last. On this account small beer brewed in summer, when the air and acids more easily insinuate themselves into the liquor, ought to be enriched with oils obtained by hotter extracts, and in winter the contrary method must be pursued.

From this history of fermentation, we can with propriety account for the many accidents and varieties, that accompany this act; and a comparative review of some of them may not be unnecessary.

A cold air, closing the pores of the liquor, always retards and sometimes stops fermentation; heat, on the contrary, constantly forwards this act, but, if carried too high, immediately prevents it.

A must loaded with oils, will ferment with more difficulty, than one which abounds with acids; it likewise is longer, be-

fore it becomes perfectly homogeneous and fine, but when once so, will be more lasting.

If the quantities of oil are increased, they will exceed the power, both of the acids naturally contained in the juice, and of those that are absorbed in fermenting; the liquor will therefore require a longer time, before it becomes pellucid, unless assisted by precipitation: and there may be cases, where even precipitation cannot fine it.

These considerations naturally lead us to a general division of wines in three classes, viz. 1. of such, as soon grow fine, and soon become acid, being the growth of cold countries; 2. of those, which, by a due proportion of heat, both when the grapes germinate, and when they come to maturity, form a perfect saponaceous must, and not only preserve themselves, but in due time, become fine; and 3, of such, as having taken their first form under the highest degrees of *germination*, (as I termed them,) are replete with oils, disappoint the cooper, and render the application of menstruums useless, unless in such quantities, as to change the very nature of the wine.

This remarkable difference of different wines appears to me chiefly to arise from the climate; a similar difference may be observed in beers, and it has its origin in the different degrees of heat, the malt has been exposed to both in drying and in extracting.

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This will confirm an observation we have before mentioned, that wines are neither naturally or uniformly perfect, and consequently that they must be subject to many diseases. Sometimes they are vapid and flat, without being sour. This does not so much arise, from their imbibing the air of the atmosphere, as from their fermenting, generating, and casting off too much air of their own. To prevent this accident, they are best preserved in cool cellars, where their active and invigorating principles are kept within due bounds, and not suffered to fly off.

It sometimes falls out, that a must, though overloaded with oils, has still a greater tendency to fermentation than to putrefaction, acids not being wanting, but only enveloped. In this case, time will get the better of the disease. This sometimes happens in wines of the growth of too hot a sun; they soon become faint and sick, but recover by heat and air. The same thing happens frequently in beers extracted with too hot waters or overcharged with hops; these liquors, at a certain period, sicken, smell rancid, and have a disagreeable taste, but, by long standing, they begin to fret, and receiving more acids from the air, recover their former health and taste.

But should the quantity of oils exceed this last proportion, especially in wines formed from corn, the must, instead of fermenting, would putrify, even though, by some means, elastic air has been driven into them. In that case, the over proportion

portion of the oil and its tenacity prevent the entrance of the acids, the must receives no enlivening principle from without, and the air, at first conveyed into it, is enveloped with oils so tenacious as to be incapable of action. Nothing so much accelerates putrefaction as heat, moisture, and a stagnating air; and all substances corrupt, sooner or later, in proportion to the inactivity of the contained air, to the want of a proper vent, and to the closeness of their confinement. This ought to convince us of the truth, deduced by Dr. Hales from many experiments; that there is a great plenty of air incorporated in the substance of vegetables, which, by the action of fermentation, is roused into an elastic state, and is as much instrumental in the production of fermentation, as it is necessary to the life and being of animals.

I would here close this short and imperfect account; but as, in the art of brewing, there is no part so difficult, and at the same time so important to be in some measure understood, as the cause and effects of fermentation; and as the examination of this act, in all the different lights in which it offers itself to our notice, can hardly be thought uninteresting, I beg leave to add some detached thoughts thereon.

We have seen that all vegetable substances possess fermentable principles, though in a diversity of proportions; but that those juices only, whose constituent parts approach to the proportion necessary to the act of fermentation, can be made into wines. I would not, from what has before been said, be under-

understood, as if I thought that vegetables are more or less acid, more or less sulphureous, or in general more or less fermentable, merely from the heat of the climate they grow in. This, though one of the causes of their being so, is by no means the only one; the form and constitution of the plant is another. In very hot climates, we find acid fruits, such as limes, tamarinds, lemons and oranges; the proportions of fermentable principles in these fruits are such, as to render them incapable of making sound wines, though their juices may, in some degree be susceptible of natural fermentation. In those countries, so greatly favoured by the sun, some vines and other fruit trees attract the acids from the air, and possibly from the earth so greedily, that, when the juices are fermented, they soon become sour. On the contrary, in cold climates, we see warm aromatic vegetables grow, such as hops, horse radish, camomile, wormwood, &c. whose principles cannot, without difficulty, and perhaps not perceptibly, be brought to ferment. But these instances must be accounted the extremes on each side; for, in cold, as well as in hot countries, fruits are produced susceptible of a perfect natural fermentation, as apples, some species of which are indued with such austere and aromatic qualities, that their expressed juices ferment spontaneously, until they become pellucid, and are capable of remaining in a sound state many years. From thence it appears, that proper subjects, which will naturally ferment for making wines, may be found in almost every climate. England, says Boerhaave, is on this account remarkably happy: her fruits are capable
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of producing a great variety of wines, equal in goodness to many imported, were not our tastes, perhaps, made subservient to our prejudices.

The effect of the act of fermentation on liquors is so to attenuate the oils, as to cause them to become spirituous, and easily inflammable. When a wine is dispossessed of such oils, which is nearly the case in vinegar, far from possessing a heating or inebriating quality, it refreshes and becomes a remedy against intoxication. The term of fermentation ought, perhaps only, to be applied to that operation, which occasions the expressed juices of vegetables to become wine: but as several acts pass under the same name, it may not be improper here to investigate them.

Vegetation, one of them, is that operation of nature, wherein more air is attracted than repelled. I believe all that hath been said above concerning the juice of grapes, is a convincing proof thereof.

Fermentation is, where the communication of the external and internal air of a must is open, and in a perfect state, when the power of repelling is equal to that of attracting air.

Putrefaction is when, by the power of strong oils, or otherwise, the communication between the external and internal air is cut off, so that the liquor neither attracts the one or repels the other,

other, but, by an intestine motion, the united particles separate and tend to fly off.

Effervescence is when, by the power of attraction, the particles of matter so hastily rush into contact, as to generate a heat which expels the inclosed air; and this more or less, in proportion to the motion excited.





S E C T I O N VIII.

Of ARTIFICIAL FERMENTATION.

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 Y what has been said, it appears, that, though fermentation is brought on by uniform causes, and productive of similar effects, it is subject to many varieties, both in respect to its circumstances and to its perfection. One difference is obvious, and seems to deserve our attention, as it furnishes a useful division between *natural* and *artificial* fermentation. The first rises spontaneously, and requires nothing to answer all the necessary purposes, but the perfection of the fruit, and the advantage of a proper climate. The other, at first sight less perfect, wants the assistance of ferments, or substitutes, without which the act could, either not at all, or very imperfectly, be excited.

There are undoubtedly liquors, which, though they have of themselves a tendency to fermentation, and are naturally brought to it, yet, from some defect in the proportions of their constituent parts, either do not acquire a proper transparency, or cannot maintain themselves in a sound state for a sufficient time. These disadvantages inbred with them can hardly ever be intirely removed; and they get very little or nothing from age. Defective at first, they seldom grow much better, and therefore are really inferior to liquors, which require the assistance of substituted ferments, to become real wines.

wines. In some artificial fermentations, the ferments are so duly administered, and so intimately blended with the liquors, that in the end they approach very near to, and even vie with, the most perfect natural wines. Were I to enter into a more minute detail, it might be shewn, that wines, when transported from a hot climate to a cold one, are often hurt in their progress, and from thence become or remain imperfect, whereas beers may be so brewed, as to be adapted either to a hot or a cold region, not only without any disadvantage, but with a considerable improvement.

Hitherto I have considered grapes as a moist pulpy fruit, sufficient to furnish the quantity of water necessary for extracting the other parts: but the natives of the countries where this fruit abounds, in order to preserve them, as near as possible in the primitive state, after they are gathered, suspend them in barns, or place them in ovens, to dry. Thus, being in great measure, divested of their aqueous particles, these grapes remain almost inactive, without juices sufficient to form wines, unless water be added to them. This element becomes in this case, a substitute, and consequently the liquors produced in this manner may be accounted the *first* class of *artificial* wines.

In all bodies, the various proportions of their constituent parts, produce different effects; hence they remain more or less in a durable state, and tend either to inaction, fermentation, or putrefaction. Now, by a judicious

ous substitution of such parts as shall be wanting, they may be restored to their pristine nature; as may be proved by the observations and experiments communicated to the public by Dr. Pringle. Thus grapes, though dried and exported from their natural climate to another, by the addition of water only, ferment spontaneously, and form wines very near alike to such, as they would have produced before. It may, with confidence, be said, that, when any considerable difference appears, it arises from the injudicious manner, in which the water is administered, from the fruits not being duly macerated, or from want of such heat being conveyed to the water and fruit, as the juices would have had, if they had been expressed out of the grapes when just gathered; often from the whimsical mixture of other bodies therewith, and perhaps too, from the quantity of brandy, which is always put to wines abroad, to prevent their fretting on board a ship. Upon the whole, though, from what just now has been said, some small difference must take place, it rather proves than contradicts the fact, that, a due quantity of water being applied to dry raisins, an extract may be formed, which will be impregnated with all the necessary constituent parts the grapes had in them when ripe upon the vine, and consequently will spontaneously ferment, and make a vinous liquor.

Vegetables, in their original state, are divisible into the pulpous and farinaceous kinds, both possessing the same constituent parts, though in different proportions. If from the farinaceous such parts be taken away as they superabound

perabound in, and others be added, of which they are defective, these vegetables may, by such means, be brought to resemble, in the proportion of their parts, more especially in their musts, the natural wines I have before been treating of: and this being universally acknowledged to be the standard of wines, the nearer any fermented liquor approaches thereto, by its lightness, transparency and taste, the greater must its perfection be.

To enquire which of the pulpous or which of the farinaceous kinds of vegetables are fittest for the purpose of wine-making, would here be an unnecessary digression. Experience, the best guide, hath on the one side, given the preference to the fruit of the vine, and on the other to barley. To make a vinous liquor from barley, having all the properties of that produced from the grape, is a task, which can only be compassed by rendering the wort of these similar to the must of the other.

As malt liquors require the addition of other substitutes, besides water, to become perfect wines, they can only be ranked in the *second* class of *artificial* fermentation. These substitutes are properly called *ferments*, and deserve the closest attention of the brewer.

Ferments, in general, such as yeast, flowers or lees of wine, honey, the expressed juices of ripe fruits, are subjects more or less replete with elastic air, and conveying the same

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to the musts, which stand in need of it. Boerhaave has ranged these, and several others, in different classes, according to their different powers, or rather in proportion to the quantity of air they contain for this purpose.

The juice of the grape, when fermented, forms more lees than the decoction of malt. May we not infer from thence, that in the fruit, the elastic air is both more abundant, and contained in a greater number of stronger, though smaller, vesicles, than it is in the malt? The barley, being first saturated with water, and then dried and parched, has its air in part driven out; for the heat, which performs the operation of malting, much exceeds the limits of fermentation. The expulsion of air from the worts of beers and ales is still farther effected by the long boiling which the extracts of malt undergo. Hence the necessity of replacing the lost elastic air, in order that these extracts may become fermentable. This is effected by means of the yeast, which, consisting of a collection of small bubbles, filled with air, and ready to burst by a sufficient heat, becomes the ferment, which facilitates the change of the wort into a vinous liquor.

The musts of malt generally produce two gallons of yeast from one quarter of the grain, whereas, in the coldest fermentable weather, one gallon of yeast is sufficient to work that quantity of malt. Much elastic air still remains in beer, or wine from corn, after the first act of fermentation is
over,

over, and the liquor is separated from the yeast above mentioned, as it is then neither flat, vapid, or sour. If then we say that malts, by their being dried, and having their extracts boiled, loose one part in three of their air, we shall not perhaps be very far from truth.

As the lost air, just mentioned, is replaced chiefly by means of the yeast, it must be observed that the aerial vesicles of yeast, the lees or flowers of malt liquor, are of a weaker texture, and more equal in size than those of grapes; and consequently that the air in the bubbles is not so much compressed. This probably arises from the oils of the malt being less tenacious than those of the grapes, from their first fermentation being completed in a much shorter time, and from the greater heat in the fermentation which produced the flowers. Their effect is therefore more speedy, inasmuch that, were the air bubbles produced from malt, and applied to a must, equal in number to those produced from the same quantity of the unfermented juice of grapes, their quick explosion could scarcely be termed a fermentation, the spirituous parts would fly off, the liquor soon sicken, and be void of every enlivening principle.

Hops, which have the quality to check the proneness that malts have to ferment, are therefore necessary to beers intended to be kept long; and, on this account also, all artificial fermentations should be carried on in the coolest and slowest manner possible. This shows likewise, that beers,
but

but more especially ales, ought not to be racked from their lees, as it is frequently practised for natural wines, unless, on account of some defect, they are to be blended with fresh worts under a new fermentation.

As all ferments, as well as hops, are liable to be tainted, great care ought to be taken in the choice of them, every imperfection in the ferment being readily communicated to the must. It would not therefore be an improper question to be determined by physicians, whether, in a time of sickness the use of those, which have been made in infected places ought to be permitted, and whether, at all times, a drink fermented in a pure and wholesome air is not preferable to that which is made among fogs, smoke, and nauseous stenches*.

Wines from corn are distinguished by two appellations, viz. those of ale and beer. As each of these liquors has suffered in its character, either from prejudice or want of a sufficient enquiry, it may be proper to levy the objections made against their use, before we enquire into the means of their formation. The most certain sign of the wholesomeness of wines, is transparency and lightness; yet some which are rich, more especially ales, tho' perfectly fine, have been said to be viscid. Transparency ap-

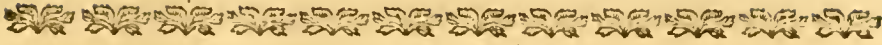
* By Dr. Hales's experiments made for discovering the proportion of air generated from different bodies, it appears that raisin wine, absorbed, in fermenting, a quantity of air equal to nearly one third part of its volume; and ale, under the like circumstances, absorbed one fifth.

pears indeed in many wines, before the oils are attenuated to their highest perfection, as we have before remarked, and some viscosity may therefore be consistent with some degree of pellucidity. Where the powers of the oils and the salts are equal, which is denoted by the brightness of the liquor, viscosity can only arise from the want of age: in this case the fault is not in the defect, but in the misapplication of the liquor, which has been used too soon.

That beers retain igneous or fiery particles, seems equally a mistake. Malts dried to keep have undoubtedly their particles removed by fire, beyond their sphere of attraction: else they would not be in a fit state to preserve themselves sound. For this reason, when they first come in contact with the water, which is to extract them, they cause an effervescent heat, which adds to the extracting power, and should be looked on by the brewer as an auxiliary help; but it is impossible that the malt or the must, should ever inclose and confine the fire employed in their formation. It is of so subtile a nature, that its particles, when contained in a body, continually tend to fly off, and mix with the surrounding air; so that only an equal degree, with what is in the atmosphere, can be continued in the grain, or any liquor whatever; after it has been, for some time, exposed thereto. Brown beers made from malt more dried than any other are, from experience, found to be less heating than liquors brewed from pale malt; which probably arises from hence, that brown beers contain a less quantity of elastic air than pale beers, as pale malt liquors contain less than wines, produced from vege-

tables in their natural state: and as malt liquors contain their elastic air in bubbles of a weaker consistence than those made from the juices of the grape, the effect of beer, when taken in an over-abundant quantity, is neither of so long a continuance, nor so powerful as that of wine, supposing the quality and quantity of each to be equal. This may appear to some persons to be the effect of prejudice, yet it is but a justice due to the produce of my country, to add, that some physicians have given it as their opinion, that strong drinks from malt are less pernicious than those produced from grapes. As far as these gentlemen, I hope I may advance, without being thought guilty of assuming too much, or countenancing debauch, by pointing out the wines that occasion the fewest disorders.





SECTION IX.

Of the NATURE of BARLEY.

BARLEY is a spicated, oblong, ventricose seed, pointed at each end, and marked with a longitudinal furrow. The essential constitution of the parts in all plants, says Dr. Grew, is the same: thus this seed, like all plants which have lobes, is furnished with radical vessels, which having a correspondence with the whole body of the corn, are always ready, when moistened, to administer support to the plume of the embryo, or what is usually called the *acrospire*. These radical vessels, at first, receive their nourishment from a great number of glandules dispersed almost every where in the grain, whose pulpous parts strain and refine this food so as to fit it to enter the capillary vessels; and such an abundant provision is made for this nourishing of the plume, that the same author says, these glandules take up more than nine tenths of the seed.

It is sown about March, sooner or later, according to the soil that is to receive it, and generally housed from ten to twenty weeks time after. Most plants, which so hastily perform the office of vegetation, are remarkable for having their vessels proportionably larger; and that these may be thus formed, the seed must contain a greater quantity of tenacious oils, in proportion, than those seeds, whose vessels being smaller, re-

quire more time to perform their growth, and come to maturity. Barley also, as may be observed, grows and ripens with the lower degrees of natural heat; from whence and from the largeness of the size of its absorbent vessels, it must receive a large portion of acid parts. It is said to be viscid, though at the same time a great cooler, water boiled with it being often drank as such; and however it be prepared, it never heats the body when unfermented.

From these circumstances, of its being viscous and replete with acids, it would at first appear to be a most unfit vegetable, from which vinous liquors, to be long kept, should be made; and indeed the extracts from it in its original state are not only clammy, but soon become sour.

When the grain is at full maturity, its constituent parts seem to be differently disposed, than when in a state of vegetation. By germination alone all its principles are put in action; the fibrous parts possess themselves of a great quantity of tenacious oils, leaving the glandules and finer vessels replete with water, salts and the purest sulphur. If, in this state, the corn is placed in such a situation, that, by heat, the acid and watery parts may be evaporated, the more such heat is suffered to affect it, the more dry, and less acid will the corn become; its parts will be divided, its viscosity removed; its taste become saccharine, by the acids being sheathed or covered over with oils; and these last be rendered more tenacious in proportion to the greater quantity of heat they have received. This process

process regularly carried on is what is termed *malting*, and will hereafter be explained at large.

But before we enter thereon, it is necessary to consider the state of the grain as it comes from the field. When mowed, though upon the whole it may be said to be ripe, yet every individual part, or every corn cannot be so. In some seasons, this inequality is so remarkable, as to be distinguished by the eye. The difference in the situation, the soil, and the weather, the changes of the winds, the shelter some parts of the field have had from such winds, are sufficient to account for this, and indeed a much greater variety. When the greater part of the corn is supposed to have come to maturity, it is cut and stacked; the ripest parts have the least moisture, and the fewest acids; and the greenest abound in both. In this state, the unripe grains of the corn communicate, to such as are more dry, their moisture and acid parts, which coming in contact with their oils, an agitation ensues, more or less gentle, in proportion to the power of the acids and water; and from this arises a heat, the degree whereof can hardly be determined.

When this sweating in the mow is kept within its proper limits, the whole heap of the corn, after the fermentation is over, becomes of one equable dryness, and is not discoloured; but if the grain be put together too wet or too green, the heat occasioned thereby will produce such a violent intestine motion, as to charr and blacken the greatest part thereof, nay often make it burst into actual flame.

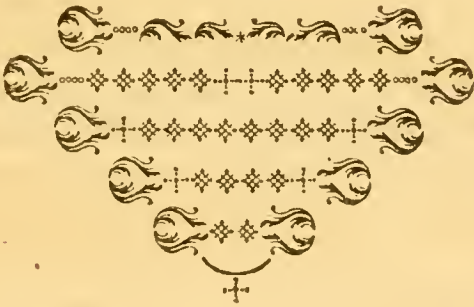
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The effect, which a moderate and gentle ferment has on the corn, is that of driving the oils towards the external parts of its vessels, and skin; by this means, it becomes more capable of preserving itself against the injuries of the weather. The more it is in this state, the backwarder will it be to germinate, when used to this purpose; and if this act is carried too far, as we have before seen, the plume and root of the enclosed embryo must be quite scorched, and the corn become inert and incapable of vegetation. This effect is produced, by a motion sufficient to remove the particles of the grain from each other beyond their sphere of attraction; and the heat, by which this motion is excited, has been found by experience to be at about 120 degrees.

It is likely, that vegetables, in general, are susceptible of a large latitude in this respect, according to their different textures. The degree of heat just now mentioned may, perhaps, be applicable only to barley: the seeds of some grapes endure 124 degrees of heat, and may be capable of being impressed with more, and yet vegetate. But if the oils of the corn become so tenacious as to be discoloured, the seed can scarcely be revived; and this may happen sooner or later, by heat, in proportion to the cohesion and weight of the parts. This is a point properly to be judged of by the color of the grain, and is more immediately the business of the farmer and maltster than that of the brewer.

Thus,


Thus, though it may be disadvantageous to the maltster, to steep grain which has not sweated in the mow, as, from this reason, it will not equally imbibe the water; so barley that is overheated, or *mow burnt*, cannot be fit for his purpose. It is in fact scarcely possible, that any large quantity of barley, from the same stack, should make equally perfect malt, as, on its being put together, the heat generated is always greatest in the center of the rick, and considerably more so there, than in its exterior parts.





SECTION X.

Of MALTING.


 HIS process is intended to furnish proper means, for setting the constituent principles of the grain in motion: so that the oils, which before served to defend the several parts, may be enabled to take their proper stations. This is effected by steeping the barley in water, where it strongly attracts moisture, as all dry bodies do; but it requires some time before the grain is fully saturated therewith. Two or three days, more or less, are necessary, in proportion to the heat of the air: for vegetables receive the water only, by its straining through the outward skin, and absorbent vessels, and their pores are so very fine, that they require this element to be reduced almost to a vapor, before it can gain admittance. Heat hath not only the property of expanding these pores, but perhaps also that of rendering water more fit to make its way into them.

By the water gaining admittance into the corn, a great quantity of air is expelled from it, as appears from the number of bubbles which arise on the surface of the water; yet still much remains therein. A judgment is formed that the corn is fully saturated with water, so as not to be able to imbibe any more of it, from its turgidity, and pulpousness, which occasions

cautions it readily to give way to an iron rod dropped perpendicularly therein. Then is the water let go, or drawn off, the grain taken out of the cistern, and laid in a regular heap. As hay, or any other moist vegetable, when stacked together, grows hot, so doth this heap of barley. The heat, assisted by the moisture, puts in motion the acids, oils, and elastic air remaining in the corn, and these, with united power, force the juices from the glandular parts into the roots, which are thereby disposed to seek and receive nourishment for the embryo or acrospire, and the plume is softened by its proximity to the body of the grain. The root having received some power (before it expands its fibres) by the heated elastic air, presses the oils towards the acrospire. The corn in the heap is however not suffered to acquire too great a degree of heat, and carry on the germination too fast, by which not only the finer but also the coarser oils, would be raised and entangled together, and the malt when made become bitter and ill tasted; it is therefore, at a due temperature, dispersed in beds on the floor of the malt house, and gradually spread thinner and thinner. Care is taken to turn it frequently from time to time, in proportion as it is more or less slow in growth, so that it may come tolerably dry to the kiln, in such a state as its fibrous roots shall be spread, and the spire be near coming through the outward skin of the barley. By these signs the maltster is satisfied, that every part of the grain has been put in motion, and separated. The corn, thus prepared for drying, is, in this lively and active condition, spread on the kiln; where meeting with a heat su-

perior to that requisite for vegetation, its farther growth is stopped: though in all probability, from the gentleness of the first fire it ought to be exposed to, none of the finer vessels are, by this sudden change, rent or torn, but, by drying, only shrivelled up, rendered inactive, and put in a preservative state. Now let it be observed, that those oils which fill the roots, being with them pushed out from the body of the grain, and dried by heat, are lost to any future wort, not being soluble in water; which is likewise true of those parts which are contained in the shoot or plume: so that the internal parts of the malt have remaining in them a greater proportion of salts to the oils than before, and consequently are less viscid, more saccharine, and easier to be extracted.

In this process, the acid parts of the grain, though they are the most ponderous, yet being very attractive of water, become weaker, and, by the continued heat of the kiln, are volatilized and evaporated with the aqueous steam of the malt. Thus, by malting, the grain acquires new properties, and these vary at the different stages of dryness; in the first it resembles the fruits ripened by a weaker sun, and in the last those which are the growth of the hottest climates.

When the whiteness of the barley has not been greatly changed by the heat it has been kept in, it is called pale malt, from its having retained its original color; but when the fire in
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the kiln has been made more vehement, and kept up a longer time, it affects both the oils and the salts of the grain, in proportion both to the degree of the heat, and to the time it has been maintained, and thus occasions a considerable alteration in the color. Actual blackness seldom is, and ought never to be, suffered in malts, but in proportion to the intenseness of the fire they have been exposed to, they nearer and nearer come to that tinge, and from the different brown they show, receive their several denominations.

The condition the barley was gathered in, whether green or ripe, is also clearly discernible when it is malted. If gathered green, it rather loses than gains in quantity; for the stock of oils of unripe corn being small, the whole is spent in germination, the malt becomes of a smaller body, appears shrivelled, and is often unkindly hardened. That, on the contrary, which hath come to full maturity, encreases by malting, and if properly carried through the process, appears plump, bright and clean, and, on being cracked, readily yields the fine mealy parts, so much desired by the brewer.

The malts, when dried to the pitch intended by the maker, are removed from the kiln into a heap. There their heat gradually diminishes, and from the known properties of fire, flies off, and disperses itself in the ambient air, sooner or later as the heap is more or less voluminous, perhaps too in some proportion to the weight of the malt, and as the fire has caused it to be more or less tenacious. Nor can

it be supposed, that any of its parts are capable to retain the fire in such a manner, as not to suffer it to get away. So subtile an element cannot be confined, and much less be kept in a state of inactivity, and imperceptible to our senses. Bars of iron or brass, even of a considerable size, when heated red hot, cool and lose their fire, though their texture is undoubtedly much closer than that of malt or barley. The experiments made by Dr. Martin, on the heating and cooling of several bodies, leave no room to doubt of this fact, I should not be so particular about it, was it not to explain the technical phrase used by brewers, when they say, *malts are full of fire, or want fire*. Hence a prejudice hath by some been conceived against drinks made from brown malts, tho' they have been many months of the kiln, and have no more heat in them, either whole or ground, than the air they are kept in. The truth of the matter is, that in proportion as malts are dried, their particles are more or less separated from one another beyond their sphere of attraction, and coming in contact with another body, such as water, strongly attract from it the uniting particles they want. The more violent this intestine motion is, the greater is the heat just then generated, and no ways durable. An effect somewhat similar to what happens on malt being united with water, must occur on the grain being masticated; and the impression made on the palate most probably gave rise to the technical expression just taken notice of.

The minute circumstances of the process of malting will be more readily conceived from what will hereafter be said. The effects that fire will have, at several degrees, on what from having been barley is now become malt, are most particularly the concern of the brewer; and that they are various, both as to the color and properties of the malt, is certain. A determinate degree of heat produces, on every body, a certain alteration, and hence, as the action of fire is stronger or weaker, the effect will be different from what it would have been in any other degree.

Barlies may, at a medium, be said to lose, by malting, one fourth part of their weight, including what is separated from them by the roots being skreened off: but this proportion varies, according as they are more or less dried.

As the acrospire, and both the outward and inward skins of the grain are not dissoluble in water, the glandular or mealy substance is certainly very inconsiderable in volume and in weight; but as this alone possesses the fermentable principles of the grain, it deserves our utmost attention.

We have before seen, that wines, beers and ales, after the first fermentation, are meliorated through age, by the more refined and gentle agitations they undergo, and which often are not perceptible to our senses. To secure this favorable effect we must form worts capable of maintaining themselves, for some time, in a sound state. This quality, however, if not originally

originally in the malt, is not to be expected in the liquor. Some objections have been raised against this method of arguing, and these aided by prejudices often more powerful than the objections themselves. It is therefore necessary, as malting may be esteemed the foundation of all our future success, to enquire after the best and properest methods of succeeding in this process. Let us, for this purpose, re-assume the consideration of the grain, as it comes from the mow, trace it to the kiln, and observe every change it undergoes by the action of the fire, from the time that it receives the first degree of preservation to that, when it is utterly altered and nearly destroyed.

Barley in the mow, though it scarcely supports a heat much greater than of 100 degrees, may be extracted or brewed without malting. This the distiller's practice daily evinces; but then the extracts, made from this unchanged corn, are immediately put in the still after the first fermentation, else they would not long remain in a sound state. Nor is this method even practicable in summer time, as the extracts would turn sour, before they were sufficiently cooled to ferment. It is true indeed, that, by this means, all the charge of the malt duty is saved; but our spirits are thereby made greatly inferior to those of the French. Boerhaave recommends the practice of that nation, which is to let the wines ferment, subside, and be drawn off fine from the lees, before they are distilled. Was this rule observed in England, distillation would only be attempted from malted grain, and the difference in the spirit would soon shew, how useful, nay how necessary it is to
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give wines, (either from grapes or corn,) time to be softened, before they are used for any purpose whatever.

But might not barleys be dried without being germinated? Undoubtedly they might; but as they abound with many acids and strong oils, they would require a heat more intense than malt doth, before they were sufficiently penetrated, and then the oleaginous parts would become so compact, and so resinous, as nearly to acquire the consistence of a varnish, scarcely to be mollified by the hottest water, and hardly ever to be entirely dissolved by that element.

