"Were it to be spread thin after this removal, it would become dry, and no vegetation would ensue: but being thrown into the couch, a kind of vegetative fermentation commences, which generates heat, and produces the first appearance of germination. This state of barley is nearly the same with that of many days continuance in the earth after sowing: but being in so large a body, it requires occasionally to be turned over, and spread thinner; the former to give the outward parts of the heap their share of the required warmth and moisture, both of which are lessened by exposure to the air; the latter to prevent the progress of the vegetative to the putrefactive fermentation, which would be the consequence of suffering it to proceed beyond a certain degree.

"To supply the moisture thus continually decreasing by evaporation and consumption, an occasional but sparing sprinkling of water should be given to the floor, to recruit the languishing powers of vegetation, and imitate the shower upon the cornfield. But this should not be too often repeated; for, as in the field, too much rain, and too little sun, produce rank stems and thin ears, so here would too much water, and of course too little dry warmth, accelerate the growth of the malt, so as to occasion the extraction and loss of such of its valuable parts, as by a slower process would have been duly separated and left behind.

"By the slow mode of conducting vegetation here recommended, an actual and minute separation of the
parts takes place. The germination of the radicles and acrospire carries off the cohesive properties of the barley, thereby contributing to the preparation of the saccharine matter, which it has no tendency to extract or otherwise injure, but to increase and meliorate, so long as the acrospire is confined within the husk; and by how much it is wanting of the end of the grain, by so much does the malt fall short of perfection, and in proportion as it has advanced beyond, is that purpose defeated.

"This is very evident to the most common observation, on examining a kernel of malt in the different stages of its progress. When the acrospire has shot but half the length of the grain, the lower part only is converted into that yellow saccharine flower we are solicitous about, whilst the other half affords no other signs of it than the whole kernel did at its first germination. Let it advance to two thirds of the length, and the lower end will not only have increased its saccharine flavour, but will have proportionally extended its bulk, so as to have left only a third part unmalted. This, or even less than this, is contended for by many maltsters, as a sufficient advance of the acrospire, which they say has done its business as soon as it has passed the middle of the kernel. But we need seek no further for their conviction of error, than the examination here alluded to.

"Let the kernel be slit down the middle, and tasted at either end, whilst green, or let the effects of masti-
cation be tried when it is dried off; when the former will be found to exhibit the appearances just mentioned, the latter to discover the unwrought parts of the grain, in a body of stony hardness, which has no other effect in the mash tub than that of imbibing a large portion of the liquor, and contributing to the retention of those saccharine parts of the malt which are in contact with it; whence it is a rational inference, that three bushels of malt, imperfect in this proportion, are but equal to two of that which is carried to its utmost perfection. By this is meant the farthest advance of the acrospire, when it is just bursting from its confinement, before it has effected its enlargement. The kernel is then uniform in its internal appearance, and of a rich sweetness in flavour, equal to any thing we can conceive obtainable from imperfect vegetation. If the acrospire be suffered to proceed, the mealy substance melts into a liquid sweet, which soon passes into the blade, and leaves the husk entirely exhausted.

"The sweet thus produced by the infant efforts of vegetation, and lost by its more powerful action, revives and makes a second appearance in the stem, but is then too much dispersed and altered in its form to answer any of the known purposes of art.

"Were we to inquire by what means the same barley, with the same treatment, produces unequal portions of the saccharine matter in different situations, we should perhaps find it principally owing to the different qualities of the water used in malting. Hard water is very unfit for every purpose of vegetation, and
soft will vary its effects according to the predominating qualities of its impregnations. Pure elementary water is in itself supposed to be only the vehicle of the nutriment of plants, entering at the capillary tubes of the roots, rising into the body, and there dispersing its acquired virtues, perspiring by innumerable fine pores at the surface, and thence evaporating by the purest distillation into the open atmosphere, where it begins anew its round of collecting fresh properties, in order to its preparation for fresh service.