Barley then ungerminated, either in its natural state or when dried, is not fit for the purpose of making wines; but when, by germination, the coarser oils are expelled, and the mealy parts of the grain, become saccharine, might not that suffice, and where is the necessity of the grain being dried by fire? I shall not dwell on the difficulty of stopping germination at a proper degree without fire, so that sufficient quantities of the grain thus prepared, may always be provided for the purposes of brewing; nor even insist upon the difficulty, and perhaps impossibility of grinding such grain, as it would then be spongy and tough. I think it sufficient to mention solely the unfitness of this imperfect malt, for the purpose it is to be applied to, that of forming beers and ales capable of preserving themselves for some time. We should find so many acids blended with the water still remaining in the grain, that, in the most favorable seasons for brewing, they would
often

often render all our endeavours abortive, and in summer time make it impracticable to brew the extracts from such grain in any manner whatever.

I have heard of a project of germinating grain, and drying it by the heat of the sun in summer time, in order, by this means, to save the expence of fuel : but, tho' the hottest days in England may be thought sufficient for this act, as well as for making hay, yet as barley and grass are not of equal densities, the effects would not be the same. This however is not the only objection to this scheme. As the grain is to be grown to a certain degree before it is stopped, this very hot season, favorable in appearance to one part of the process, would be directly contrary to the other ; for the barley, by this heat, would shoot and come forward so fast as to entangle too much the constituent principles of the grain with one another, and drive the coarser ill tasted oils among the finer sweet mealy parts, which alone, in their utmost purity, are the subject required for such as would obtain good drinks.

Here I cannot help observing the general disposition of mankind to wish for the gifts of providence, in a different manner than they have been vouchsafed to us. These various schemes, if I mistake not, have sprung from the desire of having beers and ales of the same appearances with white wines. But as they are naturally more yellow or brown, all such projects, by which we endeavour to force some subjects to be of a like color with others, are but so many attempts against nature, and the

the prosecution of them must commonly be attended with disappointments. It is true, that, though malts be dried slack, yet if they be made in winter, speedily used, and brewed in the most proper season, they may make a tolerable drink, which will preserve itself sound for some time: but as the proportion, which should be kept between the heat which dried the malt, and that which extracts it, cannot in this case take place, and as the grain will be more replete with air, water and acids, than it ought to be, the drink, even by supposing the most fortunate success, and that it doth not soon turn acid, will still be frothy, produce explosions, and be therefore greatly wanting in salubrity; for an excess in any of the fermentable principles is always hurtful.

Barley then, to be made fit for the purpose of brewing, must be malted; that is, it must be made to sprout or germinate with degrees of heat nearly equal to those which the seed should be impressed with when sown in the ground; and it must be dried with a heat superior to that of vegetation, and capable of checking it. How far germination should be carried on, we have already seen; the law seems to be fixed universally, as to the extent of the acrospire: the degree of dryness admits of a larger latitude, and to what extent it may be properly pushed shall be the subject of our next enquiry.

Malt dried in so low a degree, as that the vegetative power is not intirely destroyed, will, on laying together in a heap, generate a new, tho' small, heat, germinate afresh, and send

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forth

forth its plumes and acrospires quite green. The ultimate parts of the nourishing principles are then within each other's power of acting, else this regermination could not take place; and such grain cannot be said to be malted, or in a preservative state. Bodies, whose particles are removed, by heat, beyond their sphere of attraction, can no more germinate; but coming in contact with other bodies, as malt with water, they effervesce. The grain, we are now speaking of, first shews this act of effervescence, when it has been thoroughly impressed with a heat of 120 degrees, when also its color, from a white, begins to incline to the yellow. Such are the malts, which are cured in a manner to be able to maintain themselves sound, though in this state they still possess as much air, and as many acid and watery particles as they are capable of. This therefore may be termed the first or lowest degree of drying this grain for malt.

To discover the last or greatest degree of heat it is capable of enduring, we have no circumstance to direct us, with the same certainty as effervescence helped us to the first. We must therefore have recourse to the observation of that heat, which wholly deprives the grain of its principal virtues. Now, to use Dr. Shaw's words, *alcohol is one of the most essential parts of wine*; when absent, the wine loses its nature, and when properly diffused, it is a certain remedy for most diseases incident to wines, and keeps them sound and free from corruption; from whence was derived the method of preserving vegetable and animal substances from corruption. The same excel-
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lent author had before this observed, that *no subjects but those of the vegetable kingdom are found to produce this preserving spirit*. Is alcohol then a new body created by fermentation and distillation, or did it originally, though latently, reside in the vegetable? *I have, for a good while, been satisfied, by experiments, (says Boerhaave,) that all other inflammable bodies are so only as they contain alcohol in them, or, at least, something that, on account of its fineness, is exceedingly like it, the grosser parts thereof, that are left behind, after the separation of this subtil one, being no longer combustible.*

Now as the same author has clearly proved*, that fire, by burning combustible bodies, as well as by distilling them, separates their different inflammable principles, according to their various degrees of subtility, the alcohol residing in the barley, when exposed to such a degree of heat as would cause it to boil, i. e. 175 degrees, must make great efforts to disengage itself from the grain. Is it not therefore most natural to conclude, that, in a body like malt, prepared for fermentation, or the making a vinous liquor, this event will probably happen at the same time that malt chars? and if this is true, may not charring be termed the last degree of dryness, as, when it takes place, the acid parts and finest oils, which are necessary for forming a fermentable must, fly off, and cannot be recovered. Charring seems to be a crisis in solid bodies, somewhat analogous to ebullition

* Boerhaave Elem. of Chem. Vol. I. p. 195-199. Exp. 8, 9, 10, 11, 12, and 13.

in fluids. Both are thereby perfectly saturated with fire, their volatile and spirituous parts dissipated, but their fixed principles not entirely destroyed. Now, as liquors boil with a greater or less heat, in proportion to their tenacity and gravity, solid bodies may likewise be charred with different proportions of heat. The whole body of the barley cannot, at the same instant, become black, nor, where any quantity of the grain is otherwise in similar circumstances, if not equally germinated, can the whole char with the same degree of heat.

To the several reflections, before made, I thought proper to add the surer help of experience. I therefore made the following trial, with all the care I was capable of. If the effects of it appear, as I hope they will, satisfactory, by gaining two limited and distant degrees, we may determine and fix the properties of the intermediate spaces, in proportion to their expansion.

In an earthen pan, of about two feet diameter, and three inches deep, I put as much of the palest malt, unequally grown, as filled it on a level to the brim. This I placed over a little charcoal lighted in a small stove, and kept continually stirring it from bottom to top.

At first it did not feel so damp as it did about half an hour after. In about an hour more it began to look of a bright orange color on the outside, and appeared more swelled than before.

before. Every one is sensible, that a long-continued custom makes us sufficient judges of colors, and this sense in a brewer is sufficiently exercised. Then I masticated some of the grain, and found them to be nearly such as are termed brown malts. On stirring and making a heap of them towards the middle, I placed therein, at about half depth, the bulb of my thermometer, and found that it rose to 140 degrees: the malt felt very damp, and had but little smell.

At 165 degrees I examined it in the same manner as before, and could perceive no damp; the malt was very brown, and on being chewed, some few black specks appeared.

Many corns, nearest the bottom, were now become black and burnt; I placed my thermometer nearly there, and it rose to 175 degrees: but as the particles of fire ascending from the stove act on the thermometer in proportion to the distance of the situation it is placed in, through the whole experiment an abatement of five degrees should be allowed, as near as I could estimate. Putting a little after my thermometer in the same position, where about half the corns were black, it shewed 180 degrees. I now judged, that the water was nearly all evaporated, and I observed, that the heap grew black apace.

Again, in the center of the heap raised in the middle of the pan, I found the thermometer at 180 degrees; the corn tasted burnt, the surface appeared, about one half part a full brown, and the rest black. On being masticated still
some

some white specks appeared, which I observed to proceed from those barley-corns, which had not been thoroughly germinated, and whose parts cohering more closely together, the fire, at this degree, had not penetrated. Their taste was insipid, the malt brittle, the skin ready to part. The thermometer was now more various, as it was nearer to, or farther from the bottom; and in my opinion all the true malt was charred.

I, nevertheless, continued the experiment, and at 190 degrees, still found some white specks on chewing the grain, the acrospire always appearing of a deeper black or brown than the outward skin; the corn, at this juncture, fried at the bottom of the pan.

I still increased the fire; and the thermometer, placed in the middle between the bottom of the pan and the upper edge of the corn, shewed 210 degrees. The malt hissed, fried and smoaked abundantly. Though, during the whole process, the grain had been kept stirring, yet on examination, the whole was not equally affected by the fire. I found a great part thereof reduced to perfect cinders, easily crumbling to dust between the fingers, some of a very black hue, without gloss, some very black, with oil shining on the outside. Upon the whole, two thirds of the corn were perfectly black, and the rest of a deep brown, but more or less so, as the grains were hard, steely, or imperfectly germinated. This was easily discovered by the length of the shoot: most of the grains seemed

to have lost their cohesion, and had a taste resembling that of high-roasted coffee.

In the last stage of charring the malt, I placed over it a wine glass inverted, into which arose a pinguious oily matter, which tasted very salt. It may, perhaps, not be unnecessary to say, that the length of time this experiment took up, was four hours, and that the effect it had, both on myself, and on the person who attended me, was such as greatly resembled that of inebriation.

Though, from the result of this experiment, some doubt may remain about the exact degree of heat in which malt charrs, which possibly it is equally difficult and unnecessary to fix with the utmost precision, yet we see that black specks appeared, when the thermometer was at 165 degrees; that some of the corns were entirely black at 175, and at 180; that the grains thus affected were such as had been perfectly germinated, and that those, which bore a greater heat, were defective in this respect. May we not, from thence, conclude, with an exactness, surely sufficient for the purposes of brewing, that true germinated malts are charred in heats, between 175 and 180 degrees? as these correspond to the degrees, in which pure alcohol, or the finest spirit of the grain itself boils at, does not that ethereal enlivening principle disengage itself from malted barley, by that heat? and are we not hereby instructed of one reason, why this grain is the fittest for the purposes of brewing?



SECTION XI.

Of the different PROPERTIES of MALT.

THE consequences, resulting from the before-mentioned experiment, have already been hinted at. But it is necessary to trace them farther, and to shew how much they may tend to the information and use of the brewer.

Germinated barleys, so little dried, as that their particles remain within their sphere of attraction, are not in a preservative state, and cannot properly be termed malts.

The first degree of dryness, which constitutes them such, is, as we have seen before, that which occasions them to cause some effervescence. This cannot be effected, when they are dried with less than 120 degrees of heat, the highest that leaves them white. When urged by a fire of 175 degrees, they charr and turn black. Now this difference in heat, being 55 degrees, and producing, in the grain, so great an alteration, as from white to black, the different shades or colors belonging to the intermediate degrees of heat, cannot, with a little practice, easily be mistaken.

White

White, we know from Sir Isaac Newton's experiments, is a composition of all colors, as black is owing to the absence of them. These two terms indicate the extremes of the dryness of malt. The color, which a middling heat impresses upon it, is brown, which being compounded of yellow and red, the four tinges, which shade malt differently, may be said to be white, yellow, red and black. The following table, constructed on these principles, will, on chewing the grain, readily inform the practitioner of the degree, to which his malts have been dried.



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A TABLE of the different degrees of the dryness of malt, with the changes of color occasioned by each increase of the degrees.

Degrees.

- 119 — White ————— White
 124 — W, W, Yellow ——— white turning to a light yellow.
 129 — W, W, Y, Y, ——— light yellow inclining to amber.
 134 — W, W, Y, Y, Red, — Amber
 138 — W, W, Y, Y, R, R, — high amber, or first brown.
 143 — W, Y, Y, R, R, ——— Brown.
 148 — Y, Y, R, R, ——— middling brown.
 152 — Y, R, R, ——— high brown.
 157 — Y, R, R, Black ——— brown inclining to black.
 162 — Y, R, R, B, B, ——— high brown speckled with black.
 167 — R, R, B, B, ——— blackish brown with black specks.
 171 — R, B, B, ——— Coffee color.
 176 — Black ——— Black.

N. B. The several letters against each degree, it is apprehended, will help in practice to fix the color.

The

The foregoing table not only enables us to judge of the dryness of the malt by its color, but also, when a grist is composed of several sorts of malt, to foresee the effect of the whole when blended together by extraction. Some small error may possibly occur in judgments thus formed upon the report of our senses; but as malts occupy different volumes in proportion to their dryness, if, in the practice of brewing, upon mixing the water with the malt, the expected degree is observed, such parcel of malt may be said to have been judged of rightly, in regard to its dryness. So that the first trial either confirms or corrects our opinion thereof.

Though malts, dried to 120 degrees, are in a preservative state, yet they are the least so as malts. They still possess the whole of their acids; which occasions their fermentation and frettings often to return of themselves, and with much violence: hence wines, formed from such malts, are not of long duration, and soon become sour. If the heat, which is made use of in the extraction of these malts, is kept up in proportion to that which dried them, even should the fermentation be very coolly carried on, and the ales and beers be brewed in the most favorable season, they will arrive at a state of ripeness, in so small a space of time as two weeks. We may therefore consider this, as the first fixed term, for obtaining a fermentable liquor, and such a one indeed, which in the least time will be fit for use.

When malts charr and become black, their parts are ultimately divided, they can scarcely possess any acids, nor

consequently remain susceptible of fermentation; for fermentation is a division of parts, and that cannot admit of a proper division that is already too much divided. The degree of heat then, prior to that which produces this effect, is the last, which still retains part of the fermentable properties. In malts thus highly impressed by fire, fermentation would proceed with so slow and reluctant a pace, that, in this case, the liquor might be said to be in the utmost state of preservation. No term can be fixed for its duration. A liquor of this sort, brewed with a heat similar to that which dried the malt, might keep many years, and thus become rather more accommodated to the temperature of the place it was deposited in, than to its own constituent parts. Experience has shewn, that two years are the limited space for drinks made from malts dried with 162 degrees of heat, before they be in a drinkable state; and at this degree of heat, we have seen that the grains were of a very high brown and speckled with black, and consequently had many of their finer parts charred. From these two extremes, and on such principles, the following table is formed, exhibiting the length of time that drinks made from malts of each respective degree of dryness properly brewed, and in the most favorable season, will require, before they come to their due perfection to be used.



A TABLE, shewing the age beers will require, when properly brewed from malts of different degrees of dryness.

Degrees.

119	White	—————	2 Weeks.
124	W, W, yellow	—————	1 Month.
129	W, W, Y, Y,	-----	2 Months.
134	W, W, Y, Y, Red	----	4 Months.
138	W, W, Y, Y, R, R,	----	3 Months*.
143	W, Y, Y, R, R,	———	4 Months.
148	Y, Y, R, R	—————	6 Months.
152	Y, R, R	-----	12 Months.
157	Y, R, R, black	———	18 Months.
162	Y, R, R, B, B	———	2 Years.
167	R, R, B, B,		
171	R, B, B		
176	Black.		

* When the medium heat of the dryness of the malt, and of the heat of the extracts are so high as to require the liquors to be forced or precipitated, in order to become pellucid, part of the oils, which supported them sound, being carried down by the precipitant, they will be less capable of preserving themselves, after having been precipitated, than they were before.

It

It must be observed, that the foregoing table is constructed on the supposition, that these different sorts of malt be brewed and fermented with the utmost care, and have a proper addition of hops; an ingredient which shall be considered in its proper place. What is meant by the *extracts being in proportion to the dryness of the malt*, may merit some explanation.

Grapes, when ripe, carry with them the water they have received, both during their growing state, and that of their maturity. This quantity is sufficient to form their musts with. To dried grapes or raisins, water is applied, to supply what they have lost; and for the same reason it is requisite in regard to malt: but as grapes stood in no need of artificial fire, to give to their fermentative principles a due proportion, so what they produced by themselves, or by cold water added to them, when dry, is a sufficient menstruum. But barleys, wanting the assistance of a great heat to bring their parts to the necessary proportion, require also a similar or rather a greater heat to resolve them. Without that, the flour of the grain would come away undissolved, and thus considerably impoverish the grist. Should, on the other hand, too great a heat be applied, an equal loss would be sustained, from some of the finer parts being coagulated or dispersed. The proportioning therefore the heat of the water to the dryness of the malt, more especially in respect to the strength of the drink, is of real necessity.

It is certainly true, that we often see liquors brewed from very pale malts, preserve themselves for, and become fit to be
drank

drank only in, a long time, and some brown malts so managed, as to give beers which soon will become stale. The first of these cases happens, when the extracts are made with very hot water, and the latter, when the water is too cold for the purpose. Too much being extracted in one case, and too little in the other, the time, which improves the first drink, must necessarily spoil the latter. Our table indicates the medium, both of the dryness of the malt and of the heat of the extracts, and upon the supposition of an equality, always desirable, between them, shews the space of time, which the liquor may keep, before it is full ripe.

Well-brewed drinks should not only preserve themselves sound their due space, in order to be meliorated by time; they should likewise be fine and transparent. This may be esteemed the most certain sign of the artist's skill and care, as well as of the salubrity of the drink, and is at once the surest mark and proof of a well-formed must, and of a perfect fermentation. If then the rules for obtaining these ends can be deduced from the foregoing principles, and experiments, we may flatter ourselves with possessing a theory, which will answer our expectations in practice.

According to the laws of nature discovered by Sir Isaac Newton, the spaces between the parts of opaque bodies are filled with mediums of different densities, and the discontinuity of parts, each in themselves transparent, is the principal cause of their opacity. Salts in powder; or infused

in

in an improper medium, will intercept the light; gums make a muddy compound, when joined to spirits; and oils, unassisted by salts, refuse to be incorporated with water. Musts therefore, which are not saponaceous, or in other words, whose constituent parts are not capable of being dissolved by water into one homogeneous body, are not fit, either for a perfect fermentation or a pellucid drink.

When extracts are made with an improper degree of heat, that is, when either the malts are not sufficiently dried, or the water is not powerful enough in heat, the oils of the malt do not mix perfectly with the water, and the liquor must be deficient in transparency.

On the other hand, extracts made with waters so hot, that the constituent parts are removed beyond their sphere of attraction, or the oils coagulated so as to form a body separate from the water, must needs be opake. Worts or musts can never, in either of these cases, yield a transparent wine; whereas with a due or mean heat, between these two, they must perfectly become so; and as they recede from this medium, they will be more or less valuable.

Length of time, which improves beers and wines, often rectifies our errors in this respect; for the oils being, by various frettings, more attenuated, and more intimately mixed, the liquor is frequently restored, and becomes of itself pellucid. Yet I never found this to succeed, where the error on the
whole

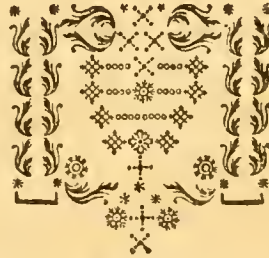
whole of the dryness of the malt, and the heat of the extracts, exceeded the medium by 14 degrees.

Art has also, in some measure, concurred with nature, to remedy this defect. When beers or wines have been suffered to stand, till they are rather in an attracting than in a repelling state, that is, when their fermentations and frettings have had their course; then, if they do not become spontaneously fine, they may be precipitated, by mixing with them a more ponderous fluid. The floating particles, that occasioned the foulness, are, by this means, made to subside to the bottom, and leave a limpid wine: but the power of dissolved isinglass, the ingredient generally used for this purpose, seldom takes effect, when the error exceeds the medium, as before, by more than 14 degrees.

Other ingredients, indeed, have been used, which carry this power near 10 degrees farther. It is not my province to determine, whether such be salutary: undoubtedly it would be better if there were no occasion for them. Beyond these limits, precipitation has no effect; the liquor, which cannot be fined thereby, if attempted, by increasing the quantity of the precipitants, will be overpowered by the menstruum, and injured in its taste. How frequent this last case of *cloudiness* is, would answer no purpose in this place to enquire. The use of doubtful ingredients, and such errors as have been mentioned, need no longer blemish the art, when a constant and happy practice will be both the effect and the proof of a solid and experimental theory.

The THEORY of BREWING.

Beers which become bright of themselves, or by time alone, as well as those precipitated either by dissolved isinglass, or by more powerful means, each possess their respective properties in a certain latitude or number of degrees; and as these effects arise wholly from the heats employed in drying the malts, and in forming the extracts, the following table will be of use to point out the limits, within which each drink may be obtained.





A TABLE shewing the tendency beers have to become fine, when properly brewed from malts of different degrees of dryness.

Degrees.

119	White	} Latitude of pale malts, which, when properly brewed, soon become spontaneously fine, or where, as in pale ales, the fermentations are periodically repeated.
124	white, turning to a light yellow	
129	light yellow inclining to amber	
134	amber	
138	high amber or first brown	
143	brown	} by precipitation these grow bright in a short time.
148	middling brown	} with precipitation these require from 6 to 12 months to be bright
152	high brown	
157	brown inclining to black	} these may be fined by precipitation, but never will be bright
162	high brown speckled with black	
167	blackish brown with black specks	} These with difficulty can be brewed, without the goods being set, but will by no means become bright, not even with the help of the strongest acid menstruum.
171	coffee color	
176	black.	


Before this section is concluded, permit me to draw one inference more from the foregoing experiment. As malts char and become black with the same degree of heat, at which alcohol boils, and as the effect the vapours rising from them had on the persons attending the experiment was a slight inebriation, it appears, that this spirit was resident therein, and parted therefrom, when the heat was carried to the degree of ebullition. Hence, if dry and moist heats are equally capable of putting the grain into a state of preservation, malt ought not, when in possession of the whole of its properties be made to indure such moist heats as are equal to 175? Will not the extracts, by such a degree, be, at least in part, deprived of the spirit, its most preservative principle? and, as in fermentable musts this spirit is not to appear divested of the other principles of the grain, ought it not to be intimately mixed with such as are necessary, in order to soften, sheath and retain it the desired time?

Thus does the success of this art depend on the instrument so often mentioned, which, by indicating the expansions caused by different heats, becomes a sure guide in our operations. I shall now close this account of mal', as I did that of fermentation, by comparing with the principles here laid down the defects, which we, but too often, meet with in barley when malted.



SECTION XII.

OBSERVATIONS *on defective* MALTS.


 IN the preceding enquiry, some of the defects of malts have been occasionally mentioned: but as a perfect knowledge of the grain, especially when it has undergone this process, is a matter of no small concern to the brewer, I shall now bring such defects into distinct view, both to compare them with the foregoing principles, and that the knowledge of them may be more at hand, on every occasion, when wanted.

Every different degree of heat acting on bodies causes a different effect: and this varies also, as such heat is more or less hastily applied. The growth of vegetables is in general submitted to these laws; but yet I conceive there is some difference between germination and vegetation, which I beg leave to point out. The former seems to be the act caused by heat and moisture, while the plume or acrospire is still enveloped within the teguments of the parent corn, and it is most perfectly performed by the gentlest action, and consequently by the least heat, that is capable of moving the different principles in their due order. Vegetation, again, is that act which takes place, when the plant issues forth, and, being rendered stronger by the impressions of the air, becomes capable of resisting its inclemencies, or the warmth of the sun-shine. Germination is the only act necessary for malting, the intention being solely to
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put in motion the principles of the grain, and not to push up the embryo to a plant. Now, as this begins in barley at the degree where the water first becomes fluid, or nearly so, the cold season, when the thermometer shews from about 32 to 40 degrees, would seem the most proper for this purpose. How far its latitude may with propriety be extended, experience alone can determine. Maltsters continue to work so long as they think the season permits, and leave off generally in may, when the heat of the water extends at a medium from 50 to 55 degrees. But the nearer they come to this medium, with the greater disadvantage must they malt: as, by such warmth, the vessels of the corn are much distended, the motion of the fluids violent, and the finer parts too apt to fly off. Thus the coarser oils, gaining admittance, the glandular parts become filled with an impure and less delicate sulphur, which, instead of a sweet, inclines to a bitter, taste. This is so manifest, and so universally experienced, that in general brewers carefully avoid purchasing what is termed *latter-made malts*.

Malt, which has not had a sufficient time to shoot, so that its plume may have reached to the extent of the inward skin of the barley, remains overburthened with too large a quantity of earth and oils, which otherwise would have been expended in the acrospire and radical vessels. All those parts of the corn, which have not been separated, and put in a motion by the act of germination, will, when laid on the kiln to dry, harden and glutinize; no greater part thereof will
be

be soluble in water, then so far as the stem or spire of the barley rises to, or very little farther, and as much as is wanting thereof, will be lost to the strength of the drink.

When malts are suffered to grow too much, or until the spire is shot through the skin of the barley, which indeed is not often the case, though all that is left be malt, that is containing salts dissoluble in water, yet as too large a portion of oils has been expended out of the grain, such malts cannot be fit to brew drinks for long keeping. There is besides a real loss of the substance of the corn occasioned by its being overgrown.

Malts, which have been but just enough grown, and have been duly worked upon the floors, if not sufficiently dried on the kiln, even though the fire be excited to a proper heat, retain many watery parts. The corn, when laid together, will be apt to germinate afresh, perhaps so to heat as to take fire, and should it continue long in this state, must at least grow mouldy, and have but an ill flavor.

Malts well grown, and worked as before, but over dried, though with a proper degree of heat, will become of so tenacious a nature, as to require a long time, before they can admit of the outward impressions of the air to relax or mellow them, that is, before they be fit to be brewed with all the advantages they otherwise would have.

Malt

Malts dried on a kiln not sufficiently heated must require proportionably a longer time to receive the proper effect of the fire; the want of which will bring them in the same state as malts not thoroughly dried.

If too quick or fierce a fire be employed, instead of gently evaporating the watery parts of the corn, it torrifies the outward skin, divides it from the body of the grain, and so rarefies the inclosed air as to burst the vessels. Such are called *blown malts*, and, by the internal expansion, occupy a larger space than they ought. If such a fire be continued, it even vitrifies, or at least changes into a brittle substance, some parts of the grain, from whence the malts are said to be *glassy*. Those, which, from their being thus hardened and rendered of a steely nature, will not dissolve, or but in a small proportion, are very troublesome and dangerous in brewing, as they frequently occasion a total want of extraction, which is termed, *setting the grist*.

Malts, just, or but lately, taken from the kiln, remain warm for a considerable time. Until they become equally cool with the surrounding air, they cannot be said to be mellow, or in a fit state to be brewed; for as their parts will be harsh and brittle, the whole of their substance cannot be resolved, and the proper heat of the water, which should be applied to them for that purpose, is therefore more difficult to be ascertained.

The practice of those maltsters, who sprinkle water on malts newly removed from the kiln, to make them appear as having been made a proper space of time, or, as they term it, to *plump* them, is a deceit which ought to be discouraged. By this practice, the circumstance of the heat, and harshness of the malt, is only externally and in appearance removed, and the purchaser grossly imposed on. The grain, by being thus heated, occupies a greater volume, and if not speedily used, soon grows mouldy, heats, and is greatly damaged.

The direct contrary is the case of high dried malts, which have been made a long time: the dampness of the air has relaxed them, and so much moisture has insinuated itself into the grain, that some doubt must arise how much hotter the mash should, for this reason, be. Yet supposing no distemper, such as being mouldy, heated, or damaged by vermin, is observed, malts, in this case, may more certainly be helped in brewing, than those just abovementioned.

From what has been said, it appears, how necessary it is to procure malts, which have been wetted and germinated to their true pitch, dried by a heat raised to a moderate, yet true, degree, so that the moisture of the corn be duly evaporated, then cured in a manner to preserve themselves a due time, without being blown, vitrified, or burnt by too hot or hasty fires. I need not say how easy it is to regulate this process in the cistern, on the floors, and on the kiln, when the maltster uses no artifice to save his excise. But

with what certainty and ease the whole might be carried on by the help of the thermometer, I leave such to determine, who are modest enough to think, that the art may be brought to more accurate rules than those of the bare report of our unassisted senses. As such rules may easily be deduced from the principles here laid down, I shall not be more particular in shewing their application, that not being my immediate purpose, nor my business as a brewer. I have neither leisure, nor the conveniency of a malt-house, to make experiments of this sort; yet I may with truth say, that such as would not be disappointed in their brewing, must take care not to be deceived in their malts. This, however, being but too frequently the case, it is undoubtedly useful to be aware of their faults, and know how to correct them. If they are treated in the same manner as if they were perfect, the well-malted parts alone will be digested. If they be too slack dried, they may be corrected by an addition of heat, and if overdried, or injured by fire, they may be proportionably helped. By applying the thermometer to the first extract, the brewer will, to a sufficient degree of exactness, be informed of the defects he can mend, and hardly be ever at a loss for the properest means he can safely employ.

I flatter myself, some satisfaction must arise from seeing both what is perfect, and what is defective in the principal processes of this art, agreeing so well with its theory, and
af-

affording so many proofs of its certainty; and though there be several incidents, (as yet unmentioned,) inseparable from the practice, such will only serve to confirm this truth, that, as our task is to imitate *nature*, it is our duty to inform ourselves of, and industriously to be steady to, her laws.



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PART II.

THE

PRACTICE

OF

BREWING.



BEFORE I enter upon the practical, and indeed
B most important, part of this work, it will, I think,
not be improper to give a distinct, though ge-
neral, view of the different parts it is to consist of.

Thus is a general map prefixed before any book of geography, to point out the countries described in it, and their connexion one with another.

To extract from malt a liquor, which, by the help of fermentation, may acquire the properties of wines, is the general object of the brewer, and the rules of that art are the subject of these sheets.

An

An art truly very simple, if, according to vulgar opinion, it consisted in nothing else than applying warm-water to malt, mashing these together, multiplying the taps at discretion, boiling the extracts with a few hops, suffering the liquor to cool, adding yeast to make it ferment, and trusting to time, cellars, and nostrums, for its taste, brightness and preservation !

This might be sufficient, were the place and constitution of the air always the same, the materials and vessels employed intirely similar, and lastly the malt drinks intended for the same use and time ; but, as every one of these particulars is liable to variations, the rules, by which the artist is to govern himself, would only serve to deceive him, if he applied them indiscriminately, or trusted to indefinite signs, and insufficient maxims, in his deviation from them.

A more certain foundation has been laid down in our first part, and the principles there established will, it is hoped, in all cases, answer our ends, provided we make use of the proper means to settle their application. In order to effect this, nothing seems more proper than to follow, as much as possible, that plan, which the rational brewer would, in every particular circumstance, sketch to himself, before he proceeded to business. His first attention ought to be directed not only to the actual heat of the weather, but also to that which may be expected in the season of the year he is in. The grinding of his malt must be his next object, and as the difference of the drinks greatly depends upon that of the extracts, he can
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but chuse to have distinct ideas of what may be expected from each of them. Hops, which are added as a preservative to the extracts, become too important a part of them, to be employed without a sufficient knowledge of their power. The strength of our malt liquors depending principally on their quantity or lengths, it is necessary to ascertain the heights in the copper, which answer to these lengths. The differences in the boiling, with regard to different drinks or seasons, the loss of water by evaporation, the proper division of it according to the different degrees of heat to be given, the means to ascertain these degrees by determining what quantity of cold water is to be added to that, which is at the point of ebullition, as well as to a certain volume of grist, come afterwards under the consideration of the artist. He will next employ himself in ascertaining the manner and time of mashing, and as many unexpected incidents may have produced some small variations between the actual and the calculated heat of his worts, it will be incumbent upon him to make a proper estimation and allowance for them. To dispose these worts in such forms and depths, as may render the influence of the ambient air the easiest and most efficacious upon them, and then, by the addition of yeast, to supply the part of that internal and most powerful agent, which was lost in boiling, are the next requisites. The fermentation, which follows, and which the brewer retards or forwards according to his intentions, compleats the whole of his process, and it must be an additional satisfaction to him, if, upon comparing his operations with those of the most approved practitioners in

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his art, he finds himself able to account for those signs and established customs, which before were loosely described, authoratively dictated, and never sufficiently determined or explained. An object of still greater importance to him, is to know the proper stock of beer he ought to keep, in order to have at all times a sufficient quantity fit for use. As precipitation is requisite in certain cases, the common methods for effecting it should be known, and likewise the means practised among coopers to correct the real or imagined errors of the brewer, and to render his drinks agreeable to the palate of the consumers. This will naturally, and lastly, lead him to consider what true taste is, and by employing the means, by which it may safely be obtained and improved, he will have done all what was in his power, to answer his customer's expectation, and to secure his success.

This arrangement, which appears the most simple, is that, which the reader will find observed in the following sections. The proper illustrations of tables and examples have not been omitted, and from the complete plans for brewing, under two forms of the most dissimilar kind, which have been proposed, it will be found that the rules are adapted to all circumstances, and applicable to every purpose.

If, notwithstanding my endeavours, some things should appear out of their places, and some others in more than one, if redundancies, chiefly occasioned by the natural temptation of accounting for particular appearances, have not always been
avoid-




















avoided, if, lastly, inaccuracies should now and then have escaped me; let it be remembered, (by the good-natured it certainly will,) that, in new and intricate subjects, digressions and repetitions are in some measure allowable, that an overfulness is preferable to an affected and too often obscure brevity, and lastly, that the improvement of the art, rather than the talent of writing, must be the brewer's merit, and was my only aim.
























SECTION I.

Of the heat of the air, as it relates to the practical part of brewing.

N and about the city of London, the greatest cold, that has been observed, is 16 degrees, and the greatest heat has made the thermometer rise to 87.

Within these limits are comprehended all the fermentable degrees, and consequently those necessary for carrying on the process of brewing. If the lowest degree proper for fermentation be 40, and the highest 80, the medium of these two would, at first sight, appear to be the fittest for this peculiar purpose. The internal motion, necessary to bring on fermentation, excites a heat superior to the original state of the must by 10 degrees. Hence if 60 degrees be the highest eligible heat a fermenting must should arise to, 50 should be the highest for a wort to be let down at to ferment. This can only be obtained, when the degree of heat in the air is equal thereto, and it denotes the highest natural heat for beers and ales to be properly fermented. With regard to the other extreme or the lowest heat, however cold the air may be, as the worts, which form both beers and ales, gain by boiling, a degree greatly superior to any degree allowed of in fermentation, it is constantly in the artist's power to adapt his worts to a proper state. The brewing season, then, may justly be esteemed all that part of the year, in which the medium heat

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of the day is at, or below, 50 degrees, that is in our climate, from the beginning of October to the middle of May, or 32 weeks.

As the extractions are made by heats far superior to any natural ones, though the actual temperature of the air neither adds to, or diminishes from, their strength, yet it is to be known for the following reason. The proper heat is given to the mash, by means of cold added to boiling water, and cold water generally is of no other heat than that of the air itself. Indeed, when the cold is so intense, as to occasion a frost, and to change water into ice, that which is then used for brewing, being mostly drawn from deep wells or places, where frost never takes place, may be esteemed at 35 degrees, and this will be sufficiently exact.

The following table shews the temperature of the air for every season in the year, and confirms what I have just now said concerning the time proper for brewing, and the actual heat of the water. It was deduced from many years observations made with very accurate instruments, at 8 o'clock in the morning, the time in which the heat is supposed to be the medium of that of the whole day.

31	31	31	31
30	30	30	30
29	29	29	29
28	28	28	28
27	27	27	27
26	26	26	26
25	25	25	25
24	24	24	24
23	23	23	23
22	22	22	22
21	21	21	21
20	20	20	20
19	19	19	19
18	18	18	18
17	17	17	17
16	16	16	16
15	15	15	15
14	14	14	14
13	13	13	13
12	12	12	12
11	11	11	11
10	10	10	10
9	9	9	9
8	8	8	8
7	7	7	7
6	6	6	6
5	5	5	5
4	4	4	4
3	3	3	3
2	2	2	2
1	1	1	1
0	0	0	0

A TABLE

The PRACTICE of BREWING.

XX

A TABLE, shewing the medium-heat, for every season of the year, in and about *London*, deduced from observations made from 1753 to 1759, at eight o'clock each morning.

		Degrees.			Degrees.
January	1	} 36' 38	July	1	} 60' 52
to . . .	15		to . . .	15	
to . . .	31		to . . .	31	
February	1	} 34' 97	August	1	} 60' 29
to . . .	14		to . . .	15	
to . . .	28		to . . .	31	
March	1	} 35' 51	September	1	} 59' 89
to . . .	15		to . . .	15	
to . . .	31		to . . .	31	
April	1	} 38' 11	October	1	} 58' 48
to . . .	15		to . . .	15	
to . . .	30		to . . .	31	
May	1	} 37' 99	November	1	} 55' 17
to . . .	15		to . . .	15	
to . . .	31		to . . .	30	
June	1	} 39' 72	December	1	} 54' 13
to . . .	15		to . . .	15	
to . . .	30		to . . .	31	
		} 43' 13			} 48' 66
			to . . .	15	
			to . . .	31	
		} 46' 04			} 46' 72
			to . . .	31	
		} 49' 05			} 42' 26
			to . . .	15	
			to . . .	31	
		} 53' 67			} 39' 40
			to . . .	30	
		} 57' 20			} 38' 61
			to . . .	15	
			to . . .	31	
		} 59' 14			} 37' 54
			to . . .	15	
			to . . .	31	

To ascertain the authority of this table, and to make it useful to several purposes, I have carried to decimals the mean numbers resulting from my observations. But such an exactness has been found, in the practice of brewing, to be more troublesome than necessary. I have therefore constructed another table similar to the former, but where the fractions are omitted, and the whole numbers carried on from five to five. The heat, in the latter end of October and beginning of November, has been set down rather higher than it really is; as, at this time of the year, the hops fit to brew with are old and weak, and I could not devise any means more easy to allow for their want of strength.



A TABLE,

 A TABLE, shewing the medium-heat of the air, in
 and about *London*, for every season of the year,
 applicable to practice.

Degrees.		Degrees.	
January 1	} 35	July . . 1	} 60
to . . 15		to . . 15	
to . . 31	} 35	to . . 31	} 60
February 1		August 1	
to . . 14	} 35	to . . 15	} 60
to . . 28		to . . 31	
March 1	} 40	Septem. 1	} 60
to . . 15		to . . 15	
to . . 31		to . . 30	
April 1	} 45	October 1	} 50
to . . 15		to . . 15	
to . . 30		to . . 31	
May . 1	} 50	Novem. 1	} 45
to . . 15		to . . 15	
to . . 31		to . . 30	
June . 1	} 55	Decem. 1	} 40
to . . 15		to . . 15	
to . . 30		to . . 31	
	} 60		} 35

As nothing is so inconstant as the weather, we are not to be surprized when it deviates from the progression specified in the table: The flowing water used in the brewery, at the coldest seasons, we have fixed at 35 degrees, and the highest heat to carry on the process for beers brewed for long keeping at 50°. The length proper to be drawn, or the quantity of beer to be made from each quarter of malt being fixed, the brewer, at any time, has it in his power to make calculations for brewings, at 35, at 40, at 45, at 50, and even at any degree of heat whatever, so as never to be unprovided against any season, which may happen. Water, being a body more dense than air, requires some time to receive the impressions either of heat or cold, for which reason the medium heat of the shade of the preceding day will most conveniently govern this part of the process, unless some very extraordinary change should happen in the atmosphere. This must make the business of the artist, in this respect, very easy, for he has only to correct the little changes that occasional incidents give rise to, and the calculations will answer all his purposes so long as the lengths of beer to be brewed from the same quantity of malt remain unaltered, or that the coppers he employs are the same.

The best method, to know the true heat of cold water, would be to keep a very accurate and distinct thermometer, in the liquor back, but as this, in every place, is not to be expected, and inaccuracies must arise from a change in the air, to prevent their consequences in practice, we must have recourse to

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experience.

experience. This has taught us that a difference of 8 degrees, between the actual heat of the water, and that from, which the brewing was computed, will produce in the first extract, a difference of 4 degrees.

Most brewers coppers, though they vary in their dimensions, are generally made in proportions nearly uniform; the effect of one inch of cold water more or less will therefore nearly answer alike, that is, it will alter the heat of the tap by 4 degrees. But this will only hold good in such cases, where the water is in the same proportion to the volume of the grist. In brewing brown beers or porter, three worts are generally made, and the extracts therefore must be of different lengths from what they are in beers brewed at two worts only. In this case, the water of the first extract, necessary to wet all the malt, being more in quantity than it otherwise would be, occasions the second to be proportionably less; and as it is of great consequence, if the first tap doth not answer to its proper degree, that the second should be brought to such a heat, as to make up the medium of the first and second extracts, the second or piece liquor, by reason of its shortness, is more conveniently and exactly tempered in the little copper; and one inch cooling is then found, both by calculation and experience, to occasion a difference of one degree of heat.

One of the principal attentions, in forming beers and ales of any sort whatever, is that they may come to their most perfect state, at the time they are intended to be used. Com-

mon small beer requires from one to four weeks, and as it is impossible to prejudge the accidental variations, as to heat and cold, that may happen in any one season of the year, it is rational to act up to what experience has shewn is to be expected, and to mix such quantity of cold water with that, which is made to come to ebullition, as to bring the extract to the degree fixed for each particular season, let the heat, at the time of brewing, vary therefrom, in any degree whatever.

In treating on the subject of air in the former part of this work, I observed the effect it had in penetrating the parts of the malt, or in the technical term used by brewers, in flacking them. If this is the case, when the grain is entire and whole, it is more so when ground, and experience teaches us, that, when malt has been about 24 hours from the mill, the dampness it has imbibed is equal to half an inch more of cold water applied to the first liquor, and produces therefore a diminution of 4 degrees in the heat*.

An effect, somewhat resembling to this, is caused by the impression of the air on the utensils of a brewhouse, which are not daily used; the heat received from a foregoing process has expanded their pores, and rendered them more susceptible of cold and moisture. From this circumstance, the heat of the first mash, will be affected in a proportion equal to half an inch cooling, or in the space of 24 hours, to 4 degrees of heat.

* I chose this manner of expressing the most easy for the direction of the quantity of moisture received in the first extract.
ground malt from the air, as it is

The PRACTICE *of* BREWING.

The time of the day, in which this first extract is made, becomes another consideration; for as 8 o'clock in the morning is the time of the medium heat in the whole 24 hours, the other hours will give different proportions. When a first mash is made about 4 o'clock in the morning, the following table shews the difference between the heat at 4 and at 8; that of the other hours, in the like case, may be learned by observation. It has been observed, that, in the cold months, from the sun's power being less, the heat of the day and night are more uniform, and also that the coldest part of the 24 hours is about half an hour, or an hour before sun-rising. I have judged it convenient, to place, in the same table, the several incidents affecting the first extract.





INCIDENTS occasioned by the air affecting the heat of the first extract, to be noticed more particularly, when small beer is brewed, as the quantity of water is then greatest, and the mash more susceptible of its impressions.

Morning at 4	
January ———	0
February ———	0
March ———	2
April ———	4
May ———	6
June ———	8
July ———	10
August ———	8
September ———	6
October ———	4
November ———	2
December ———	0

Colder by so many degrees than at 8 o'clock in the morning.

Utensils, for want of being used, in 24 hours loose 4 degrees of heat, equal to half an inch of cold water.

Malt, which has been ground 24 hours, imbibes moisture equivalent to half an inch, which lessens the heat by 4 degrees.

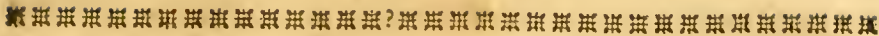
The difference between the actual heat of the air, and that naturally expected is to be allowed in proportion of 8 degrees to one inch.

Malts, from having been long kept, or old, become considerably flacked.

Before

Before we quit this subject, it may not be improper to observe, that, in the hottest season, and in the hottest part of the day, the difference between the heat of the air in the shade, and that in the sun's beams, is about 16 degrees, and also that the cellars or repositories for beers are in winter generally hotter by ten degrees, than the external air, and in summer colder by five.





SECTION II.

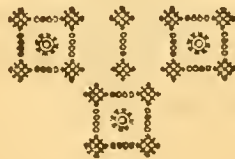
Of GRINDING.

MALT must be ground, in order to facilitate the action of the water on the grain, which otherwise would be obstructed by the outward skins. Every corn should be cut for this purpose, but not reduced to a flower or meal, for, in this last state, the grist would not be easily penetrable. It is therefore sufficient that every grain be divided into two or three parts, nor can there be any necessity for varying this, in one sort of drink more than in another. The intention of grinding is the same, in every brewing, and the transparency of the liquor, mentioned by some people on this occasion, depends, by no means, on the cut of the corn.

It has been a question, whether the motion of the mill did not communicate some heat to the malt; but, if this should be the case, it can be but in a very small degree; and that must again be lost by shooting the grain out of the sacks, or uncasing the grist into the mash ton.

We have before observed, that malt, by being ground and exposed for some time to the air, more readily imbibes moisture than when whole, and that the dampness, thus absorbed by the grain, being in reality so much cold water, a grist, that has been long ground, is capable of being impressed with hotter waters than otherwise it would require. In country places, where
the

the people are ignorant, that a certain heat is necessary to form a proper extract with, and where, instead of the determinate degree, boiling water is indifferently applied, the effects of this error are in some measure prevented, by grinding the malts a considerable time, as a month or six weeks before the brewing. This method, from the inconstant state of the air, must be more uncertain than any other, and few or no arguments are necessary to explode it. The truth is, the merit of country ales so often mentioned, proceeds from the people not being obliged to tap their drink, but when it is in the fittest state for use. Thus does time not only correct the errors of the operators, but also give them, in the eyes of the ignorant, the credit of an extraordinary knowledge and unmerited ability.



SECTION III.

Of EXTRACTION.

EXTRACTION is a solution of part, or the whole, of a body, made by means of a menstruum. In brewing, it is chiefly the mealy part of the grain that is required to be resolved, and fire and water combined are sufficient to perform this act. Water properly is the receptacle of the parts dissolved, and fire the power, which conveys into the vehicle more or less of these parts.

When all the parts necessary to form a vinous liquor are not employed, or when more than are required for this purpose are extracted, the liquors must vary in their constituent parts, and consequently be different in their effects. This difference arises either from heat alone, or from the manner of applying it; and the properties of beers and ales, will admit of as many varieties as may be supposed in the quantity of the heat, and in its application. But as the useful differences are alone necessary to the brewer, they may all be reduced to the four following modes of extraction.

First, that which is most perfect, and for which the malt is chosen of such dryness, and the extracts made with such heats, as to give the beer an opportunity to be improved by time, and to become of itself fine and transparent.

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Secondly,

Secondly, that, which occasions the liquor to become transparent, but, for want of a sufficiency of fire, does not allow it the advantages, which age procures to the first.

Thirdly, that, which, in order to obtain every advantage of time, produces such extracts, as cannot become pellucid of themselves, but do require precipitation.

Fourthly, that, which, by conveying a greater heat to the first extract, than is done in any of the preceding cases, gives to the liquors the sweet and soft taste of wines formed from grapes ripened by the hottest sun.

These four modes of resolving the grain, being the fundamental principles, on which almost every species of drink is brewed, I must be allowed to treat of them separately, but first will set down a few general principles applicable to all.

As grapes, in their original state, are acid, from having been formed under the lower degrees of heat, the first mash or extract, in any kind of liquor, must be the least in heat of the whole brewing: and as the acids of the grapes become saccharine by the increased power of the sun, the last mash of every brewing must be so far raised by heat, as to extract a sufficient quantity of oils, to smooth over the acids produced in the first extract, and cause the wort to become sweet. These oils, raised in different proportions, constitute what, in the must or wort, may be called the *degrees of Japonaceousness*.

In the table * shewing the different effects produced in the grain by the different degrees of heat, the numbers, with respect to worts, express, not only the degrees of dryness in the malt, but also those of heat in the extracting liquor to the medium of which the degree of power in the hops is likewise to be added. The heat of the first extracting water ought to be, at least equal, if not superior, to the heat which dried the grain, to give it a sufficient power to open it, and not let fall any of its parts undissolved.

Fermentation, either in grape or barley wines, is kept back or accelerated, in proportion to the quantity of oils the must contains, and these are raised by heat alone. Nature points out, in what part of the process of brewing this increased heat should be placed, as those wines preserve themselves longest, whose grapes, every other circumstance being the same, are germinated under a hotter sun; it is therefore in the drying of the malts, and in the first part of the process, that the heat should be raised.

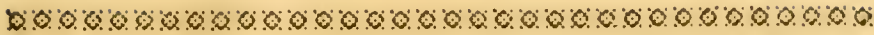
A must or wort, to be perfect, should be formed so, as that its saponaceous properties keep an even pace with the fermentable ones. The properties of a true sapo must then, as has before been said, be estimated by the same scale as the degrees of fermentation, although their respective number be different. Those of saponaceousness are comprehended between the degree of heat, by which germinated barley is first changed into

* Part I. Sect. XI. page 103.

malt, and the last degree of dryness, in which the malt preserves the whole of its constituent parts. The first of these degrees is 119, and the last, by which the grain first begins to charr, 157. The difference is 38 *, which number, being deducted from the highest degree of heat applied to malt for any intended purpose, the remainder will be the lowest. The extracts of all beers and ales, intended to become of themselves transparent, must be formed on calculations, comprehending all the saponaceous or 38 degrees, and since perfect opacity is the effect of the total want of saponaceousness, the intermediate states may be expressed by the following table.

* It might be supposed, that the real number of the saponaceous degrees of malt extends from 119 to 176, when it appears quite black and charred. But, malt, by so much as it turns to blackness, becomes defective, and improper for the true vegetable sapon for fermentation, and therefore we are to stop, where that change first takes place, viz. at 157.





A TABLE, shewing the effects of the several sapo-
naceous degrees.

38	—	spontaneously bright.
33	—	by precipitation, bright from 6 to 9 months.
28	—	by precipitation, fine from 12 to 18 months.
24	—	by precipitation, fine in 24 months.
19	—	} Different degrees of cloudiness.
14	—	
9	—	
5	—	
0	—	opake.

Whenever opacity takes place, even in so small a proportion as 32 degrees, precipitation must be used. When at 19, the powers of transparency and opacity being equal, an effect expressive of both will ensue, and a color properly belonging to neither be observed. The drinks will, in one light, appear transparent, and in another, opake; and this seems to be the true character of cloudy beers.

Though beers and ales are divided into strong and small, this division regards only the proportion of the vehicle, and not that of the constituent parts. The same means, as to the heat of the extracts, must be employed, to form small beers, capable of preserving themselves sound for some time, as are used to make strong and durable drinks: for though a small liquor possesses more aqueous parts, the oils and salts of the malt are only more dituted,

diluted, but not altered in their proportions, and this causes but a very small difference in the duration of the liquor.

It now remains to apply these rules, deduced from the theory, to the several sorts of malt liquors, which answer to the four modes of extraction just before laid down.

The first and most perfect is, when the malt is chosen of such dryness, and the extracts made with such heats, as give the beers an opportunity of being improved by time, and of becoming spontaneously bright and transparent. Under this head, may be comprehended all *pale keeping strong*, and all *pale keeping small* beers.

From its name, regard must be had to the color of the malt, and such only used, as is dried the least, or by 119 degrees of heat.

The hops * should likewise be pale, and their quantity used in proportion to the time the drink is intended to be kept; suppose in this case it is 10 months, 10lb of fine hops will be required.

The highest degree of heat, or rather the medium of the highest dryness in malt, with the mean heat of the several extractions to admit of spontaneous pellucidity, we have seen in the foregoing table (page 103) to be 138 degrees, and this me-

* Though the consideration of hops is the particular subject of the next section, I am under a necessity of anticipating here some parts of it. In all complicated subjects, this must necessarily be the case.

dium is chosen as it answers not only to the intent of long keeping, but of brightness also: and for this reason the whole number of saponaceous degrees must be employed in the calculation.



Method of determining the malt's dryness, the heat of the first and last extracts, and the value in degrees of the quantity of hops to be used, for brewing pale strong or pale small beers, intended to be kept about ten months, before they are used.

119 degrees, dryness of the malt

157 { the highest medium of the extracting heats, because, with
 { the dryness of the malt, it makes a mean answerable, to
 { the intent of duration and transparency, or 138 degrees.

276

138 as abovementioned

157 { from above, is the mean of the extracts, as would occa-
 { sion pellucidity to be in its lowest degree, but the preserva-
 { tive quality in the highest, and therefore the greatest heat,
 { the first extract could bear for this purpose

38 the whole number of saponaceous degrees to be deducted

119 this then the lowest saponaceous extract

157 this the highest saponaceous extract

276

 276

- * 138 the middle sapo, or heat of the first mash or extract
 164 the heat of the last mash or highest degree of maturation,
 because it is the only number, that will answer the following purposes

 302

- 151 the mean heat of the extracts, or of all the mashes,
 119 the malt's dryness

 270

- 135 medium of malt's dryness, and heat of the extracts
 3 value of the virtue of the hops

 138 the medium first intended.

The elements for forming pale strong or pale small beers, intended to be kept, are therefore the following,

Malt's dryness; value of hops; whole medium; first mash; last mash.

119	-----3-----	-----138-----	-----138-----	--164
			2	2

* The middle saponaceous heat is made use of instead of the lowest 119, because preservation, as well as transparency, is intended. This part of brewing is of the greatest consequence, and bears a remarkable analogy to the growth of grapes; for in the vine, the

juices raised by the preceding autumnal sun, residing still in the stem and branches of the plant, mix with those drawn up by the vernal heat, so that the grapes, though acid at their first forming, are at the same time, austere, and of a middle nature.

It is necessary to add two degrees to the heat of every mash, such being the mean of 4 degrees constantly lost in every extract, at the time they are separated from the grist, and exposed to the impressions of the air.

The second mode of extraction is that, which makes a transparent, but not a durable liquor. Under this head are comprehended *common small beer*, *brown ales*, and all malt liquors, becoming of themselves fine, and soon fit for use.

Common small beer is supposed to be ready for use, in winter, from two to six weeks, and in the heat of summer, from one week to three. Its strength is regulated by the different prices of malt and of hops; its chief intent is to quench thirst, and its most essential properties are, that in the winter it should be fine, and in the summer sound. This liquor is chiefly used in and about great cities, such as London, where, for want of a sufficient quantity of cellar room, drinks cannot be stowed, which, by long and slow fermentations, would come to a greater degree of perfection. The duration of this kind of liquor being short, and there being a necessity of brewing it in every season of the year, the incidents attending its composition, and the methods for carrying on the process must be more various and complicated, than those of any other liquor made from malt.

Beers intended for long keeping, are generally brewed, when they have the advantage of being set to ferment with a heat not exceeding 50 degrees, and as, in the coldest seasons, the tem-

T perature

perature of the cellars is in general at 45 degrees, and in the hottest at 65, the continued state of liquors long kept is nearly at 55 degrees:

Common small beer may, in winter, be impressed by such a heat, but in summer, from the shortness of the duration of the liquor, this advantage can, but in part, be obtained. In proportion as it is brewed, in a hot or in a cold season, we must employ every means, either to repel or to attract the acids circulating in the air; for this purpose, the degrees of dryness in the malt, and the quantity of hops must vary as such seasons do, as likewise the heat of the extracts, and the degree of temperature the wort is suffered to ferment with. The success, in brewing common small beer, greatly depends on its fermentation being retarded or accelerated as the seasons require. Expansion being the principal effect of heat, was a wort of this sort suffered, in winter, to be so cold as 40 degrees, the air would, with difficulty, if at all, penetrate into the must, and put it in action. This slow fermentation would not permit the beer to be ready at the time required. For these reasons, brewers let down their worts, in that season, at 60 degrees, whereas in summer the air of the night is made use of to get them as cold as possible, by which means a part of them may be 12 degrees colder than the medium of the heat of the day, and the whole of the worts, nearly 5, in the space of 24 hours.

The choice of the malt, as to its dryness and color, for brewing this liquor, is more arbitrary in the cold season than most
other

other circumstances ; the dryness forming only one part of the medium, which may be rectified by the heat given to the extracts. In the height of summer, malt dried to 130 degrees seems to be the best, as it unites the properties of speedy readiness, preservation, and transparency, and these several characters are, at that time, requisite in this liquor.

Was small beer to be used, in winter, immediately after being brewed, malts dried to their first degree or to 119, would be most fit for that season ; but the intention is, that the drink be kept some small time, and yet be readily fermented. Malt dried between the proper degree for the hottest time, or 130, and 119, which is the lowest, answers this character. Supposing therefore, that, when the heat of the air is at 40, malt of 124 degrees of dryness be the properest, and when the medium heat is at 60, that malt of 130 degrees of dryness is fixed, the following table will, from the proportion of these two extremes, shew the proper color of the grain, for every fermentable heat.



Heat in the air.	Malts dryness.	Value of hops in degrees.
35 . . .	122 . . .	1
40 . . .	124 . . .	1
45 . . .	124 . . .	1
50 . . .	127 . . .	1
55 . . .	129 . . .	1
60 . . .	130 . . .	1
65 . . .	131 . . .	2
70 . . .	133 . . .	2
75 . . .	135 . . .	2
80 . . .	136 . . .	2

What has been said for determining the dryness of the malt to brew small beer with, according to the different seasons, may, in some measure, be applied to the discovery of the heat, which is to be given to the extracting water. Dry and moist heats, are similar as to their preservative effects; to accelerate fermentation, in a cold season, a lesser heat is to be given to the extracts, than when, from the heat of the air, we are obliged to retard this operation. If no regard was to be had to the incidents attending the use of common small beer, such a dryness in the grain, and such a medium heat in the extract, as would barely place it in a preservative state, or 119 degrees in both, would be sufficient. In the highest fermentable heat, it would require that quantity of fire, by which the properties of the grain are still preserved, but, upon the least increase, would

would begin to be dispersed. The joint medium would then be 157 degrees. Though we know, that this is not exactly the case, with regard to small beer, a table founded on this supposition will assist us, when we have found the mean of all the incidents attending this liquor.

Heat of the air.		Medium of the dryness of the malt and of the heat of the extracts.
40	————	119
45	-----	124
50	————	130
55	————	134
60	-----	138
65	————	143
70	————	148
75	————	153
80	————	157

It would be very desirable, if it was possible, to fix a constant term for the duration of this liquor ; but this will vary in each different season, and according to the primitive heat the wort is made to ferment under.

All musts and worts contract heat, by the motion excited in the fermentable act ; the nearer this heat comes to 80 degrees, the less will the liquor keep sound ; and in proportion as the heat approaches 40, the more reluctantly will the wort be brought to ferment. Sixty degrees, being the mean between these two extremes, seems, therefore, the highest heat a first regular

regular fermentation should arise to. Beers, long to be kept, require more time to be under this act, and are not immediately brought to this heat; whereas, in common small beer, where dispatch is required, especially in winter, the worts are at once set to ferment at a heat of 60 degrees, and soon after conveyed to cellars generally 50 degrees hot. The mean between these two, or 55 is therefore the degree of heat, which small beer endures, when the air is at the first fermentable degree of heat, or 40 degrees. This, according to the foregoing table, (page 145) shews that the medium of the dryness of the malt and of the heat of the extracts is to be 134 degrees, upon the supposition that the drink is used immediately, or at least as soon as settled after the first fermentation is over. But we have already observed, that, in this season, small beer is expected to keep from 4 to 6 weeks, and to find out what addition is to be made on that account to the medium of 134 degrees, we must compare this liquor, under a fermenting heat of 60 degrees, to some other drink of a longer duration, nearly alike in quality, and make a proper allowance for their difference in heat, under the first fermentation.