"This theory leads us to the consideration of an attempt to increase the natural quantity of the saccharum of malt by adventitious means; but it must be observed on this occasion, that no addition to water will rise into the vessels of plants, but such as will pass the filter; the pores of which appearing somewhat similar to the fine strainers or absorbing vessels employed by nature in her nicer operations, we by analogy conclude, that properties so intimately blended with water as to pass the one, will enter and unite with the economy of the other, and *vice versa*.

"Supposing the malt to have obtained its utmost perfection, according to the criterion here inculcated, to prevent its further progress and secure it in that state, we are to call in the assistance of a heat sufficient to destroy the action of vegetation, by evaporating every particle of water, and thence leaving it in a state of preservation, fit for the present or future purposes of the brewer."
"Thus having all its moisture extracted, and being by the previous process deprived of its cohesive property, the body of the grain is left a mere lump of flour so easily divisible, that, the husk being taken off, a mark may be made with the kernel as with a piece of soft chalk. The extractable qualities of this flour are, a saccharum closely united with a large quantity of the farinaceous mucilage peculiar to bread corn, and a small portion of oil enveloped by a fine earthy substance, the whole readily yielding to the impression of water applied at different times, and different degrees of heat, and each part predominating in proportion to the time and manner of application.

"In the curing of malt, as nothing more is requisite than a total extrication of every aqueous particle, if we had in the season proper for malting, a solar heat sufficient to produce a perfect dryness, it were practicable to produce beer nearly colourless; but that being wanting, and the force of custom having made it necessary to give our beers various tinctures and qualities resulting from fire, for the accommodation of various tastes, we are necessitated to apply such heats in the drying as shall not only answer the purpose of preservation, but give the complexion and property required."
CHAPTER XV.

To make Malt.

STEEP the rye or barley in water, until it can be nearly mashed endwise between the fingers: this, in warm weather, will require from eighteen to twenty-four hours, and longer in cold weather. Then drain off the water, and throw the malt into a heap, on an earthen floor, if possible, until it has begun to sprout, which will be in about eighteen hours. In cold weather it will sometimes be necessary to cover it with a blanket and sprinkle it with warm water, in order to accelerate the sprouting; or make it come, as it is termed. It is now to be spread out to about the depth of six inches, and turned occasionally, that it may all come alike. When the sprout is as long as the grain, and before the blade and spire begins to put out, it must be spread very thin upon a dry floor, in order to put a stop to any further growth, and in thirty-six or forty-eight hours it will be fit for the kiln, where it must be made perfectly dry.
CHAPTER XVI.

To dry Malt.

BY a little attention, the surplus heat from the stills may be employed, and will be sufficient to dry malt. For this purpose, in building the chimney of the distillery, leave a hole about six inches square in one side of the chimney, a small distance above the second floor; and another of the same size on the other side, a little higher up: then on the floor, lay a coat of clay about four inches thick; to prevent the floor from taking fire; and four and a half feet long and three and a half feet wide. Build around this a brick wall sixteen inches high, and from the chimney to within six inches of the end wall, run a thin wall, of the same height. Cover the whole with a piece of sheet iron. Then by placing a damper in the chimney, between the two holes, the heat will be thrown into the kiln, pass round the intermediate wall and must be conducted to the upper hole by a small flue.

In this way four or five bushels a week may be dried.

Drying Malt by Steam.

A patent has been obtained by James Adam, esq. for the purpose—the method consists in the applica-
tion of heat from steam, which may be most conve-
niently done by confining the steam within a chest or
chests, or in hollow cylinders, or other vessels, of any
form or shape suitable to the purpose, on a floor of me-
tal, pottery, or other substance or substances, which
most easily transmit heat, and which being formed
steam-tight, permit the heat to pass through the same
without any steam or moisture; and that the malt and
other grain being spread upon the floor is thereby
dried in an equable, gentle, and regular manner, and
the degrees of heat may be easily regulated by the ad-
mission of more or less steam, so that considerable
precision in the degree of heat given to all parts of the
floor may always be attainable, and the malt or grain
stirred in the usual way.