The first mode of extraction, or that of pale small beer intended to be kept long, furnishes us with a liquor fit for this comparison. It is generally brewed when the heat of the air is at 40 degrees; the heat it is put at first to ferment with is 50, and when risen to its highest pitch, it comes to 60: the medium of the dryness of the malt and of the heat of the extracts for keeping small beer, abstracted from the value of the

the hops, we have fixed at 135 degrees in the account of its constituent parts, page 140. Such a drink, with 10 wt. of hops for every quarter of malt, will keep as many months. Was the medium of the degrees of dryness in malt, and of the extracting heat of common small beer, when the temperature of the air is at 40, to be 135 degrees, the wort set to ferment at first with a heat of 50 degrees, together with 3 wt. of hops to every quarter of malt, would preserve itself sound for three months. But, as we have observed, common small beer, in winter, is made immediately to ferment, at a heat of 60 degrees; the difference between 60° and 50°, being 10°, will produce in the effects, a difference of 8° in the numbers of the table, page 145; and since these 8 degrees are equal to 3 months keeping, 4° will answer to 6 weeks. The medium of these 4° only must be added to the medium before found, or 55°, and will bring it to 57°; consequently the number 136, or rather, on account of the hops, 137° ought to take place in the process of common small beer, when the heat of the air is at 40 degrees.

This governing number for the first fermentable degree of heat in the air being discovered, it is necessary to seek the governing number of the other fermentable extreme, but this, being attended with a variety of circumstances, can only be fixed, by making, from experience, proper allowances for them.

In cold-weather, as the temperature of the air is nearly uniform, during the term of the natural day, worts cool almost as fast at one time as at another ; but the case is quite different in summer, the evenings and nights are employed to obtain the greatest cold ; fermentation, at this season, is likewise carried on with more violence, being rather forwarded than checked by the exterior air. This internal agitation is often increased by the beers being conveyed from place to place, in the midst of the day, and in the sun-shine. Large cities are generally more hot in summer-time, than country places, where the buildings are less crowded, and as our observations, for the medium heats of the natural day, were made at Hampstead, an allowance must be made on this account. The difference in the heat of the cellars, at this time, need but little regard, and will at most produce an abatement of one degree, as those, which are allotted for common small beer, are none of the best, and the exterior air is suffered to have a free access to them.



When 60 degrees are the mean heat of the day, a first wort, by being exposed to the air until evening, may be let down at	- - -	60 degrees.
A last wort, by receiving the benefit of the evening's and night's cold	- - - -	48
		<hr/>
		108
		<hr/>
The mean heat	- - - -	54
Heat gained by fermentation	- - -	10
Allowance for the preservative quality, as before		2
Heat gained, by the drink being conveyed in the fun	- - - -	3
Difference of heat between London and Hampstead	- - - -	2
		<hr/>
		71
Deduction for the cold received in the cellars		1
		<hr/>
		70 degrees.

Now this number answers in the table, (page 145) to that of 148 for the dryness of the malt and the heat of the extracts, to which one degree more is to be added for the value of the hops. The two extremes being thus fixed, the intermediate space for every degree of heat in the air, in which common small beer is to be brewed, is easily determined. The heat of the first and last extracts, for any particular case, will be settled by the same rules, as were employed for pale strong and pale small beers long to be kept. One example, shewing

U how

how this method holds good throughout the whole, will be sufficient, and shew the means, by which the following table was formed.

When the air is at 40, the degree of dryness fixed for malts to be used for common small beer is 124, and the medium of their dryness and the heat of the extracts, together with the value of the hops added thereto, is 137 degrees.





124 Malt's dryness

150 the highest medium of the extracting heats

274

137 the medium intended

150 highest extracting medium as before

38 whole number of saponaceous degrees

112 lowest saponaceous heat for this purpose

150 highest extracting heat, the 1st mash could bear
for this purpose

262

131 heat of the first mash

165 heat of the last mash

296

148 medium of the extracting heats

124 dryness of malt

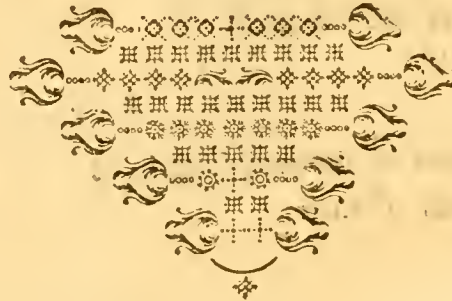
272

136 medium of malt's dryness and heat of extracts

1 value of hops

137 medium sought for, and directed as above

The medium of the heat lost in the mash tun, amounting to two degrees, is added to the heat of the first and last mash in the following table. In the hottest season, the last extracts for common small beer are made to exceed 175 degrees, a heat which alcohol boils at, but this is at a time when the malts are far from possessing the whole of their properties, and if such a heat was not used at that time, the number of degrees of saponaceousness could not take place to regulate the heat of the first mash, and the liquor would not retain a sufficient quantity of acids to be capable of fermentation, or become tolerably clear. These two circumstances experience shews to be preferable to some increase in the duration and strength of the drink.





A TABLE of the elements for forming common small beer, at every degree of heat in the air, with the allowance of two degrees of heat, in the first and last extractions.

Heat of air.	malt's dryness.	value of hops.	medium of the heat of the extracts and malt's dryness.	heat of first mash.	heat of last mash.
35	- 122	- 1	- 135	- 131	- 165
40	- 124	- 1	- 137	- 133	- 167
45	- 125	- 1	- 140	- 138	- 172
50	- 127	- 1	- 143	- 142	- 176
55	- 129	- 1	- 146	- 146	- 180
60	- 130	- 1½	- 149	- 151	- 183

From a due observation of this table, it appears, how necessary it is for brewers to be acquainted, not only with the daily temperature of the air, but also with the medium heat of such spaces of time, wherein a drink like this is expected to preserve itself. This I have estimated for every 14 days; but as the event may not always exactly correspond with our expectations, an absolute perfection in this drink, as to its transparency, is not to be expected. It greatly depends on the care and attention given to it, and on the temperature and quiescent state of the cellars it is placed in. The first of these circumstances is often
ne-

neglected, and the other hardly ever obtained, as the places, where common small beer is kept, are generally the worse of the kind. When the heat of the air is so hot as 60 degrees, such disadvantages must naturally accompany the brewing of this liquor, that all, what can be expected from art at this time, is to make it answer somewhat near to the properties required in it.

The third mode of extraction is that, which, in order to gain every advantage of time, produces such drinks, as cannot become spontaneously pellucid, but require the help of precipitation.

The improvement, which every fermented liquor gains by long standing, is very considerable; the parts of the grain, which give spirit to the wine, being, by repeated fermentations, more and more attenuated, not only become more light and pungent, but also more wholesome. If, in order to give to beers this preservative quality, more oils are extracted, in proportion to the salts, transparency cannot take place; but, when the heat employed for this purpose does not exceed certain limits, this defect may easily be remedied, and the drink be fined by precipitation; and as time enables it to take up part of the very oils, which at first prevented its transparency, it will, by long standing, become both brighter and stronger.

Where the demand for a liquor is constant and considerable, but the quantity required not absolutely certain, it ought to be brewed in a manner that time may increase its merit, and precipita-

precipitation render it almost immediately ready for use. These circumstances distinguish this class of extraction, and justify the preference given to *porter* or *brown* beer, which come under that mode.

It appears, by the table (page 103.) that drinks brewed from malts, affected by heats, whose medium is 148 degrees, require from 8 to 12 months with precipitation to become bright; and as this is the age generally appointed for brown beers to be drunk at, 148 degrees will give the medium of the heat of the extracts, and of the dryness of the malt.

The quantity of hops, necessary for the preserving of pale beers, has been observed to be one pound weight to every quarter of malt, for every month the liquor is intended to be kept; but hops employed for these pale strong drinks are supposed to be new, and strong, whereas, in porter, where the price does not keep an equal pace with the value of the commodity, hops, rather less in quality, are thought to be sufficient. Their quantity is, on this account, increased from 12 to 14 pound, *per* quarter, and their value estimated in the calculation to 3° 75 which, being deducted from 148, seem to indicate malts of 144 degrees; but, as the dryness of the malt must constantly be less than the heat it is impressed with, was grain used of this degree of dryness, this necessary circumstance could not take place. Therefore the highest dried of the pale kind, or the first degree of the brown, has been fixed upon as more eligible, especially as it conduces to a more successful precipitation.

In

In the drinks before examined, the whole number of saponaceous degrees or 38 has been constantly employed, they being intended to become spontaneously bright; but, as this quality is in the present case only required with the assistance of precipitation, the numbers 32 or 33, in the table shewing the effects of the several saponaceous degrees (page 137) seem the properest to answer our purpose, as they correspond nearly to the time this liquor is in general made use of. These conditions being premised, the proper degrees of the first and last extract for porter will be found by the same rules as were used before.

138 Malt's dryness

158 highest mean of extracting heats

296

148 the medium of the malt's dryness and heat of extracts, with
the value of the hops required

158 as above

32 number of saponaceous degrees employed in this process

126 lowest saponaceous heat for this brewing

158 highest saponaceous heat

284

142 heat of the first mash

160 heat of the last mash

302

151 true medium of the extracts

138 dryness of the malt

289

144 $\frac{1}{2}$ medium heat of malt's dryness, and heat of extracts

3 $\frac{3}{4}$ value of the effect of the hops

148 $\frac{1}{4}$ medium sought for and directed as above.



The elements, for brewing brown strong beer, with two degrees added to the first and last extracts, for what is lost in their parting from the malt.

Malt's dryness; value of hops; whole medium; first mash; last mash.
 138 ————— 3 $\frac{3}{4}$ ————— 148 ————— 144 ————— 162

It may be observed, that 3 $\frac{3}{4}$ degrees are charged for the quantity of hops used; as this number corresponds to the quantity proper to form beer of this denomination. A greater or a less proportion of hops is indeed sometimes allowed to this drink, on account of its better or inferior quality, of the necessity there may be to render it fit for use in a shorter time than that which is commonly allowed, viz. from 8 to 12 months, and lastly of old, stale, or otherwise defective drinks blended with new guiles. In these cases, which cannot be too rare, the errors should be corrected only by the addition of hops, and no alteration be made, either in the dryness of the malts, or in the heat of the extracts.

The fourth mode of extraction is that, which, by conveying a greater heat to the first mash, than is done in the preceding cases, gives to the liquors, commonly known by the names of *pale ale*, *amber* or *twopenny*, the softest and richest taste malt can possibly yield, and makes them resemble wines formed from grapes ripened by the hottest sun.

As wines have, in-general, been named from the town or city, in the neighbourhood of which the grapes, from which they are made, are found growing, this has, though with less reason, been in some measure the case, with our numerous class of soft beers and ales. These topical denominations can indeed constitute no real or at least no considerable difference, since the birth place of any drink is the least of all distinctions, where the method of practice, the materials employed, and the heat of the climate are so nearly alike.

The ale, we have now under consideration, is to be pale; the dryness of the malts should therefore be from 119 the first degree to 130, when the color begins to change to amber. As this drink is expected to be rich with the grain, this last dryness is not to be exceeded, the strength of the extract enhancing the color. The liquors of this sort, generally brewed in and about London, are from malts of 124 degrees in dryness, or what are termed pale.

Ales are not required to keep a long time; so the hops bestowed upon them, though they should always be of the finest color and best quality, are proportionably fewer in the winter, than

than in the summer. The reason is, that the consumption made of this liquor in cold weather is generally for purl,* whereas in summer, as it is longer on draught, it requires a more preservative quality.

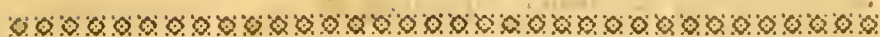
Where pungency in taste and length of preservation are intended, the heats of the first extracts ought to be the mean between the highest and lowest; but, where a must, as in this case, is required to lay long exposed, and to resist to, the acid particles floating in the air, such an extraordinary power must be given to the oils, as is equal to the time it is to be exposed to the air, which is at least three times more than what is required for common small beer. As fermentation acts more powerfully on worts, in proportion to the heat of the air, the extracts for ale worts being always uniform, are, in the hot season, enriched with oils, from the increased quantity of hops, which checks and retards the violent agitation these worts would otherwise be liable to. The following calculation, where the first extract is impressed with a degree of heat, determined by this rule, has been found by experience conducive to success; but transparency being one of the necessary properties of this drink, the whole medium ought never to exceed 138 degrees, and in proportion as the heat is raised in the first extract, it must be depressed in the last.

* *Purl*, is pale ale, in which buter aromatics, such as wormwood, orange peel, &c. are infused, used by the labouring people, chiefly in cold norn-

ings, and a much better and wholesomer relief to them than spirituous liquors.

	124 malt's dryness																			
	152 highest heat.																			
	<u>276</u>																			
<table style="border: none;"> <tr> <td style="font-size: 3em; vertical-align: middle;">{</td> <td style="padding-left: 10px;">152 highest extracting heat, the first mash could bear</td> <td style="font-size: 3em; vertical-align: middle;">}</td> </tr> <tr> <td style="font-size: 3em; vertical-align: middle;">{</td> <td style="padding-left: 10px;">38 whole number of saponaceous degrees; as pellucidity is expected,</td> <td style="font-size: 3em; vertical-align: middle;">}</td> </tr> <tr> <td style="font-size: 3em; vertical-align: middle;">}</td> <td style="padding-left: 10px;">114 lowest saponaceous heat</td> <td style="font-size: 3em; vertical-align: middle;">}</td> </tr> </table>	{	152 highest extracting heat, the first mash could bear	}	{	38 whole number of saponaceous degrees; as pellucidity is expected,	}	}	114 lowest saponaceous heat	}	<table style="border: none;"> <tr> <td style="padding-right: 10px;">138</td> <td>medium of malts dryness and heat of extracts</td> </tr> <tr> <td style="padding-right: 10px;">152</td> <td>from above, this multiplied by 3 for the reasons just given</td> </tr> <tr> <td style="padding-right: 10px;"><u>456</u></td> <td></td> </tr> <tr> <td style="padding-right: 10px;">114</td> <td></td> </tr> <tr> <td style="padding-right: 10px;">4</td> <td>[570</td> </tr> </table>	138	medium of malts dryness and heat of extracts	152	from above, this multiplied by 3 for the reasons just given	<u>456</u>		114		4	[570
{	152 highest extracting heat, the first mash could bear	}																		
{	38 whole number of saponaceous degrees; as pellucidity is expected,	}																		
}	114 lowest saponaceous heat	}																		
138	medium of malts dryness and heat of extracts																			
152	from above, this multiplied by 3 for the reasons just given																			
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114																				
4	[570																			
number of the highest and lowest saponaceous heats,	<u>143</u> heat of the first extract																			
	155 heat of the last extract																			
	<u>298</u>																			
	149 mean heat of the extracts																			
	<u>124</u> malts dryness																			
	<u>273</u>																			
	136½ medium of dryness of malt and heat of extracts																			
	1¼ medium of the value of hops used in every season																			

138 medium of the whole re-
quired.



*The elements, for brewing pale ale or amber, with the allowance of
2 degrees for the heat left in the extracts.*

		medium of the			
malts dryness	value of hops	whole	heat of first mash	heat of last mash	
124	1½	138	145	157	

The time, this liquor is intended to be kept, should entirely be governed by the quantity of hops used therein; for this ale being required to become spontaneously fine, the medium of the whole or 138 degrees cannot be exceeded. In and about London, and in some countries in England, these ales, by periodical fermentations, are made to become fine, sooner than naturally they would do, and often in a shorter time than one week. The means of doing this, by beating the yeast into the drink, as it is termed, has by some people been greatly blamed, and thought to be an ill practice. An opinion of the yeast being unwholesome has prevailed; and some brewers, erroneously led by this, and yet willing that their commodity should appear of equal strength with such as had undergone repeated fermentations, have been induced to add ingredients, to their worts, if not of the most destructive nature, at least very unwholesome. The plain truth is, that, by returning the elastic air in the fermenting ale, the effects of long keeping are greatly initiated,

tated, though with less advantage as to flavor and to strength; but as this case relates to fermentation, we shall have hereafter an opportunity of farther explaining it.

It is under this class, that the famous *Burton ale* may be ranked, and if I dont mistake, it will be found, that its qualities and intrinsic value will be the same, when judiciously brewed in London or elsewhere, from whence it may be exported at much cheaper rates to Russia and other parts, than where it is increased in price by a long and chargeable land-carriage.

We should now put an end to this section, but as other drinks are brewed besides those here particularly treated of, I shall just mention them, to shew, how their different processes are reducible to the rules just laid down.

Brown ale is a liquor, whose length is generally two barrels from one quarter of malt, and which is not intended for preservation. It is heavy, thick, foggy, and therefore justly grown in disuse. The hops used in this liquor differ in proportion to the heats of the season it is brewed in, but are generally nearly half the quantity of what is employed, at the same times, for common small beer. The system, it ought to be brewed upon, is not different from that of this last liquor, the medium of the malt's dryness and heat of the extracts are the same for each degree of heat in the air, and it requires the same management when under fermentation. But though common pale small beer and brown ale are so much alike in their theory, yet, from the difference of the dryness of the malt which, for brown ale, is constantly so high as 138 degrees, the practice will appear greatly

greatly different. Small beer is made after this ale, by the same rules as that made after pale ale or amber; the malts must, in that case, be valued according to their original dryness, and estimated at the medium, as if no extract had been taken from them. No small beer brewed after ales can ever be equal in goodness to such as are brewed from entire grists; but that which is made after brown ale, from the grain being so highly dried and nearly exhausted in the first process, is neither nourishing or fit to quench thirst.

Brown stout is brewed with brown malt, as amber is with pale; the system for brewing these liquors is the same, allowing for the difference in the dryness of the malt. The overstrength of this drink has been the reason of its being discontinued, especially since porter or brown beer has been brought to a greater perfection. That, which is brewed, with an intent of being long kept, should be hopped, in proportion to the time proposed, or the climate it is to be conveyed to.

Old bock requires the same proportion of hops, as are used in keeping pale strong or keeping pale small beer; but more or less according to the time it is intended to be kept before it becomes fit for use. The length is about two barrels, from a quarter of the palest and best malt. As spontaneous pellucidity is required, its whole medium must not exceed 138 degrees, for the drying and extracting heat. The management of it, when fermenting, is under the same rules with the liquor just now mentioned, or those which are allowed a due time to become of themselves pellucid.

Dorchester beers, both strong and small, range under the same head. They are brewed from barlies well germinated, but not dried to the denomination of malt. The rule of the whole 138 degrees for the medium, must, even with this grain, be observed to form these drinks; but, from the slackness of the malt and the quantities of salt and wheaten flour mixed with the liquor, when under fermentation, proceed its peculiar taste, its mantling, and its frothy property.





SECTION IV.

Of the NATURE and PROPERTIES of HOPS.



THE constituent parts of malt, like those of all vegetable sweets, are so inclined to fermentation, that, when once put in motion, it is difficult to retard their progress, retain their preservative qualities, and prevent their becoming acid. Among the many means put in practice, to check this forwardness of the malt, none promised so much success as blending with the extracts the juices of such vegetables, which, of themselves, are not easily brought to fermentation. Hops were selected for this purpose, and experience has confirmed their wholesomeness and efficacy.

Hops are an aromatic, grateful bitter, endued with an austere and astringent quality, and guarded by a strong resinous oil. The aromatic parts are volatile, and disengage themselves from the plant with a small heat. To preserve them, in the processes of brewing, the hops should be put into the copper, as soon as possible, and be thoroughly wetted with the first extract, while the heat of the wort is at the least, and the fire under the copper has little or no effect thereon. Whoever will be at the trouble to see this performed, by the means of rakes or otherwise, will be made sensible, that the flavor is retained,

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which,

which, when the wort comes to boil, is constantly dissipated in the air.

The bitter is of a middle nature, or semivolatile; it requires more fire to extract it, than the aromatic part, but not so much as the austere or astringent. Hence it is plain, that the principal virtues of this plant are best obtained by decoction, and that the austere parts do not exhibit themselves, but when urged by so violent and long continued boiling, as is seldom, or never practised in the brewery. It would be greatly satisfactory to fix, from experiments, the degrees of heat, that first disperse the aromatic, next the bitter, and lastly the austere parts: and it is likely that, by this means, a more easy and certain method of judging of the true value and condition of hops, than any yet known, might be discovered.

This vegetable is so far from being, by itself, capable of a regular and perfect fermentation, that, on the contrary, its resinous parts retard the aptness which malt has to this act. Hops, in this manner, keep barley-wines sound a longer space of time, and by repeated and slow frettings, give an opportunity to the particles of the liquor to be more separated and comminuted. Fermented liquors acquire thus a greater pungency, so that, even if they did receive no additional strength from this mixture, the direct contrary of which might easily be made to appear, still would hops, from the circumstance just mentioned, be the occasion of an improvement of taste and an increase of strength.

Dr. Grew seems to think, that the bitter of the hops may be increased by a greater degree of dryness; but perhaps this is only one of the means of retaining longer this quality, which undoubtedly decreases through age, in a proportion which, as near as can be guessed, is from ten to 15 *per cent* yearly.

The varieties in the soil, and in the seasons, in which hops are planted, may also have some share in their inequality. They seem to be much benefitted by the sea air. Whoever will try similar processes with the Worcestershire and Kentish hops, will soon perceive the difference, and the general opinion strengthens this assertion, as the county of Kent alone produces nearly half the quantity of hops used in this kingdom.

The sooner and the tighter hops are strained after having been bagged, the better will they preserve themselves. The opinion that they increase in weight, if not strained until after Christmas, may be true, but will not recommend the practice; the hops imbibe the moisture of the winter air, which, when the weather grows drier, is lost again, together with some of the more spirituous parts. Nor is this the greatest damage occasioned by this delay, as hops, by being kept slack bagged in a damp season, too often become mouldy.

Hops may be divided into ordinary and strong, and into old and new. The denomination of old is first given to them, one year after they have been bagged. New ordinary hops, when of equal dryness, are supposed to be alike in quality, with old strong ones.

The different teints, with which hops are affected in brewing, afford the best rule for adapting their color to that of the malt; in general the finest hops are the least, but the most carefully, dried.

To extract the resinous parts of the hops, it is necessary they should be boiled. The method of disposing them is generally to put the whole quantity, in the first wort, which being, always made with waters less hot than the succeeding extracts, possesses the greatest share of acids, and is in want of the largest proportion of resins and bitters to defend it. The virtue of the hops is not entirely lost by once boiling, and there remains still enough to bitter and preserve the second wort. But where the first is short of itself, and a large quantity of hops are required for the whole, it is needless and wasteful to put more in at once than the first must can absorb, which appears by a thin bitter pellicle floating on the wort. No particular rules can be given to avoid this inconvenience, as the nature and quantity of the worts on one side, and the strength of the hops on the other, must occasion a difference in the management easily determinable by experience.

Hops carry with them into the wort large quantities of air, the more of which a wort possesses the more it is inclinable to ferment: and, as fire expels air, the more hops a wort contains, the longer a liquor is intended to be kept, or the hotter the season is in which it is brewed, the longer boiling it requires.

When

When waters, not sufficiently hot, have been used, the worts, for want of the proper quantity of oils, readily admit of the external impressions of the air, and are easily excited to a strong and tumultuous fermentation, which disperses the bitter particles, and diminishes the effects of the hops. The virtue of this plant is therefore retained in the drinks, in proportion to the heat of the extracts, and the slowness of the fermentation.

Hops should be used in proportion to the time that the liquors are to be kept, and the heat of the air in which they are fermented. As the medium heat which dried the malt is added to that of the extracts, the value of the oils, raised by the drying of the hops, is likewise to be added to the medium of the malt's drying and of the heat of the extracts.

The quantity requisite to preserve any drink a twelve month being known, and how much is necessary to keep beers or ales four weeks, when the air is at 40 degrees, tables may be formed ascertaining the proper quantities to be used in all cases.

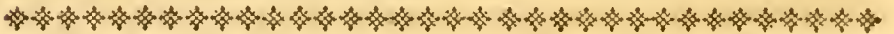
Experience has shewn that 12 pounds of hops of a good quality, joined to one quarter of malt, are a sufficient preservative for one twelve month. * It has likewise been found that 15 pounds produce upon the worts the same effect, as if 5

* This rule only takes place for such climates, as are of the same heat with ours; for when drinks are brewed to be expedit in more southern

countries, or to undergo long voyages, twenty pounds of hops to one quarter of malt have been used with success.

degrees more of heat had been added to that of the extracts. The calculations to prove this would be long and unnecessary, and the effect of hops as well as that of the malt may be judged of by the color of the extract. I would only add that hops, after they have been boiled for one purpose, are sometimes and especially in small beer brewed after pale ales, used for another, and may then be supposed to have lost three fourths of their virtue.

After having premised these observations, the construction as well as utility of the following tables will be obvious.



A TABLE of the value of the hops expressed in degrees, to be added to the medium of the dryness of the malt, and of the heat of the extracts.

Hops			new or strong			pale, low dried, old
15 lb equal	-	-	5	-	-	$3\frac{3}{4}$
12	-	-	$3\frac{3}{4}$	-	-	3
8	-	-	$2\frac{1}{2}$	-	-	2
4	-	-	$1\frac{1}{4}$	-	-	1

A TABLE



A TABLE of the quantity of hops requisite for every quarter of malt brewed for porter, supposed to be fit for use from eight to twelve month.

	lb
Old ordinary hops started over old beer -	14 <i>per</i> quarter
d ^o neat guiles - - - -	12 $\frac{1}{2}$
Strong good old hops when started over old beer.	12 $\frac{1}{2}$
d ^o neat guiles - - -	12
New strong hops when started over old beer	12
ditto neat guiles - - - -	11 $\frac{1}{2}$
New ordinary hops started over old beer -	12 $\frac{1}{2}$
ditto neat guiles - - -	12

N. B. The quantity of old beer to be blended with new is here supposed never to exceed one eight part of the whole quantity.



A TABLE of the quantity of hops requisite for common small beer, for each quarter of malt, in every season.

Heat in the air	new hops		old hops	
	lb	oz.	lb	oz.
35°	2	8	2	8
40	3	0	3	0
45	3	8	3	8
50	4	4	4	8
55	5	0	5	8
60	6	0	6	8
65	6	12		
70	7	8		
75	8	4		
80	9	0		

The medium heat of the hottest days in England, seldom at any time, exceeds 60 degrees, but I continued the table proportionably, as the quantities are here set down from repeated experiments. It appears, that, as, at the lowest fermentable degree of heat, 3 pounds of hops are required for each quarter of malt, at the highest, 9 pound of hops should be allowed for each quarter.

A TABLE



A TABLE of the quantity of hops necessary to each quarter of malt in brewing amber or two-penny.

Heat of the air				lb	oz.
35°	-	-	-	1	6
40	-	-	-	2	0
45	-	-	-	3	0
50	-	-	-	4	0
55	-	-	-	5	0
60	-	-	-	6	0

Amber is a liquor, which, by repeated periodical fermentations, is so attenuated, as to be soon fit for use, and by its strength is supposed to resist longer the impressions of the air than other liquors, especially in winter; for this reason, though soon fit for use in this season, it requires fewer hops than common small beer, and wants only the same quantity in the summer, from its fermentations being quick and violent.

+++++

A TABLE of the quantity of hops necessary for each quarter of malt, in brewing Burton ale.

This liquor requires fewer hops than such ales, which are more diluted by water: as it is always brewed in the winter, the quantities here set down are for the number of months it is supposed to be kept, before it is drank or bottled.

Months	lb	oz.
1	1	0
2	1	8
3	2	0
4	2	8
5	3	0
6	3	8
7	4	0
8	4	8
9	5	0
10	5	8
11	6	0
12	6	8

Though common amber, keeping amber and Burton ales require the same degree of heat in their extracts, yet some small exception must be made to this rule, on account of the different quantity of hops used.

Besides

Besides the use of hops for keeping the musts of malt, they may be also employed, to strengthen the extract, or at least to give it a power to resist infection or acidity. One or two pounds in a net suspended in the water the extract is to be made with, are sufficient for that purpose.

Though the purchasing the materials, used in any manufacture, does not immediately relate to its practical part, yet as, in this case, it is of great importance to the brewer to know what stock it is prudent for him to keep of an ingredient equally necessary and variable in its value, I hope the attempt of a calculation on this subject will easily be pardoned.

The amount of the duty upon hops, for 13 years, from 1733 to 1745, was £. 704198, which sum, estimating the duty at 2*s.* *per* bag, gives 670665-bags used in that time. At the beginning and expiration of this interval, hops sold at that high price, at which no stock in hand is supposed to remain, viz. from £. 8 to £. 10. *per* hundred. If, therefore, to the aforesaid quantity of 670665 bags, which may be supposed to have served for the whole consumption during this period, we add what may have escaped paying duty, and somewhat for the greater demand for this commodity at this time than it was twenty years ago, the annual consumption of hops may be estimated at 65000 bags. From these premises, the following table was constructed, which, though not capable of absolute certainty, may be of some service to the brewers; in informing them of the quantities, that probably remain in hands at any time, and the stock which prudence will suggest them to lay in.

A TABLE shewing the medium price, hops should bear, and determining the quantity to be purchased, in proportion to the stock in hand.

Prices of hops at a medium *	stock of new and old hops in the whole kingdom, after the harvest	quantity of hops equal to as many weeks consumption.
30 Shill.	130000 bags	70
35	125000	65
40	120000	61
45	115000	57
50	110000	53
55	105000	47
60	100000	44
70	95000	40
80	90000	36
90	85000	32
100	80000	28
110	75000	24
120	75000	20
130	70000	16
140	67000	12
150	65000	8
160	62000	4
170	60000	
180	57000	
190	55000	
200	52000	


* Forty shillings *per* hundred weight are supposed to be the mean difference between new and old hops, and ought to be estimated in proportion to the quantity of old left in hand, and that of new hops grown, in order to ascertain the value of the last.

SECTION



SECTION V.

*Of the LENGTHS necessary to form MALT-LIQUORS
of the several denominations.*

 Y length, in the brewery, is understood the quantity of drink made from one quarter of malt. Beers and ales differ in this respect; and the particular strength allowed to every sort of drink varies also somewhat, according to the prices of the materials. This increase or abatement is however never such as to make the profits certain or uniform; for the value of the grain being sometimes double of what it is at other times, a proportionable diminution in strength can by no means take place.

It might be expected to find here tables determining the differences in strength and quality of each drink, in proportion to their prices and the expences of the brewer. But this, on many accounts, would be inconvenient, and in some respects impracticable. He, who chuses to be at this trouble, ought not only to take in his account the prices of malt and hops, and the duties paid on each commodity, but the hazards in the manufacturing of them, those of leakage, of bad cellars, and of careless management, the frequent returns attended with many losses, the wearing out of utensils and especially of casks, which last article engrosses at least one fifth of the brewer's capital, the charges of servants, horses, and carriages for the delivery

delivery of the drinks, the duties paid immediately to the government without any security for the reimbursement, at least in point of time, the large stock and credit necessary to carry on this trade, and many other incidents hardly to be estimated with a sufficient accuracy, and never alike to every brewer. In general it appears, that the expences of malt and hops are seldom more than equal to the charge attending the manufacture, or about half the value of the drinks. Hence this conclusion, sensibly felt by every honest trader, must result, that, from change of circumstances, the reputation of the profits has outlived the reality of them, and that a trade, perhaps the most useful to the landed interest and to the government, of any, seems distinguished from all, by greater hazards and less encouragement.

But, in a treatise like this, where only the rules, upon which true brewing is founded, are laid down, I would avoid any thing, that might, though undesignedly, give handle to invidious reflections, and ill-timed controversies. I therefore content myself, with setting down the latitudes of lengths generally allowed to drinks of every denomination.



Lengths of common small beer.

- | | | |
|--|---|------------------------------|
| 4 $\frac{1}{4}$ Barrels to 5 $\frac{1}{4}$ | } | from one quarter
of malt, |
| Lengths of keeping small beer. | | |
| 4 $\frac{3}{4}$ Barrels to 5 $\frac{1}{2}$ | | |
| Lengths of amber or pale ale. | | |
| 1 $\frac{1}{2}$ Barrel to 1 $\frac{3}{4}$ | | |
| Lengths of brown strong or porter. | | |
| 2 $\frac{1}{4}$ Barrels to 2 $\frac{3}{4}$ | | |
| Lengths of Burton ale. | | |
| 1 Barrel to 1 $\frac{1}{4}$ | | |





SECTION VI.

METHOD of CALCULATING the HEIGHT in
the COPPER at which Worts are to go out.

THE expected quantities or lengths of beer and ale can
T only be found by determining what height of the
 copper the worts must be at.

Brewers have several methods of expressing to what part they would have the worts reduced by boiling. *Brass*, is the technical appellation for the upper rim of the copper; it is a fixed point, from which the estimation generally takes place, either by inches, or by the nails, which rivet the parts of the copper together. These last are not very equal, either in the breadth of their heads, or their distances from each other. Inches then, though not specified on the copper, but determined by the application of a gauge, on which they are marked, claim the preference. The necessity of coppers being gauged, and the contents of what they contain on every inch, both above and below brass, known, must appear in a stronger light, the nearer we bring the art to exactness. The following tables will shew the most useful manner, in which I conceive this gauging should be specified.



Gauges of coppers.

Great copper set up November 30. 1750. Little copper set up August 3. 1753:

			* B.	F.	G.		B.	F.	G.
			Full						
			17	3	4	15	2	7	
			16	2	1	14	1	5	
			15	0	5	13	0	3	
			14	2	8	12	3	1	
			13	1	4	11	1	7	
			12	3	7	10	0	6	
			11	2	3	9	3	4	
			10	0	6	8	2	2	
Inches above Brafs.	9		12	3	2	7	0	8	
	8		12	1	5	6	3	6	
	7		12	0	1	5	2	5	
	6		11	2	4	4	1	3	
	5		11	0	8	3	0	1	
	4		10	3	3	2	2	7	
	3		10	1	7	1	1	5	
	2		10	0	2	1	0	5	
	1		9	2	6	1	3	5	
Brafts			9	1	1	2	2	5	
Inches below Brafs	1		8	3	8	3	1	5	
	2		8	2	6	4	0	5	
	3		8	1	4	5	3	5	
	4		8	0	2	6	2	5	
	5		7	2	8	7	1	5	
	6		7	1	6	8	0	5	
	7		7	0	4	9	3	4	
	8		6	3	3	10	2	5	
	9		6	2	2	11	1	6	

* B. stands for barrels, F. for firkins, G. for gallons.

By the foregoing table, it is seen that my great copper holds nearly 9 barrels of water to brass, and as the difference of the volume between boiling worts of most denominations and cold water, is nearly as 7 to 9, the quantity it will yield of boiling worts will be but 7 barrels. The diameter of this copper just above brass, is 68 inches, at a medium, and at that mean it holds 12 gallons 7 pints of cold water or nearly 11 gallons of boiling worts, upon an inch.

Hops macerated, by being twice boiled, take up for every 6 pound weight a volume, in the copper, equal to 4 gallons and $\frac{1}{2}$ of water or a *pin*.

In a copper, the gauges of which have just been set down, it is required to know, what number of inches a length of 24 barrels must go out at, with 15 pounds of hops, the guile of beer to be brewed at 2 worts.



	24 barrels, length of beer.
	14 barrels, for two full brafs,
	<hr style="width: 10%; margin-left: auto; margin-right: 0;"/>
	10
	34 numbers of gallons to a barrel accounted by the excife, out of the bills of mortality
	<hr style="width: 10%; margin-left: auto; margin-right: 0;"/>
	40 hops twice put in 15 lb. is 30
	30
	<hr style="width: 10%; margin-left: auto; margin-right: 0;"/>
	6 lb. [30
	<hr style="width: 10%; margin-left: auto; margin-right: 0;"/>
gallons of	340
boiling wort	22
upon an inch 11 [362	<hr style="width: 10%; margin-left: auto; margin-right: 0;"/>
	5
	equal to gallons 4 $\frac{1}{2}$
	<hr style="width: 10%; margin-left: auto; margin-right: 0;"/>
	22
	<hr style="width: 10%; margin-left: auto; margin-right: 0;"/>

33 inches above brafs, the 2 worts to go out together.

When 3 worts are boiled, the amount of three full brashes must be deducted from the length; and as the hops go into the copper three times, they become more macerated, and take up much less room. The proportion is then nearly of 18 pounds of hops for each 4 gallons $\frac{1}{2}$.

Thus in coppers, which have never been tried or used, we are able, by the gauges alone, to determine our lengths; but as their circumferences are not always exact, and the worts are of very different strengths, we should never neglect such tryals, as may bring us nearer to accuracy and truth.



SECTION VII.

Of BOILING.

IT has been a question, whether boiling is necessary to a wort; but as hops are of so resinous a quality, that the whole of their virtues is not yielded by extraction, decoction or boiling is as needful as the plant itself, and is, together with fermentation, productive of that uniformity of taste in the compound, which constitutes good beer.

Worts are composed of oils, salts, water, and perhaps some small portion of earth, from both the malt and hops. Oils are capable of receiving a degree of heat much superior to salts, and these again surpass in this respect the power of water. Before a wort can be supposed to have received the whole of the fire it can admit of, such a degree of heat must arise, as will be in a proportion to the quantity of the oils, the salts and the water. When this happens, the wort may be said to be intimately mixed, and to have but one taste. The fire, made fiercer, would not increase the heat, or more exactly blend together the constituent parts; this purpose once obtained, the boiling of the worts is completed.

It follows from thence, that some worts will boil sooner than others, receive their heat in a less time, and be saturated with less fire; but, as it is impossible and indeed unnecessary to estimate exactly

exactly the quantities of oils, salts and water contained in each different wort, it is out of our power to fix, for any one, the degree of heat it is capable of. This renders the thermometer in this case useless, and obliges us to depend entirely on experiment, and to observe the signs, which accompany the act of ebullition.

Fire, as before has been mentioned, when acting upon bodies, endeavours to make its way through them in right lines. A wort set to boil, makes a resistance to the effort of fire, in proportion to the different parts it is composed of. The watery particles are, it is imagined, the first, which are saturated with fire, and, becoming lighter in this manner, endeavour to rise above the whole. The salts are next, and last of all the oils. From this struggle, proceeds the noise heard, when the worts first boil, which proves how violently they are agitated, before the different principles are blent one with an other. While this vehement ebullition lasts, we may be sure that the worts are not intimately mixed, but when the fire has penetrated and united the different parts, the noise abates, the worts boil smoother, the steam, instead of clouding promiscuously as it did at first round the top of the copper, rises more upright, in consequence of the fire passing freely in direct lines through the drink, and when the fierceness of the fire drives any part of the drink from the body of the wort, the part so separated ascends perpendicularly. Such are the signs, by which we may be satisfied that the first wort, or the strongest part of the extracts, has been so affected by the fire as to become nearly of one taste. If, at this time, it is turned

out

out of the copper, it appears pellucid, and forms no considerable sediment.

The proper time, for the boiling of the worts, has hitherto been determined, without any regard to these circumstances; hence the variety of opinions, on this subject, greater perhaps than on any other part of the process. While some brewers would confine boiling to so short a space as five minutes, there are others, who believe two hours absolutely requisite. The first alledge, that the strength of the wort is lost by long boiling; but this argument will not hold good against the experiment of boiling worts in a still, and examining the collected steam, which appears little else than mere water. Those, who continue boiling the first wort a long time, do it in order to be satisfied, that the fire has had its due effect, and that the hops have yielded the whole of their virtue. They judge of this, by the worts curdling, and throwing out flakes like snow. If a quantity of this sediment is collected, it will be found to the taste both sweet and bitter, and if boiled again in water, the decoction, when cold, will ferment and yield a vinous liquor. These flakes, therefore, contain part of the strength of the wort; they consist of the first and choicest principles of the malt and hops, and by their subsiding, become of little or no use.

It appears from these circumstances, that boiling a first wort too short or too long a time is equally detrimental, that different worts require different times, and that these times can only be fixed by observation.

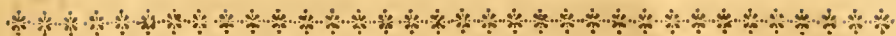
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The first wort having received, by the assistance of the fire, a sufficient proportion of bitter from the hops, is separated therefrom. The hops being deprived of their virtues, are, on the other hand, enriched with some of the glutinous particles of the malt. They are afterwards a second and sometimes a third time boiled with the following extractions, and thereby divested, not only of what they had thus obtained, but also of the remaining part of their preservative qualities. The thinness and fluidity of these last worts render them extremely proper for this purpose. Their heat is never so intense as that of the first wort when boiling; because they consist of fewer oils and are incapable of receiving so great a degree of heat. This deficiency can only be made up by doubling or tripling the space of time the first wort boiled, so that what is wanted in the intenseness of the heat be supplied by its continuance.

The following table is constructed from observations made according to the foregoing rules.



A TABLE



A TABLE shewing the time each wort requires to boil for the several sorts of beer, in every season.

Degrees of heat in the air.	Brown beer, keeping pale strong and keeping small beer.			Small beer.			amber	Burton	small after amber	keeping small after amber
	hours	hours	hours.	hours	hours	hours.	hours	hours	hours	hours.
	1 wort	2 wort	* 3 wort	1 wort	2 wort	3 wort.				
35°	1	2	4	$\frac{1}{2}$	1	2	$\frac{1}{2}$	$\frac{1}{2}$	1	2
40°	1	2	4	$\frac{1}{2}$	1	2	$\frac{1}{2}$	$\frac{1}{2}$	1	2
45°	1	2	4	$\frac{1}{2}$	1	2	$\frac{1}{2}$	$\frac{1}{2}$	1	2
50°	1	2	4	$\frac{1}{2}$	1	2	$\frac{1}{2}$	$\frac{1}{2}$	1	2
55°	1	2	4	$1\frac{1}{2}$	3		$\frac{3}{4}$	$\frac{3}{4}$	1	2
60°	2	4	0	$1\frac{1}{2}$	3		$\frac{3}{4}$	1	$1\frac{1}{2}$	2

It may, perhaps, be objected, that, by a long boiling of the last worts, the rough and austere part of the hops may be extracted, and give a disagreeable taste to the liquor; but let it be observed, that, this only happens, either in beers long to be kept, or in such as are brewed in very hot weather. In the first case, the roughness wears off by age, and grows into strength, and in the last, it is a check to the process must have in such seasons to ferment.

* When there are but two worts in boiling is to be observed as marked for brown strong, keeping strong, keeping pale small, or common small, the second and third worts.


One observation more is necessary under this head; most coppers, especially such which are made in London, and set by proper workmen, waste or steam away, by boiling, about three or four inches of the contained liquor, in each hour. The quantity wasted being found on tryal, and knowing how much water the copper holds upon an inch, the quantity lost by boiling in each brewing may easily be estimated.



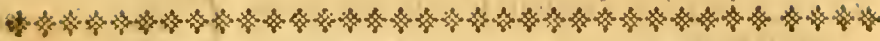


SECTION VIII.

Of the QUANTITY of WATER wasted; and of the application of the preceding rules, to two different processes of brewing.


WASTE water, in brewing, is termed that, which, though of service in the process, yet does not remain in the beers or ales when made. Under that head is comprehended the water steamed away in the boiling of the worts; that which is lost by heating for the extracts; that which the utencils imbibe when dry; that which necessarily remains in the pumps and underback; and more than all the water which is retained in the grist. The fixing to a minute exactness how much is thus expended, is both impossible and unnecessary. Every one of the articles just now mentioned varies in proportion to the grist, to the lengths made, to the construction and order of the utencils, and to the time employed in making the beer. To these different causes of the steam being lessened or increased, might moreover be added every change in the atmosphere. However, as, upon the whole, the quantity of water lost varies from no reason so much as from the age and dryness of the malt, experience is in this case, our sole and surest guide. I have, in the following table, placed under every mode of brewing, how much I have found necessary to allow for this waste.

Brown



Brown strong and pale strong beers.

Barrels pins.

For old malts allow - - - - - 1 5 *per quarter*
 For new * malts - - - - - 2 0 *per quarter*

Keeping small and common small beers.

For either new or old malt allow - - 2 4 *per quarter*

Amber or pale ales.

For either new or old malt allow - - 1 4 *per quarter*

Keeping small or common small after amber.

Allow for waste. - - - - - 0 2 *per quarter*

It is now time to begin the account of two brewings, which admit of the greatest variety, both in themselves, and in the season of the year. The same processes will be carried on, in the sequel of this work, until they be completed.

On the 10th of July a brewing for common small beer is to be made with 6 quarters of malt.

* By new malt, I understand such, having laid more than a sufficient time to be thoroughly impressed therewith. as has not lost the whole of the heat received on the kiln, and by old such, as is of equal heat with the air, by

The PRACTICE of BREWING.

By page 123 the medium heat of the air at } 60 degrees
 this time is - - - - - }

By page 144 the malt to be used for this } 130 degrees
 purpose should be in dryness at. - - }

By page 172 the proper quantity of new hops is 6 pounds *per* quarter. The length, according to the excise gauge without the bills of mortality, may be rated at 5 barrels $\frac{1}{4}$ *per* quarter, or from the whole grist at 30 barrels $\frac{1}{4}$.

By page 183, the inches required in the copper, to bring out this length, at 2 worts, will be, for coppers as gauged page 181, 56 inches in the 2 worts above brags.

The state of this part of the brewing is therefore ;

Six quarters of malt dried to 130 degrees, 36 pounds of hops for 30 barrels $\frac{1}{4}$ to go out at 56 inches above brags.

30 $\frac{1}{4}$	Length	{	Boiling by page 188
			1 wort 1 hour $\frac{1}{2}$ or 5 inches
5 $\frac{1}{4}$			2 wort 3 hours or 9 inches
15			waste water page 191

51 barrels ; whole quantity of water
to be used.

And by page 153 we find the heat of the first extract to be 151 degrees, and the heat of the last 183 degrees.

The

The other brewing, of which I purpose to lay down the process in this treatise, is one for brown beer or porter of 11 quarters of malt, to be brewed on the 20th of February.

By page 123 the medium heat of the air at } 40 degrees
 this time is - - - - - }

By page 155 the malt for this purpose should heat } 138 degrees

By page 171 the quantity of hops is 12 pounds *per* quarter. The length I would fix for this liquor, according to the excise gauge without the bills of mortality, is 2 barrels and 4 pins from a quarter, or from the whole grist 27 barrels $\frac{1}{2}$.

By page 183 the inches required, in a copper, such as I have specified page 181, to bring out this length at 3 worts, are 29 above brass.

The state of this brewing, so far as we have considered it, is therefore 11 quarters malt dried to 138 degrees, 132 pounds of hops for 27 barrels $\frac{1}{2}$ to go out at 29 inches above brass.

27 $\frac{1}{2}$	barrels the length	
	boiling by page 188	
	1 wort 1 hour or 4 inches	}
	2 wort 2 hours or 6 inches	
8 $\frac{1}{4}$	3 wort 4 hours or 12 inches	
18	waste water page 191 old malt	
		1 $\frac{2}{3}$ <i>per</i> quarter
54	barrels, whole quantity of water to be used	


And by page 157 we find the heat of the first extract to be 144 degrees, and the heat of the last extract 162.

SECTION



SECTION IX.

Of the DIVISION of the WATER for the respective WORTS, and MASHES, and of that of the heat adequate to each of these.

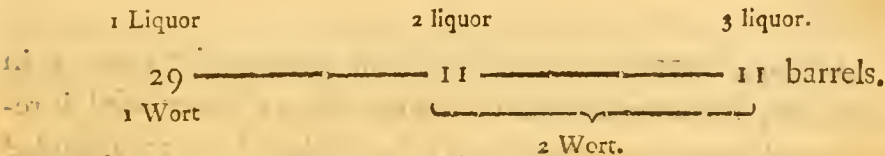

THAT the whole quantity of water, as well as that of heat, required in any brewing, ought not to be applied at once to the grist, is obvious, both from reason, and from the example of nature, who, in forming the juice of the grape, divides the process, and increasing successively both the moisture and the heat, gives time to each degree to have its complete effect. A division of the water and heat applied to the grist is equally necessary, but previous to this division the following general rules may be laid down.

The grist is, if possible, at no time, to be left with less water than what will cover the malt, and put all its parts in action. In the first mashes for strong beer, an allowance is to be made for as much water as the grist will imbibe; and lastly the whole quantity of water, used in brewing, should be divided, according to some proportion analogous to that of the degrees of heat.

Processes for brewing are carried on, either with one copper, or with two. Though the first of these methods is almost

most out of use, it may be necessary to give an example or two of the division of the water used in this case.

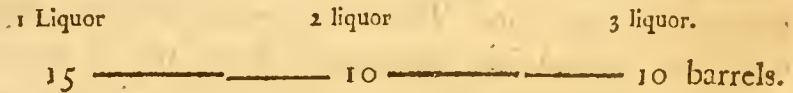
In brewing with one copper, scarcely more than three mashes can be made; otherwise the time taken up in boiling the worts and preparing the subsequent waters for extraction would be so long, as to cause the grist to lose great part of its heat, and perhaps become four. The whole water required might naturally be divided into three equal parts, was it not for the quantity imbibed in the first mash; but, as in this way of brewing, the best management is to make the first wort of one mash and the second wort of the other two, it will be found necessary to allow, for the first extracting water, four parts out of seven of the whole quantity required, and to divide the remainder equally for the other two mashes. Thus if the whole quantity of water required was 51 barrels, the lengths of the extracting waters would be as follows;



The water imbibed and retained by the malt is allowed for in this computation, which will be found just to every purpose, for small beer brewed in one copper only.

But in strong beers and ales, with three mashes, whether brewed at one, two or three worts, the case will be somewhat different, as care should always be taken to reserve for every mash

mash a sufficient quantity of water to apply to the grist. For this reason, no greater proportion ought to be used in the first mash than that of three parts out of seven, as the volume of the malt is in a greater proportion to the quantity of water than in the preceding case. If, therefore, the whole quantity of water used was 35 barrels, the length of the liquors would be ;



In general employing only one copper, is allowed to be bad management, as, in some part or other, however the process is well contrived, the business must stand still, and consequently the extracts be injured by the air, continually affecting them. The best and most usual practice is, on this account, to brew with two coppers. Other rules are here necessary to be observed, and I shall be more particular in the explanation of them.

When a brewing is to be boiled off in one entire wort, as in fine ales, no other division of the quantity of water used is required than into two equal parts ; but, when beers are intended to be made, as they commonly are, at two worts, the water must first be proportioned to these, and each of the parts be equally divided for the several mashes, which are to form the worts. Experience has shewn, that four sevenths of the whole water should be applied to the first wort, and the remainder three sevenths to the second. This will constantly be found to answer our purpose, and ought also to direct us in the division

fion of the extracting heat. Thus, if, as in the beforemen-
tioned guile of small beer (page 192,) 51 barrels be the whole
quantity of water used,

$$\begin{array}{r} 51 \\ 4 \\ \hline 7 \text{ [} 204 \end{array}$$

29 barrels will be the length of the
first wort, and 22 barrels that of the second.

The last extracting heat for this process being - 183 degrees
and the first - - - - - 151 degrees

their difference - - - 32 degrees

must be proportioned in the same manner - - 4

$$\begin{array}{r} 7 \text{ [} 128 \end{array}$$

18 degrees

therefore ought to be added to the heat of the first wort, and 14
degrees the remainder of the difference is to be added to the heat
of the last. As both the water for the mashes and the increased
heat are to be equally divided, the length and heat of each ex-
tract will be as follows :

Heat 151°	169°	176°	183°
*length 14 $\frac{1}{2}$	14 $\frac{1}{2}$	11	11
liquor 1	2	3	4
└──────────┘		└──────────┘	
1 wort		2 wort.	

* By giving to the first wort, one
seventh part more of the water than to
the last wort, a proper allowance is
made for what is imbibed by the malt
used as it is on quality of the extract on-

ly that the justness of the process depends
so is it right to add four sevenths of the
heat to the second mash the first extract
being fixed on principles before recited.

This rule constantly takes place, when there are but two worts either of strong or of small beer; but if the benefit of the drink, or the smallness of the utensils, obliges us to carry on the process with three worts, these proportions must necessarily be altered, and the following have in that case been found most advantageous.

The first and second wort ought to have two thirds of the water; the first wort two thirds of this quantity, the second the remainder of this, and the third wort one third part of the whole.

Porter or brown beer is the sort of drink; in which this division is most commonly observed. Let the whole quantity of water to be used be that of the brewing, of which the elements have been laid down, (page 193,) or 54 barrels.

$$\begin{array}{r} 54 \\ 2 \\ \hline \end{array}$$

$$3 \left[\begin{array}{r} 108 \\ \hline \end{array} \right.$$

$$36$$

$$2$$

$$3 \left[\begin{array}{r} 72 \\ \hline \end{array} \right.$$

24 barrels of water for the first wort

12 barrels for the second wort

18 barrels for the third wort.

$$54$$

The last extracting degree for this drink is 162
 the first - - - - - 144

$$\begin{array}{r}
 18 \text{ their difference} \\
 \hline
 2 \\
 \hline
 3 \quad [\quad 36 \\
 \hline
 12 \\
 2 \\
 \hline
 3 \quad [\quad 24 \\
 \hline
 \end{array}$$

8 degrees to be added to the first extracting heat, to make up that of the second mash.

4 degrees for the second wort.

6 degrees for the third wort.

18

A grist of 11 quarters of malt is too large, to admit of the water allowed for the first wort to be equally divided between the first and second mash, and the extraction could not properly be formed, if the first heat of 144 degrees was not allowed to take place; therefore, rather than use the whole 24 barrels

in one mash, with the additional 8 degrees of heat, a sufficient quantity only must be applied to the first mash, both to work it and to get as much of the extract to come down as will save the bottom of the copper, it is to be pumped into. By this management, there will be enough left to form the second extract with, or what by the brewers is termed *the piece liquor*. The exact quantity of water the first mash should have, might be referred to the following section, but the order we have laid down will excuse our anticipating thereon.

It has been found, and will hereafter be proved, that a volume of 11 quarters of malt, dried to 138 degrees, is equal to 6, 11 barrels of liquid, that malt will require twice its volume of water to wet it, and that this quantity is retained after every tap is spent.



6,11 Barrels, volume of the 11 quarters of malt
3
 18,33
 6,11
12,22 barrels of water imbibed by the grist
 24,30 whole quantity of water allowed for the first wort
3 [11,78 extract, which will be yielded from the first and se-
 3,92 cond mash length of the first piece, which is suffi-
11,78 cient to save the copper
 3,92
 12,22 quantity imbibed as above
16,14 quantity of water for the first mash
 7,86 quantity of water for the second mash.
24,00

The several lengths of the water for each mash, and the heats proportioned to them will consequently be as follows :

heat 144°	152°	156°	159°	162°	
length 16*	8	12	9	9	
liquor 1	2	3	4	5	
└──────────┘		└──┘		└──────────┘	
1 wort		2 wort		3 wort.	

Thus having shewn how to ascertain the quantities of the malt, the hops, the water and the heat to be used, and to

* Here, and in many other places, small fractions have been neglected.

propor-

proportion them to each other, as the good or bad properties of beers arise, from the extracts, and fire is the governing agent, we must now seek the means to administer the right portion of heat, and so to temper the water that is to form the extracts, as not to be disappointed of our intentions. In the calculations made for this purpose, not only the water in the copper, but the value and effect of the grist, as to heat and cold, must be considered. The proof of our success can be ascertained by no other means, than by observations made with the thermometer placed in the extract, in the nearest part it is to, and as it comes from, the malt, viz. at the cock fixed in the mash tun, to convey the liquor to the underback, in order to its being pumped up into the copper, and there joined to the hops.



SECTION X.

An enquiry into the Volume of MALT, in order to reduce the GRIST to a common measure.



THE gallon, by which malt is measured, is exactly of the same capacity with that, which is used for beer or water. The quarter of malt contains 64 gallons of this measure, and the barrel, within the bills of mortality, according to the gauges used by the excise, contains 36 gallons, but without the bills, 34; though the first quantity is the measure for sale throughout the kingdom. Hence it would appear, that proportioning the grain to the barrel of water would be no difficult undertaking. This however is so far from being the case, that, after having made use of several calculations to help us to the true proportions, we shall find, that they want the corroborating proofs of actual experience, before they can be intirely depended upon.

The ultimate parts of water are so very small, as to make this, as well as all other liquids, appear to the eye one continued uniform body, without any interstices. This cannot be said of malt laying together, either whole or ground; there are numbers of vacancies between the corns, when whole, and between the particles when ground, so that the real volume occupied by any quantity of malt is properly no more, then the space which

which would be occupied by every individual corn, either whole or cut afunder, were they closely joined together.

To determine the quantity of cold water to be added to that, which is brought to the boiling point, (an act by the brewers called *cooling in*;) it is necessary to know, what proportion a quarter of malt bears to the measure of a barrel of water. Several operations will be found requisite to come to this knowledge; viz. to take several gauges of different brewings, more especially in the first part of the process; to be well acquainted with the degree of dryness of the malt used, the heat of the first extract, and the quantity of liquor the mash tun holds upon every inch; to find out what degrees of expansion are produced by the different degrees of heat in the first mash, how much less water the mash tun holds upon an inch when hot, than it does when cold, what quantity of water is lost by evaporation, and in what proportion at the several terms of the process. In order to put this in practice, the gauges of the following brewing were taken.

5 quarters of malt dried to 125 degrees.

B.* F. G.

The quantity of water used for the first mash was 12 2 3

The mash and water gauged together in the } 25, 00 inches
mash tun just before the tap was set. - }

* B. stands for barrels, F. for firkins, G. for gallons, and the numbers past the comma, where the inches are expressed, for decimals; 34 gal-

lons are here allowed to the barrel, in compliance to the excise gauging, as these calculations were made without the bills.