For a more particular description see the 21st vo-
lume Repertory of Arts.
CHAPTER XVI.

Of Grinding.

As the grinding of the grain is the business of the miller, it is too frequently left to his discretion to judge of the coarseness or fineness which may be most proper. This however is a matter of which the distiller is the only proper judge, and is sufficiently important to require his particular attention. On this subject as on many others, distillers differ very much, some requiring rye to be ground very coarse, others very fine, while others go so far as to say it should only be ground upon country stones and very slowly!—As to this I cannot judge; it is true, that rye is sometimes so ground as to render it dead or inert and difficult to ferment, but this rarely happens with a tolerably good miller. With respect to the degree of fineness there is a medium, which may be best discovered by the observation and experience of the distiller himself. It should neither be so fine as is requisite for boulting, nor so coarse as is generally chopt for horse feed. In the latter case it is subject to a considerable loss, inasmuch as it resists the impression of the hot water in scalding. It will not form a proper union with the water, consequently cannot be made to ferment perfectly, it however imbibes a sufficient quantity of moisture to make it turn sour; the acidity is communicated to the
whole cask, and it tends rapidly to an acetous instead of a vinous product.

When ground very fine it is also subject to disadvantages, though not so great as above mentioned. The greatest danger arises from overscaling, which renders it clammy, and apt to adhere to the sides and bottom of the still.

A medium therefore is to be observed, which will be best ascertained by experiment.

Indian corn, from the flintiness of its nature, is difficult to dissolve, it therefore cannot be ground too fine.

Oats and buckwheat should be ground about as fine as rye.

The grinding of malt is not of much importance; I never found any material difference in the result whether it was merely chopped or ground very fine.

Barley when used without malting should be ground very fine.
CHAPTER XVII.

Of Vinous Fermentation.

THERE are three species of fermentation, the vinous, the acetous, and the putrefactive, each being distinguished by its products, as well as by the phenomena it presents. It has been supposed that these three succeed each other in invariable order, that the vinous always precedes the acetous, and that this equally precedes the putrefactive. Some facts are in favour of this hypothesis, or, there are substances which undergo these successive changes.

Many weak vinous liquors, by a continuance of the fermentative process, become sour, forming vinegar; and vinegar also undergoes decomposition, forms a mould, or passes into a species of putrefaction. But it is not to be concluded that these kinds of fermentation invariably succeed each other; many vegetable substances become sour, which we do not discover ever to assume any vinous state, and a still greater number undergo that decomposition analogous to putrefaction, without having passed through the other two stages of fermentation. When they do succeed one another, however, the vinous is that which precedes the others; and it never succeeds them.
This important process by which saccharine solutions are converted into intoxicating liquors is one of the most complicated in chemistry, and the precise cause of this change is as yet imperfectly known. It is therefore merely intended here to notice the conditions requisite to fermentation, the appearances that occur during the process, and the essential product of it.

Of the vegetable principles, saccharine matter is that which passes with most facility and certainty into the vinous fermentation; and fermented liquors are more or less strong, as the juices from which they have been formed have contained a greater or less proportion of sugar before fermentation, for the addition of sugar to the weakly fermentable juices will enable them to produce a strong full bodied liquor, and the most essential exit in this process is the disappearance of the sugar, and the consequent production of alcohol.