Allow-

Allowance for the space under the false bottom boards of the mash tun, as near as could be computed - 0, 66 inches

The goods gauged in the mash tun, after the first tap was spent. - - - - - } 15, 41 inches

B. F. G.

First piece gauged in the copper - - - - - 8 0 2

B. F. G.

The water employed for the second mash was 12 2 3

The grist gauged with this water just before the tap was set - - - - - } 30, 62 inches

And just after the tap was spent - - - - - 15, 63 inches

B. F. G.

The first wort consisting of these two pieces gauged in the copper - - - - - } 21 2 0

001

B. F. G.

The water used for the third mash was - - - - - 8 3 6

Just before the tap was set the grist with this gauged in the mash tun - - - - - } 24, 60 inches

And just after the tap was spent - - - - - 15, 20 inches

B. F. G.

The water used for the fourth mash was - - - - - 8 3 6

The mash gauged just before the tap was set 24, 60 inches

And just after the tap was spent - - - - - 15, 16 inches

The heat of the first extract was 136 degrees, to which adding two degrees, for what is lost by the tap spending, the true heat of the mash is 138 degrees.

The first extract, before it is blended with hops, may be estimated to be nearly equally strong with a first wort of common small beer. This, when under a strong ebullition, raised the thermometer to 216 degrees, and seven barrels of such a wort, when boiling, occupied an equal space with nine barrels of cold water, at the mean temperature of 60 degrees. Now, if the degrees of expansion follow the proportion of those of heat, the following table constructed upon this supposition will shew how many barrels of cold water would be necessary to occupy the same space with seven barrels of wort of different heat.

Degrees of heat	barrels of cold water	barrels of wort.
216	9,00	7
206	8,87	7
196	8,75	7
186	8,62	7
177	8,50	7
167	8,37	7
158	8,25	7
148	8,12	7
138	8,00	7
127	7,87	7
119	7,75	7

The quantity of water evaporated in a brewing is more considerable than it is generally apprehended to be; after repeated trials, I have found that what was lost in this manner amounted nearly to one fifth.

Now

Now since the heat of the first tap was 138 degrees, and my mash tun holds 20, 25 gallons upon an inch, the following proportion may be deduced from the preceding table.

$$\text{If } 8 \text{ ————— } 7 \text{ ————— } 20, 5$$

7,00

$$8,00 [\underline{14175,00}$$

17,71 gallons, and this is the true quantity contained in one inch, at a heat of 138 degrees.

B. F. G.

The quantity of water used for the first mash was 12 2 3, or 428 gallons, of which one fifth is supposed to be steamed away, when the first liquor is gone through the whole process of the extraction: but as the gauges of the malt and water together are taken before the tap is set, the whole evaporation ought not to be deduced, and one sixth seems to be a sufficient allowance on this account. We may therefore suppose 357 gallons to be in the mash tun at the time of gauging, which number being divided by 17,71 will shew how many inches are taken up by the water at that heat,

$$17,71 [357,0000 [20,15$$

3542

2800

1771

10290

8855

1435

D d 2

The

The PRACTICE of BREWING.

The mash gauged just before the tap was set 25, 00 inches
 Allowed for the space under false bottoms - 0, 66

 25, 66
 Deduct the inches taken up by the water - - 20, 15

Remainder for the five quarters of malt, - - 5, 51 inches
 or 1,10 inch for one quarter. This number being multiplied
 by 17,71 the quantity of gallons contained upon one inch at
 this heat, will give for 19,48 gallons one quarter of this malt.
 There now remains nothing but to bring a barrel of water of
 34 gallons under like circumstances, as to expansion and evapora-
 tion, with these 19,48 gallons, with this difference only that,
 as the proportion required is at the time the water and malt
 first come in contact, and not after the mash has been worked,
 a less allowance for steaming will be sufficient, and may well be
 fixed at one seventh.

If 7,00 ——— 8,00 ——— 34

34

3200

2400

7,00 [272,00

38,85

5,55 lost by steam

33,30 the barrel of water reduc-

ed; and as 19,48 gallons, under the same circumstances, were
 found

found equal to one quarter of malt, the following division will shew the proportion between them.

$$\begin{array}{r}
 19,48 \cdot [33,3000] \cdot 1,70 \\
 \underline{1948} \\
 13820 \\
 \underline{13636} \\
 184
 \end{array}$$

Thus in malt dried to 125 degrees, the quantity of 1,70 quarters is required to make a volume equal to 34 gallons or a barrel of water according to the excise gauging without the bills of mortality.

The more the malt has been dried, the larger the interstices are between its parts; the quantity of water it admits will consequently be greater than what is absorbed by such as is less dry. More of this last malt will be necessary to make a volume, equal to that of the barrel of water; and every different degree of dryness must cause a variety in this respect. It will therefore be proper to repeat the operation with a high dried grist.

Gauges of a brewing of 8 quarters of malt dried to 140 degrees.

B. F. G.

The water used for the first mash	- - - -	11 2 4
Malt and water gauged together in the mash	} 26, 25 inches	
just before the tap was set		- - - -

Allowed

The PRACTICE of BREWING.

Allowed for the space under the false bottom	}	0, 66 inches
of the mash tun - - - - -		
Goods gauged in the mash tun after the first	}	22, 36 inches
tap was spent - - - - -		
		B. F. G.
First piece gauged in the copper - - - - -		5 0 0

		B. F. G.
The water for the second mash was - - - - -		11 2 4
The mash gauged just before the tap was set -		35, 70 inches
Just after the tap was spent - - - - -		22, 19 inches
		B. F. G.

The wort made of these two pieces gauged in	}	17 0 0
the copper - - - - -		
		B. F. G.

The water used for the third mash was - - - - -		8 3 6
The mash gauged just before the tap was set		31, 10 inches
And just after the tap was spent - - - - -		21, 77 inches

		B. F. G.
The water used for the fourth mash was - - - - -		8 3 6
The mash gauged just before the tap was set		30, 50 inches
And just after the tap was spent - - - - -		21, 60 inches

The

The heat of the first extract was 142 degrees. Now by the table of expansions (page 206.)

If $8,05 \text{ --- } 7,00 \text{ --- } 20,25$
 $\text{---} \text{---} \text{---}$
 700

8,05 [1417500] 17,60 will be the
 805 real quantity of
 --- water upon an
 6125 inch in the mash
 5635 tun, when heated
 --- to 142 degrees.
 4900

4830

 700

B. F. G.

Quantity of water in the first mash = 1112, 4

 34

 44

 33

 17

 4

Deduction for the evaporation at this 395
 period, one sixth 65, 83

329, 17 true quantity
 of the water for the first mash, which must be divided by

the

The PRACTICE of BREWING.

the real quantity of water contained upon an inch in the mash tun.

17,60 [329,1700] 18,70 inches taken up in the
 1760 mash tun by the water used in
 the first mash.

15317
14080
12370
12320
500

The mash gauged just before the tap was set 26, 25 inches
 Allowed for the space under the false bottoms 0, 66

26, 91
Inches taken up by the water of the first mash 18, 70
Space occupied by these 8 quarters of malt 8 [8, 21 inches of
Space occupied by one quarter - = = 1, 02
17, 60
6120
714
102
17,9520 gallons of

water, equal in volume to one quarter of this malt.

If

If 7,00 ——— 8,05 ——— 34

34

3220

2415

7,00 [273,70

39,10 expansion of the barrel of water, out of which the seventh 5,58 is to be deducted for evaporation.

remains 33,52 for the barrel of water reduced, which the quarter of malt or 17,95 is to be compared to.

17,95 | 33,5200 [1,86 quantity of malt dried to

1795

140 degrees, equal to one barrel of water

15570

14360

12100

10770

1330

Having thus found the volume of the malt, at two distant terms of dryness, we might divide the intermediate degrees in the same manner as we have done before, could the certainty of these calculations be intirely depended upon; but as some allowances have been made without immediate proof, how near soever truth the result thereof may from experiments appear, it will be

worth while to point out what is wanting to make our suppositions quite satisfactory.

Some part of the calculation depends on the quantity of the evaporation; this, in the same space of time, may be more or less, as the fire under the water is brisk or slow, or as the weight of the atmosphere differs. The gauges are taken at the time the malt and water are in contact, and more or less water may be imbibed in proportion, both of the dryness and age of the malt; water as a fluid, malt as a porous solid body, must differ in their expansion, but in what proportion is to me unknown; effervescence may be another cause of want of exactness; the different cut the malt has had in the mill, its being or not being truly prepared, the difference lastly in the time of the mashing or standing of the grist, prevent our relying wholly upon the calculation. It is however not improbable that some of these incidents correct one another. Since 1,70 quarters of malt dried to 125 degrees are equal to one barrel of water, and 1,86 quarters of malt dried to 140 have the same volume, the difference being but 16 parts out of hundred, the whole of the error cannot be very great, and one quarter six bushels of malt may, at a medium, be estimated of the same volume with one barrel of water. However, as experience is the surest guide, I have, from a very great number of different brewings, collected the following proportions, and repeatedly found them to be true. I have added, in the table, the weight malt ought to have, at every degree of dryness.

A TABLE



A TABLE of the several quantities of malt differently dried, which are equal to the volume of one barrel of water, according to the excise gauge, without the bills of mortality.

	Degrees	weight in pounds	volume of grain.
Barley	80 - - - -	376 - - - -	1,56
	100 - - - -	306 - - - -	1,62
	105 - - - -	301 - - - -	1,62
	110 - - - -	296 - - - -	1,65
	115 - - - -	291 - - - -	1,67
Malt	119 - - - -	286 - - - -	1,68
	124 - - - -	281 - - - -	1,71
	129 - - - -	276 - - - -	1,74
	134 - - - -	271 - - - -	1,77
	138 - - - -	266 - - - -	1,80
	143 - - - -	261 - - - -	1,83
	148 - - - -	256 - - - -	1,86
	152 - - - -	251 - - - -	1,89
	157 - - - -	246 - - - -	1,92
	162 - - - -	241 - - - -	1,95
	167 - - - -	236 - - - -	1,98
	171 - - - -	231 - - - -	2,01
176 - - - -	226 - - - -	2,04	

With a table thus constructed, it is very easy to reduce every grist to an equal volume of water. Suppose those of the brewings we have already mentioned; that of the small beer consists of 6 quarters of malt dried to 130 degrees, the proportion of which in the table is as 1,75 to 1.

quarter of malt	barrel of water	malt	water.
If 1,75	----- 1	----- 6	----- 3,42

These six quarters of malt occupy therefore an equal volume with 3,42 barrels of water. The brown beer grist is of 11 quarters dried to 138 degrees; the proportion of this in the table is as 1,80 to 1.

malt	water	malt	water.
If 1,80	----- 1	----- 11	----- 6,11

The volume of these 11 quarters of malt is therefore the same with that of 6,11 barrels of water, and the whole being brought to the same denomination, we are enabled to find the heat of the first mash; but the effervescence occasioned by the union of the malt and water must prevent this calculation being strictly true, the consideration of which shall take place hereafter.

The circumstances are different in the other mashes; the water used in these meets a grist already saturated, and the volume is increased beyond the quantity found for dry malt. The quantity to be allowed for this increase cannot be determined

mined by our former calculations, and new trials are to be made, in order to fix upon the true proportion.

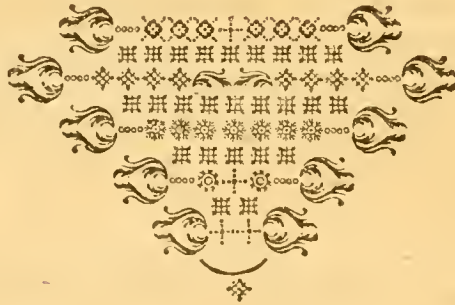
Gauging is undoubtedly the most certain method of proceeding in these researches; but even this becomes less sure, on account of the expansion, evaporation, effervescence, and other incidents already mentioned. Our errors however cannot be very considerable, when we deduce our conclusions from numerous and sufficiently varied experiments.

The volume of the grist of pale malt was found, after the parting of the first extract, to be 15, 41 inches, though the space occupied by the malt, when dry, was only 5, 51 inches; and the volume of the brown grist, at the same period, was 22, 36 inches, though the dry malt filled only a space of 8, 21 inches. The proportion in both these cases, and in all those which I have tried, answers nearly to one third, so that the volume of the grist, in the second and all subsequent mashes, may be estimated at three times the bulk of the malt when dry.

Hence might be deduced a method for calculating the volume of the malt, less intricate than that which we were obliged to make use of. I forbear mentioning it here, as it must appear manifest.

It is found, by the gauges, that the goods, after the several taps are spent, remain sensibly of the same volume, or at least very little diminished; may we not conclude, that the part absorbed

forbed by the water, in which the virtue of the grain and the strength of the beer consist, is contained in an amazing small compass? It is indeed true that hot waters and repeated mashes do swell a little the hulls and skins of the malt, but no allowance made for this increase will be sufficient, to remove the cause of our surprize,





SECTION XI.

Of the proportion of cold WATER to be added to that which is BOILING, in order to obtain the desired heat in the EXTRACT.

THE degree of heat, which causes water to boil is, as we have seen, determined, by Fahrenheit's scale, to 212. It is in our power to give to any part of the extracting water this degree of heat; and by adding to it a sufficient proportion of water of an equal heat with that of the air, and blending these two quantities with the grist of the malt, to bring the whole to the required temperature. The rules for obtaining this end are extremely simple, and cannot be unknown to those, who are skilled in arithmetical operations. But as our view is to render this part of our work generally useful, we think it will be proper briefly to lay down these rules, and to illustrate them by the examples of our two brewings.

Rule to ascertain the heat of the first mash.

Let a express the degree of boiling water, b the actual heat of the air, c the required degree for the extract, m the whole quantity of water to be used, n the volume of the malt; x , that part of the water, which is to be made to boil, will be determined by the following equation,

$$x = \frac{c - b \times m + n}{a - b}$$

or in other terms; the number of the barrels of water to be used being added to the volume of the malt, let the sum be multiplied by the difference between the actual heat of the air and that which is required for the extract, and the produce be divided by the excess of the heat of the boiling water over that of the air.

The first example is that of a brewing of small beer, when the heat of the air is at 60. The volume of the 6 quarters of malt, it consists of, was estimated at 3,42 barrels; the first liquor is $14\frac{1}{2}$ barrels, and the heat required for the first mash 151 degrees.

First mash.

$$m = 14,50 \text{ barrels of water}$$

$$n = 3,42 \text{ volume of the grist}$$

$$m + n = 17,92 \quad c = 151 \text{ heat of the mash}$$

$$c - b = 91 \quad b = 60 \text{ heat of the air}$$

$$\text{heat of boiling water } 212 \quad 1792 \quad c - b = 91$$

$$\text{heat of the air } - 60 \quad 16128$$

$$a - b = 152 \quad] \quad 1630,72 \quad [\quad 10,72 \text{ barrels of water to be}$$

$$152 \quad \text{made to boil out of the } 14\frac{1}{2};$$

$$\text{the incidents to be mentioned}$$

$$1107 \text{ hereafter are not included in}$$

$$1064 \text{ this calculation.}$$

$$432$$

$$304$$

$$128$$

This

The next example of a brewing is that of a grist of 11 quarters of malt for porter or brown beer; the medium heat of the air is 40 degrees, the volume of the grist 6,11 barrels, the first liquor to mash with 16 barrels, and the heat of the extract 144 degrees.

First mash of brown strong beer.

	16,00	barrels of water
	6,11	volume of malt
	22,11	144 heat required in the mash
	104	40 heat of the air
heat of boiling water	8844	104
heat of the air - 40	22110	
	172	[2299,44]
		13,36 barrels of water to
		be made to boil out of the
		15.
	579	
	516	
	634	
	516	
	1184	

I will give one proof of the certainty of this rule, by setting down the state of this first mash from it,

The PRACTICE of BREWING.

	16,00 water of first mash	6,11 barrels volume of grist
13,36 barrels of boil-	13,36 barrels made to boil	40 heat in the grist
212 ing water		
<hr/>	2,64 barrels to cool in	244,40 degrees of heat in the grist.
2672	40 heat of the cold	105,60 A.
1336	water	2832,32 B.
2672	A. 105,60 degrees of	
<hr/>	heat in the [22,11]	3182,32 [144 the degree of heat
B. 2832,32	cold water	2211 required in the first
number of degrees of	13,36 boiling water	mash as above.
heat in the 13,36 bar-	2,64 cold water	9713
rels of boiling water	6,11 volume of grist	8844
	<hr/>	<hr/>
	22,11 barrels, volume	8692
	of the whole mash.	

So long as the mixture consists only of two quantities of different heat, as is always the case of the first mash, the preceding solution takes place. But in the second and other mashes, as three bodies, each of different heat, viz. the boiling water, the cold water, and the mash, are to be mixed, and brought to a determinate degree, the rule must be different; yet, like the former, it is the same with what is used in similar cases of allaying, when different metals are to be melted down into a compound of a certain standard, or different ingredients of different value to be blended, in order to make a mixture of a determinate price. What the different density of the metals, or the different value of the ingredients are in these cases, the different degrees of heat of the boiling water, the grist, and the air, are in this.

Rule

Rule to ascertain the heat of the second mash, and of the subsequent ones.

Let the same letters stand for the things they signified before, and *d* express the actual heat of the grist, then will

$$x = \frac{c - b \times m + c - d \times n}{a - b}$$

or in plain terms, multiply the whole number of the barrels of water to be used by the excess of the required heat over that of the air, multiply likewise the volume of the goods by the difference between the required and the actual heat of the mash, add those two produces together, divide the sum by the difference between the heat of the boiling water and that of the air, and the quotient will give you the quantity of the water, which is to be made to boil, in order to bring the whole to the desired degree.

We may now collect the circumstances of the two brewings, we have had before, and find the quantity of boiling water required for their second and subsequent mashes, exclusively of the incidents which will hereafter be mentioned.

The first mash for the six quarters of small beer had 151 degrees of heat, but this and every mash looses, in the time the extract is parting from it, 4 degrees, which reduces the heat to 147 degrees. The volume of this grist, in its dry state, was 3,42 barrels, but now, by being expanded and having imbibed much water, it occupies three times that space or

The PRACTICE of BREWING.

10,26 barrels; the air is supposed to continue in the same state of 60 degrees of heat. The length and heat to be given to the three remaining mashes are as follows.

Degrees of heat	151	169	176	183
barrels of water	14½	14½	11	11
liquors.	1	2	3	4
	└──────────┘		└──────────┘	
	1 wort		2 wort.	

Second mash of small beer.

$c = 169$ heat required in the mash $c = 169$ heat required
 $b = 60$ heat of the air $d = 147$ heat of the goods

$$c - b = 109$$

$$c - d = 22$$

$$m = 14,50 \text{ barrels of water}$$

$$n = 10,26 \text{ volume of goods}$$

$$\underline{5450}$$

$$\underline{132}$$

$$436$$

$$44$$

$$\underline{109}$$

$$\underline{220}$$

$$c - b \times m = 158,050$$

$$c - d \times n = 22572$$

$$c - d \times n = 225,72$$

$a - b = 152$] 1806,22 [11,88 water to be made to boil, out of the quantity of barrels allowed for the second mash.

$$\underline{286}$$

$$152$$

$$\underline{1342}$$

$$1216$$

$$\underline{126}$$

Third

Third mash.

176
60

116

11,00

116,00

116

1276,00

112,86

176

165

11

10,26

66

22

110

112,86

1520 1388,86 [9,13 barrels to boil for the third mash.

1368

208

152

566

456

110



Fourth

The PRACTICE of BREWING.

Fourth mash.

183	183
60	172
<hr/>	<hr/>
123	11
11,00	10,26
<hr/>	<hr/>
12300	112,86
123	
<hr/>	<hr/>
1353,00	
112,86	
<hr/>	<hr/>

152] 1465,86 [9,64 barrels to boil for the fourth mash;

1368
<hr/>
978
912
<hr/>
666
608
<hr/>
58

The liquors of this brewing must therefore be ordered in the following manner.

boiling water ; barrels	$10\frac{3}{4}$	12	$9\frac{1}{4}$	$9\frac{3}{4}$
cold water ; barrels	$3\frac{3}{4}$	$2\frac{1}{2}$	$1\frac{3}{4}$	$1\frac{1}{4}$
	<hr/>	<hr/>	<hr/>	<hr/>
	$14\frac{1}{2}$	$14\frac{1}{2}$	11	11
liquors	1	2	3	4

The

The heat of the first mash for the $\frac{11}{12}$ quarters of brown beer was 144 degrees, and, after the parting of the extract from it, 140; the volume of the grist, in its dry state, was valued at 6,11 barrels of water, but, for the reasons before mentioned, it now occupies three times that space, or 18,33 barrels. The air is supposed to continue at 40 degrees, and the length and heat to be given to the different mashes were determined as follows.

Degree of heat	144	152	156	159	162
barrels of water	16	8	12	9	9
liquors	1	2	3	4	5
	1 wort			2 wort.	

Second mash of brown strong beer.

152		152
40		140
<hr/>		<hr/>
112		12
8,00		18,33
<hr/>		<hr/>
212	896,00	36
40	219,96	36
<hr/>	<hr/>	<hr/>
172	1115,96	96
1032	[6,48 barrels of water to boil	12
	for the second mash.	<hr/>
		219,96
839		
688		
<hr/>		
1516		
1376		
<hr/>		
140		

Third

The PRACTICE of BREWING.

Third mash.

156	156
40	148
<hr/> 116	<hr/> 8
12,00	18,33
<hr/> 232,00	<hr/> 24
116	24
<hr/> 1392,00	64
146,64	8
<hr/> 1538,64	<hr/> 146,64

172] 1538,64 [8,94 barrels of water to boil
 1376 for the third mash.

<hr/> 1626
1548
<hr/> 784
688
<hr/> 96



Fourth

Fourth mash.

$ \begin{array}{r} 159 \\ 40 \\ \hline 119 \\ 9,00 \\ \hline 1071,00 \\ 128,31 \\ \hline 1199,31 \\ 1032 \\ \hline 1673 \\ 1548 \\ \hline 1251 \\ 1204 \\ \hline 47 \end{array} $	$ \begin{array}{r} 159 \\ 152 \\ \hline 7 \\ 18, \\ \hline 21 \\ 56 \\ 7 \\ \hline 128, \end{array} $
<p>172] 1199,31 [6,97 barrels of water to boil for the fourth mash.</p>	

Fifth mash.

$ \begin{array}{r} 162 \\ 40 \\ \hline 122 \\ 9,00 \\ \hline 1098,00 \\ 128,31 \\ \hline 1226,31 \\ 1204 \\ \hline 223 \\ 172 \\ \hline 511 \end{array} $	$ \begin{array}{r} 162 \\ 155 \\ \hline 7 \\ 18,33 \\ \hline 128,31 \end{array} $
<p>172] 1226,31 [7,13 barrels of water to boil for the fifth mash.</p>	

The liquors of this brewing of brown beer must therefore be ordered in the following manner ;

barrels of boiling water	13 $\frac{1}{4}$	6 $\frac{1}{2}$	9	7	7 $\frac{1}{4}$
barrels of cold water	2 $\frac{3}{4}$	1 $\frac{1}{2}$	3	2	1 $\frac{3}{4}$
	—	—	—	—	—
	16	8	12	9	9
liquors.	1	2	3	4	5

Each of these calculations may be proved in the same manner as was done before. This method of discovering the proportion of water to be cooled in, deserves, by its plainness and utility, to be preferred to any other, which only depends upon the uncertain determination of our senses.





SECTION XII.

Of MASHING.



It may be said, that, in general, the construction and disposition of most brew-houses would admit of very little farther improvement. The great copper, in which the waters for two of the extracts receive their temperature, is built very near the mash tun, so that the liquid may readily be conveyed to the ground malt. A cock is placed at the bottom of the copper, which being opened lets the water have its course, through a trunk, to the real bottom of the mash tun. It soon fills the vacant space, forces itself a passage through some holes made in the false bottom, which supports the grist, and increasing in quantity buoys up the whole body of the corn.

In order to blend together the water and the malt, rakes are first employed. By their horizontal motion, less violent than that of mashing, the finest parts of the flower are wetted, and prevented from being scattered about, or lost in the air.

But as a more intimate penetration and mixture are necessary, oars are afterwards made use of. They move perpendicularly, and by their beating or mashing, the grains of the malt are bruised, and a thorough imbibition of the water procured.

The time employed in this operation cannot be settled with an absolute precision. It ought to be continued, till the malt is sufficiently incorporated with the water, but not so long as that the necessary heat for the extraction be lost. As bodies cool more or less speedily, in proportion to their volume and the cohesion of their parts, a mash which has but little water, commonly called a *stiff-mash*, requires a longer mashing to be sufficiently divided, and, on account of its tenacity, is less liable to lose its heat. This accounts for the general rule, that the first mash ought always to be the longest.

After mashing, the malt and water are suffered to stand together unmoved, generally for a space of time equal to that they were mashed in. Was the extract drawn from the grain, as soon as the mashing is over, many of the particles of the malt would be brought away undissolved, and the liquor be turbid, though not rich. But, by leaving it some time in contact with the grain, without any external motion, many advantages are gained. The different parts of the extract acquire an uniform heat, those that are the heaviest and most terrestrial subside, the pores being opened, by heat, imbibe more readily the water, and give way to the attenuation and dissolution of the oils. When the tap comes to be set, or the extract to be drawn from the grist, as the bottom of the mash is become more compact, the liquor is a longer time in its passage through it, and consequently extracts more strength from the malt, and becomes more homogeneous and transparent.

Such

Such are the reasons why the grist should not only be mashed pretty long, but likewise be suffered to rest an equal time. It is the practice of most brewers and experience shews it is best to rake the first mash half an hour, to mash it one hour more, and to suffer it to stand one hour and half. The next extract is commonly mashed three quarters of an hour, and stands the same space of time; the third, and all those that follow, are allowed one half hour each, both for mashing and standing.

The heat of the grist being in this manner equally spread, and the infusion, having received all the strength from the malt, which such a heat could give it, is let out of the tun. This, undoubtedly, is the fittest time, to observe, whether our expectations have been answered. The thermometer is the only instrument proper for this purpose, and it ought to be placed, where the tap is set, at the underback cock. The observation is best made, when the extract has run nearly half, and as, by it, we are to judge, with what success the process is carried on, it is necessary to examine every incident, which may cause a deviation from the calculated heat.





SECTION XIII.

Of the INCIDENTS, which cause the HEAT of the EXTRACT to vary from the calculation, the allowances they require, and the means to obviate their effects.

BY incidents, I mean such causes, as affect either the malt, the water, or the mash, so as to occasion their heat to differ from what is determined by calculation. As these might frequently be a reason of disappointment, an inquiry into their number and effects will not only furnish means to prevent and rectify the errors they occasion, but also serve to confirm our practice.

In our researches on the volume of malts, some notice was taken of the increase of bodies by heat, and the loss occasioned by evaporation. Water, when on the point of ebullition, occupies the largest space; but contracting again, when cold water is added to it, the true volume of both, when mixed together, remains uncertain, and may cause a difference between the calculated and real degree of heat. This cause, however, producing an effect opposite to, and balanced in part by, evaporation, becomes so inconsiderable, as hardly to deserve any farther consideration.

Water, just on the point of ebullition, may be esteemed heated to 212 degrees. Though, by the continuation of the fire, or
by

by any other cause*, the heat never goes beyond this, yet was cold water added to that, which violently boil's, the medium degree would be exceeded; for the cold water absorbing the superfluous quantity of fire, which otherwise fly's off, becomes hot of itself, and frustrates the intent. The time therefore of adding the cold water to the hot is immediately, before the ebullition begins, or when it is just ended; and in proportion as we deviate from this practice, the heat in the extract will differ from the calculated degree.

The water, for every mash, should, as much as possible, be got ready to boil, and be cooled in just before it is to be used. A liquor, which remains a long time after the ebullition is over, and the fire has been damped up, loses part of its heat, and if cold water is applied to it, the effect cannot be the same as it would have been at first. If, on the contrary, the liquor is got ready too soon and cold water immediately added to it, in order to gain the proper degree of temperature, by leaving the mixture long in the copper, though the fire is stopped up, more heat than necessary will be received from the copper and brickwork, especially if the utensils are large. In both cases, the degree in the extract will no more answer the heat, which was expected.

* Different quantities of water are differently affected by the same portion of fire; when the ebullition is just over, and the surface of the liquor is become smooth, if some of it is, by a cock, drawn from the bottom of the copper, where the coldest water always is, the remaining part, having a greater proportion of fire than before, again begins to boil, though not affected by any increase of heat.

The

The effect of effervescence next deserves our consideration; but only takes place when the water first comes in contact with the malt. Germinated grains must, to become malt, be dried so, that their particles be forced from one another, beyond their spheres of attraction; being thus deprived of the parts, to which their union was due, when they come in contact with other bodies, (as water,) they strongly attract the unitive particles they want, and excite an intestine motion, which generates heat. This motion and this heat are more active in proportion as the grain has more strongly been impressed by fire, and the extracting water is hotter.

A large quantity of liquor applied to the grist is less heated than a small one, by the same power of effervescence. The least quantity of water, necessary to shew the whole of that power, must be as much as malt requires to be saturated, which we have seen to be double the volume of the grain. When more water is put to the grist than what has been mentioned, the real effervescing heat is by so much lessened, being dispersed in more than a sufficient space.

A table shewing the heat of effervescence for every degree of dryness in the malt, can only be formed from observations. To apply this table to practice, and to find out, for any quantity of water used in the first mash, the degrees of heat produced by effervescence, three times the volume of the grist must be multiplied by the number expressing the effervescing heat for malt of such a degree of dryness, and this produce be divided by the real volume of the whole mash.

A TABLE



A TABLE shewing the heat occasioned by the effervescing of malt, for its several degrees of dryness.

Dryness of malt	heat of effervescence
119° - - - - -	0
124 - - - - -	3½
129 - - - - -	7
134 - - - - -	10½
138 - - - - -	14
143 - - - - -	17½
148 - - - - -	21
152 - - - - -	24½
157 - - - - -	28
162 - - - - -	31½
167 - - - - -	35
171 - - - - -	38½
176 - - - - -	40

Malt dried only to 119 degrees raises no effervescence, and the strongest is generated by malt, dried to 176 degrees. The heat occasioned by it amounts to 40 degrees, and probably would exceed this number, could the first grist, notwithstanding all our endeavours, be intirely penetrated by the water. The more it is so, the greater is the increase in the degrees of heat produced by effervescence, till the liquor be perfectly saturated; and in this state of progression, which takes up the whole time

of the first mashing and standing, the air cannot produce any diminution of heat, an incident, which affects considerably every mash but the first.

The little copper being more distant from the mash tun than the other, the water prepared in it wastes, in its passage to the goods, a greater part of its heat. And in proportion to the water used, to the number of the extracts that have been made, and according as the mashes have more or less consistency, in the same time do they part, with more or less of their heat. Observations made separately upon strong and small beer have shewn the proportions of this loss to be as follows:

For strong beer.

Mashes	2	3	4	5
heat lost	8°	12°	8°	8°

For small beer.

Mashes	2	3	4
heat lost	8°	16°	20°

By employing hard corns, or a grist not perfectly malted, the expectation of the computed degree is disappointed, as the volume cannot be such as was estimated from the dryness of the grain. It has been observed that, in true malts, the shoot is very near pressing through the exterior skin of the grain. By so much as it is deficient in this particular, must it be accounted only as dried barley, or hard corn. I know no better way of judging what proportion of the corn is hard to what is malted,

ed, than by putting some in water, as by that means, the grains not sufficiently grown will sink to the bottom. Were this to be done in a glass cylinder, the proportion between the hard and malted corn might easily be found with exactness. The unmalted parts being estimated with regard to their volume, as barley, a quarter of them will be to the barrel of water as 1,56 to 1. Supposing therefore that, in the brown beer grist before mentioned, the proportion of hard corns is of 2 quarters out of 11, to discover the true volume of such a grist, the following rule may be used.

9 quarters of true malt	2 quarters
1,80 volume at 138° of dryness	1,56 volume of
<hr style="width: 100px; margin-left: 0;"/>	— 1 quarter
16,20	3,12
<hr style="width: 100px; margin-left: 0;"/>	
3,12 volume of 2 quarters of hard corn	

total number 11] 19,32 [1,75 true volume of one quarter of this malt to one barrel of water, and consequently the 11 quarters will fill a space equal to that of 6,28 barrels.

By means of this rule, we may find what increase of heat any proportion of hard corns will require, as will be seen in the following table.

Proportions of hard corns	$\frac{1}{4}$	$\frac{2}{5}$	$\frac{1}{2}$	$\frac{1}{3}$	$\frac{1}{4}$	of the grist
greater heat of the mash	4°	3	2	1	$\frac{1}{2}$	

But the brewing of such malt ought to be avoided as much as possible, as the hard parts afford no strength to the extract.

If a grist is not well and thoroughly mashed, the heat not being uniformly distributed in the different parts of the extract, the liquor of the thermometer, when placed in the running stream of the tap, will fluctuate, and at different times, shew different degrees of heat. In this case, the best way is to take the mean of several observations, and to make that the true heat of the mash.

If the gauges of the coppers are not exactly taken, a variation must be expected.

Though the small and hourly variations in the state of the atmosphere have but little influence upon our numbers, a difference will be observed in any considerable and sudden changes either of the heat or of the weight of the air. Our instruments, and in particular the thermometer, are supposed to be well constructed and graduated. If the water cooled in with is more or less hot than estimated, or if the time of mashing or standing is either more or less than was allowed for, the computation must be found to vary from the event.

While the malt is new, and the heat received from the kiln has not sufficiently spent itself, this additional heat is not easily accounted for. This is likewise the case, when malt is laid against the hot brickwork of coppers; and on the contrary a loss of dryness may be occasioned, if the store rooms are damp.

The artist should be attentive to all these incidents; the not pointing them out might appear neglectful, enumerating more would exceed the bounds of use.

Small

Small grists brewed in large utensils lose their heats more readily, by laying thin and greatly exposed to the air; and on the contrary a less allowance, for the loss of heat, is required in large grists and proportionable vessels.

This indeed is, or ought to be, the only difference between brewings carried on in large publick brewhouses, and those that are made in small private places, in other respects constructed upon the same plan and with an equal care. I know popular prejudices are on the other side, but as I believe, not on that of truth. It has been commonly imagined that, in large places, stronger extracts could be forced from the malt, in proportion to its quantity, and that more delicate beers would be made in smaller vessels less frequently used. These assertions, from what has been said, will, I hope, need no farther enquiry. Brewings will most probably succeed in all places, where the grist is not too large to exceed the bounds of man's labour, and not so small as to prevent the heat from being uniformly maintained. The disadvantages are great on all sides, when a due proportion is not observed between the utensils and the works carried on.

It will now be proper to continue the delineation of our two brewings, and to put all the circumstances relating to them under one point of view.

A brewing

The PRACTICE of BREWING.

A brewing for porter or brown strong beer computed for 40 degrees of heat in the air.

11 quarters of malt dried to 138 degrees; 132 pounds of hops
27 barrels $\frac{1}{2}$ to go out at 3 worts, 29 inches above bras

	6,11 volume of grist	11 effervescing degrees
	<u>3</u>	<u>3</u> degrees for hard
	18,33	corns
	14 effervescing degree	14 degrees equal to 3
	<u>7332</u>	$\frac{1}{2}$ inches less cooling
volume of grist 6,11	7332	in for the first
water for first mash 16,00	<u>1833</u>	mash.
	22,11] 25662 [11	degrees of heat gained in the first mash
	<u>2211</u>	by effervescence.
	1552	

Mashes	1	2	3	4	5
Degrees of heat	144	152	156	159	162
whole quantity					
of water used, barrels	16	8	12	9	9
Quantity to be					
cooled in; barrels	$2\frac{3}{4}$	$1\frac{1}{2}$	3	2	$1\frac{3}{4}$
Coppers to be					
charged with; barrels	$3\frac{1}{4}$	$6\frac{1}{2}$	9	7	$7\frac{1}{2}$

Allowances for					
incidents;	G. C.	L. C.	L. C.	L. C.	L. C.
inches.	less $3\frac{1}{2}$.	more 2.	more 3.	more 2.	more 2.
	*	†	‡	†	†

* Deduction from the 1 mash for heat created by effervescence and hard corns.
 † Additions to the next mashes, on account of the refrigeration occasioned by mashing and standing.
 ‡ G. C. stands for great copper, L. C. stands for little copper.

A brewing

A brewing for common small beer computed for 60 degrees of heat in the air.

6 quarters of malt dried to 138 degrees; 36 pounds of hops
30 barrels $\frac{1}{4}$ to go out 56 inches above brasts.

Volume of grist 3,42

3
20,26

4° for effervescence

7 effervescing degree for 1° for hard corns

grist 3,42

malt at 130

3° for new malt hot

water] 14,50 — (see table page 237.) —

8° to be deduced from the first cooling in.

17,92] 71,82 [4 degrees of heat

7168 gained in the mash by effervescence.

14

Mashes

1

2

3

4

Degrees of heat

151

169

176

183

whole quantity of

water used, barrels

14 $\frac{1}{2}$

14 $\frac{1}{2}$

11

11

Quantity to be

cooled in, barrels

3 $\frac{3}{4}$

2 $\frac{1}{2}$

1 $\frac{3}{4}$

1 $\frac{1}{4}$

Coppers to be

charged, barrels

10 $\frac{3}{4}$

12

9 $\frac{1}{4}$

9 $\frac{3}{4}$

Allowances for

incidents; inches;

G. C.

G. C.

L. C.

L. C.

less 2;

more 2;

more 4;

more 5.

* The charge of the first liquor is for 10 $\frac{3}{4}$ barrels, with a deduction of 2 inches, according to the gauges of the coppers, page 181. These two inches answer to the 8 degrees of heat for the effervescence, hard corns, and new malt.

† The second and following mashies are to be charged with as many more inches of boiling water, as answer to the fourth part of the number of degrees of heat lost by the refrigeration of the mashies. These

These computations, perhaps will appear more troublesome than they really are the more so, as they vary, for every brewing; but, besides the facility, which exercise always gives for operations of this kind, the satisfaction of proceeding upon a less precarious foundation than what has been hitherto thought sufficient, will, I hope, encourage the practitioner in this additional labor. One advantage must greatly lessen it, and at the same time secure the uniformity of the drinks; *viz.* that tables for each may be made before hand, and will serve as often as the circumstances are the same. The trouble of the computations will by that means be saved, and by collecting together different brewings of the same kind, the artist will, at any time, have it in his power to see what influence the least deviation from his rules had upon his operations, and to what degree of precision he may hope to arrive.

That nothing may be wanted, in this work, that may facilitate the intelligence thereof, I beg leave to insert, in two tables, the examples of some actual brewings made according to the computations, I have here successively traced down. The first column contains the numbers computed, the next the brewings made from these numbers with their dates, and the last the variations in the charges of the coppers, occasioned by unforeseen incidents, upon the principle, that each inch of cooling in answers to four degrees of heat.

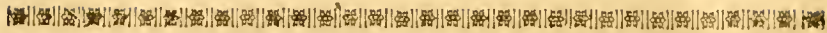


Small Beer 6 Quarters of Malt at 130°.

Length, 30 $\frac{3}{4}$ Barrels, Air at 60°.

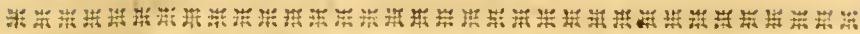
	Comput. Degrees.	1759						
		July 20.	July 22.					
1 Mash.	147	147	145					1 Liquor, great copper charged 2 inches above brass; cooled into 13 and a half inches above brass.
2 Mash.	165	163	167					2 Liquor, great copper charged 9 inches above brass, cooled into 13 inches and a half.
3 Mash.	172	174	172					1 wort came in 33 inches above brass - went out 28 inches above brass - boiled 1 hour & half 3 Liquor, little copper charged 12 inches above brass; cooled in to 13 inches above brass.
4 Mash.	179	179	179					4 Liquor, little copper charged 13 inches above brass; cooled in nothing.
								2 wort came in 39 above brass - went out 28 inches above brass Length 3 $\frac{3}{4}$ barrels

The PRACTICE of BREWING.




Porter, 11 Quarters of Malt at 138°
Length, 27½ Barrels, Air at 40°.

	Comput. Degrees.	1759		1760		
		Nov. 16.	Dec. 8.	Feb. 20.	Feb. 23.	
1 Mash	140	140	138	142	140	1 Liquor, great copper charged 6 and a half inches above brags, cooled in to 17 inches.
2 Mash	148	146	150	146	148	2 Liquor, little copper charged half an inch below brags, cooled in to three inches above brags.
3 Mash	152	154	152	150	150	1 wort came in 16 inches above brags — went out 13 inches above brags — boiled 1 hour 3 liquor, little copper, charged 9 inches above brags, cooled in to 16 inches above brags.
4 Mash	155	155	155	157	157	2 wort came in 11 inches above br. (brags went out 5 in. above — boiled 2 hours. 4 liquor, little copper charged 1 in h and a half above brags, cooled in to 6 inches above brags.
5 Mash	158	158	160	158	158	5 liquor, little copper charged 2 inches and a half above brags, cooled into 6 inches above brags. 3 wort came in 24 in. above br. (brags went out 11 in. above Length 27 bar. 3-4ths



S E C T I O N X I V .

Of the disposition of the WORTS when turned out of the COPPER, the thickness they should be laid at in the BACKS to COOL, and the heat they should retain for fermentation, under the several circumstances.


 W H E N a process of brewing is regularly carried on, the worts come in course to boil, as the extracts which formed them are produced. It would be tedious and unnecessary to describe the minutest parts of the practice; which vary as the brewing offices are differently constructed, or the utensils variously arranged. Without the assistance of a brewhouse, it is perhaps impossible to convey to the imagination the entire application of the rules before laid down, but with one, I hope, they need little, if any, farther explanation.

The worts, when boiled, are musts possessing, in their intended proportions, all the fermentable principles, except air. This was expelled by the fire, and until the boiling heat is removed, those worts cannot be said to be in a fermentable state.

In musts, which spontaneously ferment, the included air excites in the oils an agitation, which, opening the pores of the liquor, renders them capable to receive part of the external air. The case is not exactly the same with regard to

those musts, which require ferments. The air wanted in boiled worts must be supplied by the means of yeast. Was the heat of the wort such, as to occasion the immediate bursting of all the air bubbles contained in the yeast, an effervescence rather than a fermentation would insue. Now a heat superior to that of 80 degrees has this effect, and is therefore one of the boundaries in artificial fermentation; that of 40 degrees, for want of being sufficient to free the air inclosed in the yeast bubbles, and to excite their action, is the other. Within these limits, must the wort be cooled to; and the precise degree, which varies according to the different circumstances they are in, and to the intent they are to be applied to, is, together with the means of procuring this heat, the purport of this section.

Worts, when in the copper, boil at a heat somewhat superior to that of 212 degrees, and the more that heat is exceeded, the stronger the liquor is. The instant the wort is suffered to go out of the copper, it loses more heat, than at any other equal space of time after it has been exposed to the air. In the course of the natural day, or in 24 hours, the heat of the air varies sometimes, (especially in summer time,) as much as 20 degrees. If the wort, after having reached the lowest degree in this interval, was suffered to remain in the coolers, till the return of a greater heat in the air, it would be influenced by this increase, expand, and be put again in motion. Should, at that time, any elastic air happen to be in the vessels, which sometimes happens, either from the sediment of former worts, the backs

not

not being clean swept, or the wood being old and spongy, the wort supposed to be left to cool, will, before it is removed, bring on, in a lower degree, the act of fermentation; and this accident is by the artist called the *backs being set*.

For this reason, a wort should never be suffered to lay so long as to be exposed to this injury, which generally may happen in a little more than twelve hours. Thus are we directed to spread or lay our worts so thin in the coolers, as that they may come to their due temperature within this space; in summer it is sufficient if the backs be covered; in winter a height of two inches may oftentimes be allowed.

From the inclination of the coolers or backs to the place, where the worts run off, from their largeness, or from the wind and air warping them, a wort seldom, perhaps never, lays every where at an equal depth, and cannot therefore become uniformly cold in the same space of time. This renders the use of the thermometer difficult, in this case, though perhaps not impracticable. To supply the want of this instrument with some degree of certainty, the hand intended to feel the worts is brought to the heat of the body, by placing it in the bosom, until it has fully received it. Then dipping the fingers into the liquor, we judge, by the sensation it occasions, whether it is come to a proper degree of coolness to be fermented. As the external parts of our bodies are generally of about 90 degrees of heat, some degree of cold must be felt, before the worts are ready for the purpose. But that degree varies for different drinks, and in different seasons. I will endeavour to set forth

the rules to be observed in judging of small beers, A greater precision, both for that and for other drinks, will be found in the following table.

In July and August, no other rule can be given, than that the worts be got as cold as possible. The same rule holds good in June and September, except the season is unnaturally cold. In May and October, worts should be let down nearly thirty degrees colder than the hand; in April, November, and March, the worts should be about twenty degrees colder than the hand, and only ten in January, February, and December.

It may perhaps be thought that the heats here specified are great, but worts cool as they run from the backs to the working tuns, they are also affected by the coldness of the tuns themselves, and perhaps these circumstances are not so trivial, but that an allowance should be made for them. In general, the heat of no must should exceed 60 degrees, because fermentation increases this or any other degree, in proportion to that under which this particular part of the process begins.

TABLE



A TABLE



A TABLE shewing the degrees of heat, worts should have, when the yeast is applied to them, according to the several degrees of heat in the air.

Heat of the air	common small	all keeping beers	amber or ales.
25	75	59	55
30	70	56	54
35	65	53	53
40	60	50	52
45	55	50	51
50	50	50	50

55 } In these cases, when the medium heat of the air is
 66 } greater than that which the worts should ferment
 at, the cold of the night must be made use of, to bring them as
 near as possible to their temperature. It has been observed,
 that the coldest part of the natural day is about one hour be-
 fore sun rising.


The consequences of worts being set to ferment at, in an undue heat, are the following. In strong beers, or such as are intended for long keeping, if the worts be too cold, a longer time is required for their fermentation, and the drinks grow fine with more difficulty; if, on the contrary, they are too hot, acidity and a waste of some of the spirituous parts must ensue. Either of these disadvantages appears more conspicuous in common small beer, as, in winter, this drink, is seldom kept a sufficient time, to correct the defect, and in summer, from being too hot, it becomes putrid, or, in the terms of the brewery, is hereby *foxed*.

SECTION



SECTION XV.

Of YEAST, its NATURE and CONTENTS, and of
the manner and quantities, in which it is to be ad-
ded to the WORTS.


 MUSTS or worts, though ever so rich, when unfermented, yield no spirit, by distillation, nor inebriate, if drank in any quantity. The oils, which are not sufficiently attenuated for this purpose, become so by fermentation. Air is absolutely necessary for this act, in the course of which, some of the aerial parts mixing with, and being enveloped by, oils greatly thinned, are inclosed in vesicles not sufficiently strong, to resist the force of elasticity, or prevent a bursting and explosion. As the process goes on, the air joins with oils both coarser and charged with earthy particles, a coat is formed capable of resisting its expansion, and if the bubbles cannot come to a volume, sufficient to be floated in and upon the liquor, they sink to the bottom, and take the appellation of *lees of wine*.

Between these two extremes, there is another case, when the bubbles are sufficiently strong to hold the air, but not weighty enough to sink. They are buoyed upon the surface of the liquor, and there remaining entire are termed the *flowers of wine*. Both lees, and flowers, are therefore vesicles formed out of the must, and filled with elastic air, and either separately or when mixed together, they obtain the general denomination of *yeast*.

We

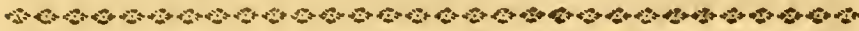
We have often mentioned the power of the fire in driving the air out of worts. Yeast fraught with the principle now wanted, for fermentation, is therefore the properest subject, to be added to the musts; but its texture is various, in proportion to the different heats of the extracts, it was formed from. Keeping drinks, extracted with hotter waters, yield a yeast, the oils of which have a greater spissitude. It is consequently slower, more certain, and most fit to promote a cool and gentle fermentation. That, on the contrary, which is produced from small beer, being weak, and acting at once, is apt, not only to puff up the drinks, but to excite a motion like that of effervescence; such yeast ought, therefore, not to be used, but when there is no possibility, to obtain the other.

The longer wines or beers are under the first act of fermentation, the greater variety will be found in the texture of the bubbles, which compose their flower and lees. Wines made out of grapes require some time, before this first period is at an end; and we have seen, that in them fermentation first brings forth air bubbles, whose constituent parts are most tender, and afterwards some that are of a stronger texture. As malt liquors require a less time to ferment, their bubbles are more similar; on this account, the whole quantity of yeast, necessary to ferment a wort, should not be applied at once, lest the air bladders, bursting nearly in the same time, should prevent that gradual action, which seems to be the aim of nature, in all her operations.

Cleansing is dividing the drink into several casks; this checks the motion, occasioned by fermentation, and consequently retards it. To prevent this from being too sensibly felt, some yeast should be put to the drink, before it is removed into the casks. As the constituent parts, in strong beers, are more tenacious, than in small, and require a greater motion to entertain the fermentation, the drinks, before they be thus divided, should, besides the addition of the yeast, be well roused with a scoop, or by some other means, for one hour. This not only blends all the parts together, but attenuates and heats the liquor, and makes it more ready to begin to ferment again, when in the casks. One sixth part of the whole of the yeast used is generally reserved for this purpose; and the remainder is equally divided as the worts are let down. It must be observed, that this stirring, though as necessary to small, as to strong, drinks, is only to be continued, for a space of time proportioned to their strength.

We have before seen, that, when malt is entirely extracted for one and the same purpose, one gallon of yeast to eight bushels of grain affords a sufficient supply of air, to perfect the fermentation. This takes place, when the heat of the air is at 40 degrees; and in the hottest weather, experience shews, that half that quantity is the least that ought to be used. But as, in some ales, the whole virtue of the malt is not extracted, and what remains is appropriated to the making of small beer, the quantity of yeast, used for these drinks, must be only in proportion to the strength extracted. From these pre-
mises,

mises, the following tables have been formed, exhibiting the quantity of yeast necessary, for the several sorts of drinks, and the different heats of the air.



A TABLE shewing the quantities of yeast necessary for common small beer in every season.

Heat of the air	pints of yeast to one quarter of malt	
35	- - - 9	} The whole quantity of yeast to be put into the first wort.
40	- - - 8	
45	- - - 8	
50	- - - 7	
55	- - - 7	} The first wort to have $\frac{3}{4}$ The second wort to have $\frac{1}{4}$.
60	- - - 6	
65	- - - 6	} The first wort to have one half of the whole quantity. The second wort to have the remainder.
70	- - - 5	
75	- - - 5	
80	- - - 4	



A TABLE shewing the quantities of yeast necessary for all keeping drinks, both brown and pale, small and strong.

Heat of the worts*	pints of yeast to one quarter of malt
30 - - - - -	9
35 - - - - -	9
40 - - - - -	8
45 - - - - -	8
50 - - - - -	7
55 - - - - -	7
60 - - - - -	6
65 - - - - -	5
70 - - - - -	5
75 - - - - -	4
80 - - - - -	4

* In beers intended for long keeping, the fermentation is to be governed by the heat of the worts or muffs, more than by that of the exterior air.



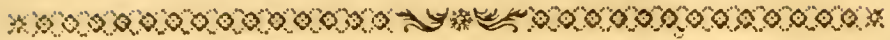


A TABLE shewing the quantities of yeast necessary for amber and all sorts of ales, after which small beer is made.

Heat of the air	pints of yeast to one quarter of malt
30 - - - - -	6 $\frac{3}{4}$
35 - - - - -	6 $\frac{1}{4}$
40 - - - - -	6
45 - - - - -	5 $\frac{1}{2}$
50 - - - - -	5 $\frac{1}{4}$
55 - - - - -	5
60 - - - - -	4 $\frac{1}{2}$
65 - - - - -	4
70 - - - - -	3 $\frac{3}{4}$
75 - - - - -	3 $\frac{1}{4}$
80 - - - - -	3

In every heat of the air, the quantity of yeast to be used for the small beer made after ale, must be one third part of the quantity, which the ale required.





SECTION XVI.

Of practical FERMENTATION, and the management of the several sorts of MALT LIQUORS, to the period, at which they are to be cleansed or put into the CASKS.

THE laws of fermentation are universal, and uniform; and when it proceeds regularly, its different periods are known by the different appearances of the fermenting liquor. As a particular appellation is given to each of these appearances, it may not be unnecessary here to describe them.

1. The first sign of a wort fermenting is a fine white line, composed of very small air bubbles, attached to the sides of the tun; it is then said to *have taken yeast*.

2. When these air bubbles are extended over the whole surface of the must, the wort is said to be *creamed over*.

3. Bubbles continuing to rise, a thin crust is formed; but as the fermentation advances rather faster near the sides of the tun, than in the middle, this crust is continually repelled; from which arises the denomination of *the wort parting from the tun side*.

4. When the surface becomes uneven, as if it were rock work, this stage of fermentation, which has no particular use, is distinguished by its *height*.

5. When

5. When the head becomes lighter, more open, more uniform, and of a greater depth, being round or higher in the middle, than in any other part, and seeming to have a tendency still to rise, the liquor, in the case of strong beer, is said to be, by so many inches, *not fit to cleanse*.

6. This head having rose to its greatest height, begins to sink and to become hollow in the middle, and at the same time, more solid, the colours changing to a stronger yellow or brown; the wort is then said to be *in a fit state to cleanse*.

After this, no farther distinctions are made; and if the fermentation is suffered to proceed in the tun, the head continues to sink, and the liquor is often injured.

As the denominations and tastes of liquors brewed from malt are numerous, it is impossible to specify each separate one; we shall therefore only particularize such sorts of drinks, as were taken notice of in the section of extraction, they being most in use; but, from what will be said about them, the method of managing any other malt liquor may easily be deduced.

Spontaneous pellucidity arises from a due proportion of the oils to the salts, in the worts, but the advantage of long keeping depends not only on the quantity of oils and hops the musts possess, but also on the fermentation being carried on in a slow and cool manner. The drinks, intended to be kept, are therefore best formed in cold weather, and made to receive their yeast at such temperature, as is set forth in the table. The quantity of the yeast is divided in proportion to that of the wort let down, un-
till

till the whole, being mixed together, receives all its allotted yeast, except that part, which is put in just before cleansing. Under these circumstances, drinks, which are brewed for keeping, without the assistance of precipitation, are suffered to go through the first process of fermentation, till they are so attenuated, that the liquor becomes light, and the head, or the yeast, laying on the surface of the beer, begins to sink. When this head has fallen to nearly half its greatest height, a remarkable vinous smell is perceived, and the liquor; at this term, is to be put into casks, being first well roused with the remaining part of the yeast, in the manner mentioned in the preceding section.

By the description given of the origin of yeast, it appears that it is formed rather of the coarser oils of the worts. If the cleansing is not done when the head is sunk down to half the greatest height, it rose too, by falling lower, some part of these coarser oils return into the beer, then under fermentation, and give it a flat greazy taste, technically termed *yeast bitten*. When, on the contrary, beers or ales are removed too soon from the first tumultuous fermentation, for want of having been sufficiently attenuated, and from not having deposited their lees, nor thrown up in flowers their coarser oils, they are less vinous, than otherwise they would have been, but appear heavy, aley, and are said *not to have their body sufficiently opened*.

The fermentation of common small beer is, through necessity, carried on so hastily, that it is hardly possible to wait
for

for the figs, which direct the cleansing of other beers. This drink being generally brewed and fermented within twenty four hours, its state, with regard to fermentation, is best judged of by the quantity of its froth or head at the time of cleansing, which, in proportion to the heat of the air, may be determined by the following table.



A TABLE shewing the proper quantity of head, which common small beer should have to be properly cleansed, in every season of the year.

Heat of the air	head on the beer in the tun.
25 degrees - - -	6 inches
30 - - - - -	5
35 - - - - -	$4 \frac{1}{4}$
40 - - - - -	$3 \frac{1}{2}$
45 - - - - -	$2 \frac{3}{4}$
50 - - - - -	2
55 - - - - -	$1 \frac{1}{2}$
60 - - - - -	1
65 - - - - -	$\frac{3}{4}$
70 - - - - -	$\frac{1}{2}$
75 - - - - -	$\frac{1}{4}$
80 - - - - -	just taken.

As it is chiefly by the action of the air that wines are formed, if we contrive to shift this powerful agent on the surface of a
L I
must

must under fermentation, and to convey it both more forcibly and more hastily into it, its efficacy will be renewed, the fermentation accelerated, the liquor quickly become transparent, and soon be brought to the state of maturity age might slowly make it arrive at.

Amber, or pale ales, require very hot extracts to be rendered soft and smooth to the palate; but, as a continuation of a great degree of heat prevents speedy pellucidity, and ales do not admit of any large quantity of hops, which would alter their nature, there is a necessity to perform hastily the act of fermentation, and to carry it on to a higher degree than is common in other malt drinks. As the method of exciting and conducting repeated fermentations, with success, is perhaps not only the most difficult, but the most curious, part of the process, I shall conclude with an account of it; what I have to say with regard to the practice of fermentation.

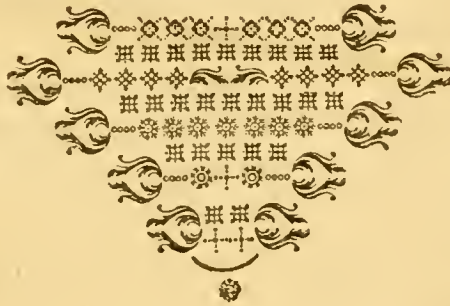
The amber wort being let down, at its proper degree of heat, into the fermenting tun, out of the whole quantity of yeast allowed for this drink, in the table page 257, one gallon must be kept to be used as hereafter shall be mentioned. Suppose that the heat of the air is at 40 degrees, and that eight quarters of malt have been wetted for this purpose; the whole of the yeast required is 6 gallons, from which one is to be reserved. Of the five remaining gallons, one half, or two gallons and a half are to be put to the wort on its first coming down, and of the last 2 · gallons, about three quarts must be
added

added to the drink, every twelve hours, untill it ferments to the highest pitch of the period mentioned in article 5 page 259. This successive putting in of the yeast is called *feeding the drink*; about the time the head is got to this height, all the dirt or foul yeast, that rises on the surface, must be carefully skimmed off; it is easily distinguished from the pure white froth, by its color, and by the sinking of the head occasioned by its weight. Length of time might attenuate some of these coarser oils in a less artificial fermentation, but as this help is wanted, and every obstacle to pellucidity is to be removed, the brewer's attention to this point cannot be too great. At this time, the reserved gallon of yeast is to be used, in order to give to the ale a sufficient power to bear the repeated fermentations it is to undergo, by being beat in, every two hours, with a jett or scoope, for one quarter of an hour, so that the head on the drink be reduced to the least height it is capable of. This striking in being continued, the drink will periodically require it, and be damaged if it be neglected. After it has undergone more or less of these fermentations, in proportion to the heats of the worts and of the air, the brewer is carefully to observe, when the head ceases to rise to its accustomed height, and then to examine the drink, by having the jett filled with it at the bottom, and brought through the whole body to the top, a small part of which being poured in an handgatherer, he will see whether the lees form themselves in large white flakes and readily subside, and be informed, by the taste, whether the sweet of the wort is gone of, and the ale become vinous. When

these two circumstances concur, the drink is to be beat in with the jett as before, but not roused as porter or other beers are, for, by this management, the lees, which in this drink are in greater quantity, would so intimately be mixed with it, as with difficulty to separate themselves. It is then time to cleanse it; but the casks, more especially in summer time, must be well filled up with clean drink, that is, part of the very drink, which was cleansed, avoiding that produced in the stillings, as this, for want of standing a sufficient time, is always yeasty, and the yeast, being greatly attenuated by the working of the drink easily dissolves in the ale, and renders it foul and ill tasted.

As the brewing of amber well is looked upon as the highest pitch of the art of pale beer brewing, I have dwelt thereon more than otherwise it might seem necessary, to shew the connection there is between every sort of malt liquors, and to remove this prejudice, that an artist, by brewing well one kind of drink, is incapacitated of excelling in another. But, to return to our ale, the same method of fermenting it, is to be practised, both winter and summer, varying only the quantities of yeast in proportion to the season; so that whereas, in winter time, this drink is fed with three quarts of yeast, in every twelve hours, half a gallon will be sufficient in summer. Though the process is thus contrived to accelerate fermentation, yet the more coolly and gently it is performed, the better will the ales be. I have before hinted, that, if Madeira wines were fermented in this manner,

manner, they would sooner become fit for use, more especially, as they need no ferment to excite them. This method of fermenting drink has, indeed, been taxed with being unwholesome, but, upon what grounds, I could never discover; as no reason of any moment has ever been alledged for this assertion.





SECTION XVII.

Of the SIGNS generally employed in the processes of BREWING, and their comparison with the foregoing THEORY and PRACTICE.

WE have now brought our barley wines into the casks, { W } and this, on principles which are agreeable and consonant to each other. The charge of novelty may, perhaps, still be alledged, to invalidate what has been offered. It is but just to pay so much regard to a long and, upon the whole, successful practice, as to recite, if not all, at least the principal, maxims, and signs in brewing, which hitherto have guided the artist. By comparing these with the present method, they will not only illustrate each other, but perhaps cause both to be better understood; and though, with respect to the art itself, this may be thought rather a curious than an instructive part, yet we may learn from hence that such practice, which long experience has proved to be right, will always correspond with true theory.

1. *When a white flour settles, either in the underback or copperback, which sometimes is the case of a first extract, it is a sure sign, that such an extract has not been made sufficiently hot, or in technical terms, that the liquor has been taken too slack.*

Malt, when dried, has it's oils made tenacious, in proportion to the power of heat it has been affected with; the grain,

grain, though ground, if the water for the extraction is not at least as hot, as what occasioned this tenaciousness, must remain in great measure undissolved in the first extract, and deposite itself as just now was mentioned.

2. *The first extract should always have some froth or head in the underback.*

The oils and salts of the malt, being duly mixed, form a saponaceous body, the character of which is that, on being shook, it bears a froth, on it's surface.

3. *The head or froth in the underback appearing red, blue purple or fiery, shews the liquors to have been taken too hot.*

The more hot the water is, when applied to the malt, the more must the extract abound with oils, and consequently be more capable to reflect colors in a strong manner. But how precarious this method of estimating the quality of an extract is, in comparison to that which the thermometer affords, will appear from the following observation of Sir Isaac Newton; “ saponaceous bubbles will, for a while, appear tinged with
“ a variety of colors, which are agitated by the external air,
“ and those bubbles continue until such time as growing excessive thin, by the water trickling down their sides, and
“ being no longer able to retain the inclosed air, they burst”. Now as these bubbles vary in their density, in proportion to their duration, the colors they reflect must also continually change; it is therefore, hardly possible to judge of the condition and saponaceousness of the extracts, by the appearance of their froth.

4. *When*

4. *When the grist feels slippery, it generally is a sign that the liquors have been taken too high.*

This appearance proceeds from an over quantity of oil being extracted, and this is the effect of too much heat.

5. *Beer ought always to work kind, out of the cask, when cleansed, but the froth, in summer time, should be somewhat more open than in winter.*

The higher and hotter the extracting water is, the more oils doth it force into the must; when a wort is full charged with oils, the fermentation is neither so strong nor so speedy, and consequently the first froth, especially, is thin, open and weak. This improves as the liquor is more attenuated, and in summer time, heat, which expands all bodies, must act in the same manner on yeast, the principal part of which is elastic air.

However vague and indeterminate these signs are, it would not be impossible to bring them to some degree of precision; but as, upon the whole, they would still be much inferior to the rules we have endeavoured to establish, we think it unnecessary to pursue any farther a research rather more curious than useful.



S E C T I O N XVIII.

An enquiry into what may be, at all times, a proper stock of BEER, and the management of it in the CELLARS.



HE business of a brewer is not confined to the mere manufacture of his commodity; his concerns, as a trader, deserve no less regard, and, in a treatise like this, should not be intirely omitted.

As it is a fault not to have a sufficient stock of beers, in the cellars, to serve the customers, it is one also to have more than is needful. By the first of these errors, the beers would be generally new and ill disposed for precipitation; by the other, quantities of stale beer must remain, which becoming harder and harder, will at last be unfit for use, unless blended with new brewed beers, to their detriment. These faults, if continued, may in time affect a whole trade, and ought therefore carefully to be avoided. For these reasons, the whole quantity to be moved or expected to be supplied from the brewer's store cellars, during the space of one twelvemonth, should be calculated, as near as possible; half this quantity ought to be the stock kept up from November to May inclusive, and nearly one third part the stock remaining in September. From hence a table may be formed, by which it will be very easy, at one view, to know the quantity, that should be maintained at every season of the year, and to avoid almost every inconveniency,

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which

which otherwise must arise. Suppose for example, the number of casks expected to be moved in a year to be 320 butts and 248 puncheons, the store cellars ought to be supplied, as to time and quantity, in the following proportion.

	Butts				puncheons.
January	160	-	-	-	124
February	160	-	-	-	124
March	160	-	-	-	124
April	160	-	-	-	124
May	160	-	-	-	124
June	146	-	-	-	113
July	133	-	-	-	103
August	120	-	-	-	93
September	107	-	-	-	82
October	133	-	-	-	103
November	160	-	-	-	124
December	160	-	-	-	124

After beers have been started in the cellars, the casks should be well and carefully stopped down, as soon as the repelling force of fermentation is so much lessened, as not to be able to oppose this design. Otherwise the elastic air, which is the vivifying principle of the drink, being lost, it would become vapid, and flat; and if left a long time in this condition, perhaps grow sour.

It has already been observed, that cellars, in winter, are more hot than the exterior air by 10 degrees, and more cold in summer by 5 degrees. But besides this general difference,

reposit-


repositories of beer vary surprisingly in their temperature; from the nature of the soil in which they are built, from their exposition to the sun, or from other incidental causes. As heat is a very powerful agent in accelerating fermentation, it is by no means surprisng, not only that some cellars do ripen drinks much sooner than others, but also that a difference is often perceived in the same cellar. The persons, intrusted with the choice of beers, with which the customers are served, should not be satisfied to send out their guyles, in the progressive order, in which they were brewed, but ought, on every occasion, to note any alteration, that happens in the drink, as this is doing justice both to the commodity, and to the consumer, who has a constant right to expect his beer in due order.





SECTION XIX.

Of PRECIPITATION and other REMEDIES, applicable to the DISEASES incident to BEERS.

 O accident can be so detrimental in cellars as leaky or stinking casks, which lose or spoil the whole or part of the contained drink. The necessity of having, on these occasions, a remedy at hand was undoubtedly the reason, why coopers were first introduced in store cellars. Constant practice might have qualified their palates so, as to make them better judges of the tastes of wines and beers, and to enable them to know which were the fittest for immediate use. The preparing or forcing them for this service was a matter, which the profit gained by it made them ready enough to undertake. The chymists, whom they consulted on this occasion, gave them some informations, and by these means, the coopers became the possessors of a few nostrums, the effects of which they were supposed to have experienced. But, as they are ignorant of the cause of these effects, and unacquainted with the constituent parts of beers, it is not to be expected that their success should be constant and uniform. The brewer certainly knows best, how he formed the drink, and ought consequently, in any disorder, to be prepared to direct the properest remedy.

The intent of this treatise has been to discover the means, by
which

which errors may be avoided. Chymical applications are intended to remedy those errors, which may be occasioned either by carelessness or accident. The wholesomeness or propriety of the applications, which will be indicated, must be left to the judgment of my readers; it is most likely that there is sufficient room for improvement, and we might expect it from those, whose profession it is to study every thing, that may be conducive to the safety of mankind.

Whatever vegetables, wines are produced from, whenever they deviate from the respective perfection, a well conducted fermentation might have made them arrive at, they may be said to be distempered. Foulness or want of transparency, is not the least evil, but according to its degree it obtains various appellations, and requires different helps. From what has been said, nothing can be more plain, than that it is always in our power, to form beers and ales, which will be bright. Yet porter or brown beer is constantly so brewed as to need precipitation: the reasons for this management have before been offered. Were we to wait, till the liquor became transparent by age, a more real disorder would ensue, than that of acidity. Precipitation is then serviceable, especially when beers are to be removed from one cellar to another, a short space of time before they are to be used. By being shook, and the lees mixed with the liquor, a strong acid taste is conveyed therein, and the power of subsiding, which is wanted, renders forcing in that case absolutely necessary. In beers brewed with high dried malts, no flatness is occasioned thereby; as the case is, under
like

like circumstances, with liquors produced from pale or low dried grain. The degree of foulness in porter may however be limited; its bounds ought not to exceed the power of one gallon of dissolved isinglass, to a butt. Isinglass is dissolved in stale beer, and strained through a sieve, so as to be of the consistence of a jelly. The beer is set in motion with a stick, which reaches one third part down the cask, before and after this jelly is put in, and a few hours are sufficient to obtain the desired effect. We have before observed, that this quantity of jelly of isinglass is equal to a medium of 14 degrees dryness in the malt, and heat of the extracts. When the opacity exceeds this degree, the liquor is termed *stubborn*; the same quantity of dissolved isinglass repeated is often sufficient, in that case; and, if not, six ounces of the oil of vitriol, are mixed with it. An effervescence is, by this addition, produced; the oils of the drink become more attenuated, and the weight added to the precipitating matter, is a means to render it more efficacious. Instead of the oil of vitriol, six or eight ounces of the concrete of vitriol pounded and mixed with the isinglass are sometimes used with success.

A foulness in beer beyond that which is called *stubbornness*, gives to the drink the denomination of *gray beer*. This arises from the oils which float upon the surface, and which the liquor has not been able to absorb. In this case, the same methods, as before mentioned, are repeated; the quantity of dissolved isinglass is often increased to three gallons, that of vitriol to more than twelve ounces, and sometimes a small quantity of *aqua fortis* is added to these ingredients.

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The next stage of opacity is *cloudiness*; when the cooper confesses, that the distemper exceeds the power of his menstruums, and that his attempts extend no farther than to hide the evil. Calcined treacle, from its acidity, is of some small service, and by coloring the drink somewhat lessens the grey dusky hue thereon; a quart of this is generally used in a butt. This ingredient is called *blackening*; and to prevent it to be known by the consumer, the practice is to put thereon what is called *a good caul flowered head*. This might be done by using as much pounded salt of steel as will lay upon a shilling, but the difference in price between this salt and copperas makes the last generally to be preferred. The strong froth on the top of the pot, and that which foams about it, together with somewhat of a yellow cast, are often mistaken for the signs of a superior merit, though in fact they are those of deceit. A little reflection that the natural froth of beer cannot be yellow, nor continue a long time, especially if the liquor has some age, would soon cure mankind of this prejudice. Cloudy beers, under these circumstances, though not cured, are generally consumed.

Beers become *sick*, from their having so large a portion of oils, as to prevent the free admission of the external air into them. The want of this enlivening element makes them appear flat, though not vapid. Such beers should not, if possible, be brought immediately into use, as age alone would effect their cure. But when this cannot be complied with, every means that will put the beer upon the fret, or under a new fermentation, must be of service. By pitching a butt head over head,
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the lees of the beer, which contain a large proportion of air, being mixed again with the drink, help to bring on this action, and to remove the *sicknefs*.

Burnt hartshorn shavings, to the quantity of two penny worth put into a butt, are often of use.

Balls made with eight ounces of the finest flower, and kneaded with treacle, convey likewise air to the drink, and promote its briskness.

Beers, by long standing, often acquire so powerful an acid, as to become disagreeable. The means of correcting this defect is by alkaline, or testaceous substances, and in general by all those which have the property of absorbing acids. To a butt of beer in this condition, from four to eight ounces of calcined powder of oyster shells may be put, or from six to eight ounces of salt of wormwood. Sometimes a penny worth or two of whiting is used, and often twenty or thirty stons of unslacked lime; these are better put in separately than mixed with the ifinglass.

In proportion as beers are more or less forward, from two to four ounces of salt of wormwood and salt of tartar, together with one ounce of pounded ginger, are successfully employed.

Two pounds of hops boiled in some of the drink, eight ounces of calcined oyster shells, and as many of bean flower, kneaded with some of the liquor into a paste, and dropp'd into the cask, will mellow and soften the beer. The sooner the effect is intended to take place, the flacker the paste must

be

be made. As all these substances absorb acids, they, at the same time, leave a flatness in the liquor.

Sometimes in summer, when beer is wanted for use, we find it on the fret; as it is then in a repelling state, it does not give way to the finings, so as to precipitate. In this case about two ounces of cream of tartar are mixed with the isinglass, and if this is not sufficient, four ounces of oil of vitriol are added to the finings next used, in order to quiet the drink.

Some coopers attempt to extend their art so far as to add strength to the beer; but let it be remembered that the principal constituent parts of beer should be malt and hops. When strength is given to the liquor by any other means, its nature is altered, and it is no more beer that we drink. Treacle in large quantities, half an ounce of the berries of the *Cocculus Indicus*, of the grains of paradise, or of the Indian ginger pounded fine, and mixed with a precipitating substance, are said to produce this extraordinary strength.

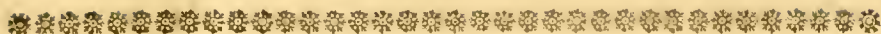
To heighten the flavor of the drink, half an ounce of grains of paradise pounded are used, and this, in my opinion, is the least hurtful ingredient among them.

Formerly brown beers were required to be of a very dark brown, inclinable to red. As this color could not be procured by malt properly dried, the juice of elder berries was frequently mixed with the isinglass. But this juice seems now to have given way to the calcined sugar; both are needless, when

the malt and hops have been properly chose, and applied to their intended purpose.


Such are the remedies chiefly made use of for brown beers. Drinks formed from pale malts are always supposed to become spontaneously fine, and when they are so, by being bottled, they are saved from any farther hazard. As it is impossible for any fermented liquor to be absolutely at rest, the reason of beers being preserved by this method is that, by it, more than by any other means, they are deprived of a communication with the air, and without risk, gain all the advantages, which age, by slow degrees, can procure, and art can never imitate. Were we as curious in our ales and beers as we are in the liquors imported, did we but give, to the product of our own country, the same care and attendance which we bestow on wines; we might enjoy them in a perfection, at present scarcely known, and perhaps cause foreigners, to esteem our beers, as much as we do their wines.





SECTION XX.

Of TASTE.


DOCTOR Grew, who has treated of this matter, divides taste into simple and compound; he mentions the different species of the first, and calculates the various combinations of the latter, the number of which exceeds what at first might be expected. Without entering in this detail, I think that the different tastes residing in the barlies, or formed by their being malted, and brewed with hops, may be reduced to the following; the acid, which is a simple taste; the sweet, which is an acid smoothed with oils; the aromatic, which is the compound of a spirituous acid, and a volatile sulphur; the bitter, which, according to our author, is produced by an oil well impregnated either with an alkaline or an acid salt, shackled with earth; the austere, which is both astringent and bitter; and lastly the nauseous and rank, which is, at least in part, some times found in beers, which have either been greatly affected by fire, or by long age have lost their volatile sulphurs, and have nothing left but the thicker and coarser oils, resembling the empyreumatic dregs of distilled liquors not carefully drawn.

The number of circumstances, on which the taste of fermented liquors depends, are so various, that perhaps there never was any two brewings, or any two vintages, which pro-

duced drinks exactly similar in taste. But in this as well as in other things, varieties may be reduced under some general classes; the better to distinguish these, let us enquire, which tastes belong to different malt liquors, according to the several circumstances in which they are brewed.

In beers and ales, the acid prevails in proportion as the malt has been less dried, and heat was wanting in the extracting water. The sweet will be the effect of a balance preserved between the acids and the oils. When, by the means of hotter water, oils more tenacious are extracted from the grain, the taste becomes higher in relish, or aromatic. If the heat is still increased, the greatest part of the acids, and the most volatile oils, will be dissipated, and the bitter of the hops appear more distinctly. A greater degree of fire will impress the liquor with an austere, rough or harsh taste; and a heat beyond this chars or burns the particles of the grain, and extracts the empyreumatic and nauseous oils. Besides heat, there may be other causes, which produce some variation in these tastes; as a superior dryness in the hops; an irregularity in the ordering of the heat of the extracts; too great an impetuosity or slowness in the fermentation; the difference of time in which the drink is kept; but as these causes affect the liquor, in a low degree, in comparison to the drying and extracting heats of the grain, an enquiry into their consequences is not absolutely material.

Beers or ales, formed of pale malt, in which a greater portion of acids is contained, with less tenacious oils, are not
only

only more proper to allay thirst, but in general more aromatic, than brown drinks. The oils of these last being, by the effect of fire, rendered more compact, and more tenacious of the terrestrial parts raised with them, are attended with something of an austere and rank taste. This seems to be the reason, why brown beers require more time, after they have been fermented, to come to their perfection. The air, little by little, softens and attenuates these oils, and by causing the heterogeneous particles to subside, makes them at last, unless charring heats have been used, pleasing to the palate, whereas they were before austere, rank and nauseous.

By means of the thermometer, we have endeavoured to fix the different colors of malt, the duration of the principal sorts of drink, and the tendency each has to become transparent. The same instrument cannot probably have the same use, when applied to distinguish the different tastes, as these depend on a variety of causes not easy to be ascertained. Yet something of this nature may be attempted, upon the following principles.

As the chief circumstance, which produces a variety of tastes in malt liquors, is fire or heat acting on the malt and hops, and the effect of the air, put in motion by the same element, the table here subjoined may point out what tastes are in general occasioned by the combination of these two causes.

A TABLE

A TABLE determining the tastes of malt liquors.

Heat of the air	dryness and extracting heat	predominant tastes
80°	- - - - 119°	Acid
76	- - - - 124	ac. ac. sweet
73	- - - - 129	ac. fw.
70	- - - - 134	ac. fw. fw. bitter
66	- - - - 138	fw. fw. bit.
63	- - - - 143	fw. bit.
60	- - - - 148	bit. bit. aromatic
56	- - - - 152	bit. arom.
53	- - - - 157	bit. arom. austere
50	- - - - 162	arom. aust. aust.
46	- - - - 167	aust. aust. nauseous
43	- - - - 171	aust. nau.
40	- - - - 176	nauseous.

The first column of the table shews the fermentable degrees reversed, as the hotter the season is, the more fermented drinks tend to acidity, the direct contrary of which is the consequence of an increase in the heat, malt or hops are dried or extracted with.

The assistance of this table, though small, ought perhaps not to be intirely slighted, as it seems at least to shew that the useful is seldom separated from the pleasing, and that a medium between extremes is most agreeable both to the operations of nature, and the constitution of our organs.

The

The impressions of tastes are less in proportion as the drinks are weak. The strongest wine yields the most acid vinegar. Time wears away this acidity much sooner, than it doth the nauseousness occasioned by vehement heats. This circumstance shews how necessary it is, in the beginning of the process of brewing, to avoid extracts which are too weak, and, in its conclusion, such as too great a heat would render rank and disagreeable. That proportion between the salts and the oils, which constitutes true saponaceousness, is most pleasing to the taste, and seems to be the utmost perfection of the art. As the sun never occasions a heat capable of charring the fruits of the vine, we never meet with wines, endued with a taste resembling to the empyreumatic, which we have here represented. This error, being inexcusable in any liquor, ought carefully to be guarded against, and from what we have here said we may learn this important truth; that nature is the best guide, and that, by following her operations, we shall never be disappointed in our ends.



APPENDIX.

THOUGH this work has already been carried to a great length, I hope those of my readers, who may have done me the honor to go attentively through the whole of it, will pardon me the addition of a few incidental thoughts and queries. The chain of arts is so well connected, that researches originally intended for the illustration of any one of them, can hardly fail of throwing some light upon others.

1. The seed of plants cannot be put in a fitter place, for perfect vegetation, than when buried under ground, at a depth sufficient to defend the young shoots from the vicissitudes of heat and cold, and the disadvantages of too much moisture. The manuring of the earth, and the steeping the seed into solutions of salts or calcined substances, have been found, in some cases, to increase the strength of the grain, to correct its original defects, and to prevent the noxious impressions of a vicious ground. Plants are made to germinate in water alone, and this experiment so successfully carried on every winter, in warm apartments, may still be improved by dissolving alkaline salts in the water. Could the barley used for malt-

ing be put in the ground, its growth would be more natural, and its oils becoming more miscible with water, by the saline nourishment derived from the earth, might yield more vinous, more strong, and more lasting liquors. But as this method is impracticable, would it be impossible to increase the efficacy of that which is used? Might not lime be added to the water, with which the grain is moistened? Is it not used with success to manure land? Is not a solution of it in water employed by the farmer to steep his sowing seed in? Might it not attract many useless acids from the grain, and possibly from the water itself, as it doth those of the sugar? I barely mention this as one of the substances, that might be employed in the malting of barley, and am far from thinking it the only one. Perhaps different salts should be used, according to the nature of the soil, from which the corn was produced; but a variety of experiments seems to be required, in order to discover how far art might in this case imitate and improve nature.

2. A small quantity of malt, at all times, but especially when brewed in large vessels, parts too readily with the heat which extraction requires; and on the contrary, that heat may be continued too long, if the quantity of malt be very great and not sufficiently spread. A forward beer inclinable to acidity often results from too short a grist, a thick, stubborn, and rank liquor is produced from too large one. Every advantage may be had in brewing, properly, five or six quarters of malt; it is difficult to succeed if the number exceeds fifty.

3. The

3. The strong pungent volatile spirit, which exhales from a must, when under full fermentation, has in general been supposed to be a loss, which might be prevented; and accordingly attempts have been made to retain these flying impetuous particles, by stopping the communication between the atmosphere and the fermenting drink. That there is a dispersion of spirits is beyond doubt, and that these exhaling vapors consist of the finest oils, which the heat forces out of the must, is equally certain. But this loss seems to be abundantly supplied by the stronger oils, which the same degree of heat attenuates and substitutes, in a larger quantity, to the former. The last oils could never come under the form of a vinous liquor, but by a power, which sooner or later dissipates some of the first. Pale ales or amber not only lay, for many days, exposed to the open air, but suffer, by the periodical renewal of the action of the air, every two or four hours, a much more considerable loss of spirits, than when fermentation is carried on uniformly. Yet experience shews, that so many oils are, by this method, attenuated, that the strength acquired greatly surpasses that which is lost.

4. The practice of fermenting *by compression*, recommended to distillers, seems, on this account, less useful, than it might be concluded to be from theory, since the intent of the distiller as well as of the brewer is to extract the greatest quantity of spirituous oils. It is impossible to ferment a must *in vacuo*; air is absolutely necessary for carrying on this operation, and even a superabundant quantity of oils, by obstructing the free admission of the air, impedes fermentation, prevents the wine from be-

coming pellucid, and sometimes may in part render it putrid.

5. When the purest spirit is intended to be drawn from the grain, the fermented wash ought to be suffered to settle, till it becomes transparent. The dispatch, with which the distillery is generally carried on, prevents this useful circumstance taking place, and occasions a want of vinosity in the liquor. In many cases, the extraordinary charges of extracting the grist in the manner, which has been directed for drinks intended long to be kept, and of suffering the mash to become spontaneously transparent, might be abundantly repaid. Yet, if hurry must be a part of the distiller's business, he should at least make such extractions as admit of the speediest and readiest fermentation. He cannot expect corn spirits equal to the brandies of France, unless his worts are similar to the wines distilled in that kingdom. He would therefore secure to himself the greatest probability of success, did he regulate his extracts by such heats as have been fixed for small beer, especially as the length used in distillery is nearly the same. The omission of the hops would render such musts fit for the still, immediately after fermentation. By too strong heats, more oils are forced into the must than can be converted in spirits; and fermentation being, by this over charge, in some measure, clogged and impeded, a less yield is made, and a liquor obtained of a rank and often empyreumatic taste.

5. Why are the brandies of Spain inferior to those prepared in France? The wines of the last country are the growth of a weaker sun; they contain no more oils than can be assimilated by fermentation, and form a clean dry nutty spirit. The Spanish wines abounding with more oleaginous than acid parts, this over proportion becomes not only useless but hurtful in the still, and produces the rankness observed in Spanish brandies. The cleanness of the spirit arises in great measure from the weakness of the must, and its vinosity from the due proportion of the oils to the salts. This seems to be the reason why the most grateful spirits are produced, from wines unable to bear the sea or to be long kept.

6. The native spirits of vegetables, says Boerhaave, are separated by heats between 94 degrees and 212. To obtain the whole of these, the fire must be gradually increased; for a superior heat dissipates the spirits raised by an inferior one. Such parts as might be obtained by 100 degrees are lost if the heat applied be much greater. Though the parts of vegetables immersed in water cannot so easily be dissipated as if they were in open air, yet, by the rarefaction of the liquid, a proportional evaporation must insue, and the oils raised by a greater heat may so effectually envelope the finer ones, as to make them hardly perceptible either to our smell or taste. Thus, though heated water is able to extract all the virtues residing in the vegetables, the different application of the fire will alter, not only their proportions, but perhaps their properties also.

7. The

7. The vinegar maker is equally concerned with the distiller in the brewing process. Vinegar is produced by the last stage of fermentation, when a gross, tartareous, unctuous matter, consisting of the coarser oils extracted either from the grain or the grapes, generally falls to the bottom of the liquor, and no longer prevents its acidity, or affects its flavor. Though the best vinegar proceeds either from the strongest wines or beers, this strength consists in the quantity of fermentable principles, and not in that of mere oleaginous parts. By properly adapting the extracting waters, this hurtful impediment may be removed, and the vinegar from malt liquors become as neat and as strong as that, which is extracted from wine.

8. As the acid taste of vinegar is the effect of a continued fermentation, many people have thought it immaterial how speedily the first parts of the operation were carried on. But violent fermentations not only dissipate some of the fine oils, which should be retained in the vinegar, but also cause the must to tend towards putrefaction. Boerhaave, after he has directed a frequent transvasion of the liquor, observes that, whenever the weather or the workhouse is very hot, it is often necessary to fill the half emptied vessels every twelve hours, not only to procure a supply of acids from the air, but also to cool the wine, and check the too violent fermentation, which arising in the half full casks, might dissipate the volatile spirits before they are properly secured and intangled by the acid. Hence the liquor might be sower indeed, but at the same time flat, and would never become a sharp and strong vinegar.

9. Uses

9 Uses have frequently been found for materials, which before were supposed of no value. The grains, after the brewer has drawn his worts out of them, are generally employed for the feeding of cattle ; but I do not know that hops, after their boiling, have been put to any farther use. Is there nothing more left in this vegetable, after it has imparted the virtue wanted to the beer? All plants burnt in open air yield alkaline salts, though in a greater or less quantity, according to the quality of the plants. Boerhaave says that those, which are austere, acid, or aromatic, yield in their ashes a great abundance of salts, and that these being put in fusion, and mixed with flint or sand run into glass. Hops thrown, after decoction, in no great quantity on the fire, cause the coals to vitrefy, or as it is generally termed, to *run into clinkers*. If therefore the remains of the hops were burnt in open air, or in a proper furnace, it seems most likely that no inconsiderable quantity of somewhat like potashes might be obtained, and this, considering the many tun weight of hops employed in large cities, and thrown away as useless, might become an object of private emolument to the brewer, and of public benefit to the nation.

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E R R A T A.

PART I. Page 36, line 6, dele $161\frac{1}{3}$, p. 51, l. 15, for *soon* read *sooner*, p. 109, l. 7, for *beated* read *wetted*.

PART II. Page 117, line 18, for *worts* read *extracts*, p. 119, l. 1, dele *lastly*, p. 147, l. 2, for 10 *wt.* read 10 *lb. wt.* p. 147, l. 7, for 3 *wt.* read 3 *lb. wt.* p. 174, l. 6, for *before* read *before*, p. 191, l. 7, for 1, 4, *per quarter* read 1, 3, *per quarter*, p. 201, l. 6, for 24, 30, read 24, 00, p. 221, l. 15, for $15\frac{1}{2}$ read 16, p. 224, l. 16, for 158, 0, 50, read 1580, 50, . 235, l. 10, for *as much* read *as near* p. 237, l. 21, for *notwithstanding* read *with*, p. 243, l. 3, for 138, read 130, p. 243, l. 7, for 20, 26, read 10, 26, p. 253, l. 6, after *yield* dele a p. 262, last line for 2 *gallons* read 2 *gallons* $\frac{1}{2}$, p. 274, l. 21, for *stubborness* read *stubborn*.