Certain circumstances, however, are necessary to enable it to commence and proceed. These are, a due degree of dilution, in water, a certain temperature, and the presence of substances which appear necessary to favour the subversion of the balance of affinities by which the principles of the saccharine matter would otherwise be retained in union, or at least would be prevented from entering into those combinations necessary to form vinous spirit. These substances, from this operation, are named ferments.
1. A certain proportion of water to the matter susceptible of fermentation is requisite. If the latter is in large quantity proportioned to the water, the fermentation does not commence easily, or proceed so quickly; on the other hand, too large a proportion of water is injurious, as causing the fermented liquor to pass speedily into the acetous fermentation. The necessary consistence exists naturally in the juice of grapes, and in the saccharine sap of many trees; and other spontaneously fermentable liquors: for, if these very liquors be deprived by gentle evaporation of a considerable portion of their water, the residue will not ferment until the requisite consistence is restored by the addition of a fresh portion of water.

2. A certain temperature is not less essential; it requires to be at least 55 deg. of Farenheit. At a temperature lower than this, fermentation scarcely commences, or if it has begun, proceeds very slowly; and if too high, requires to be checked to prevent it from passing into the acetous state. Lastly, though sugar or substances analogous to it are the matters which serve as the basis of fermentation, and from which its products are formed, the presence of other matter is requisite to the process; it has been often stated indeed, that sugar alone, dissolved in a certain quantity of water, and placed in a certain temperature, will pass into a state of fermentation. It is doubtful however, if this happens with a solution of pure sugar; and any change which is observed is imperfect
and irregular; nor does the liquor become vinous, but rather sour.

The substance usually added to produce fermentation is called yeast: but Mr. Cooper says, "by ferments, we mean any substance which being added to any rightly disposed fermentable liquor, will cause it to ferment much sooner and faster than it would of itself, and consequently render the operation shorter, in contradiction to those abusively called so, which only correct some fault in the liquor, or give it some flavour.

When the proper sort of ferment is pitched upon, the operator is next to consider its quantity, quality, and manner of application. The quantity must be proportioned to that of the liquor, to its tenacity, and the degree of flavour it is intended to give, and to the despatch required in the operation. From these considerations he will be able to form a rule to himself; in order to the forming of which, a proper trial will be necessary to shew how much suffices for the purpose.

The greatest circumspection and care are necessary in regard to the quality of the ferment, if a pure and well flavoured spirit be required. It must be chosen perfectly sweet and fresh, for all ferments are liable to grow musty and corrupt; and if in this state they are mixed with the fermentable liquor, they will communicate their nauseous and filthy flavour to the spirit, which will scarcely ever be got off by any subsequent
process. If the ferment be sour, it must by no means be used with any liquor, for it will communicate its flavour to the whole, and even prevent its rising to a head, and give it an acetous instead of a vinous tendency.

When the proper quantity of a well conditioned ferment is prepared it should be diffused in the liquor to be fermented, in a tepid or lukewarm state; when the whole is thus set to work, secured in a proper degree of warmth, and kept from a too free intercourse with the external air, it becomes as it were the sole business of nature to finish the operation and render the liquor fit for the still.

The first signs of fermentation are, a gentle intestine motion, the rising of small bubbles to the top of the liquor, and a whitish turbid appearance. This is soon followed by the collection of a froth or head, consisting of a multitude of air bubbles entangled in the liquor, which as the process advances, rise slowly to considerable height, forming a white dense permanent froth. A very large portion of the gas also escapes, which has a strong, penetrating, agreeable, vinous odour. The temperature of the liquor at the same time increases several degrees, and continues so during the whole of the process. Sooner or later these appearances gradually subside, the head of the foam settles down and the liquor appears much clearer and nearly at rest, having deposited a copious sediment, and from being viscid and saccharine, is now become
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vinous, intoxicating, much thinner, or of less specific gravity.

The process of fermentation however does not terminate suddenly, but goes off more or less gradually according to the heat at which it was commenced, and of the temperature of the external air.

The gas of fermenting liquors has been long known to consist for the most part of carbonic acid; it will therefore extinguish a candle, destroy animal life, convert caustic alkalies into alkaline carbonats, and render lime water turbid by recomposing lime stone, which is insoluble, from the quick lime held in solution.*

But beside the carbonic acid, it has been proved by Scheele, to hold in solution a sensible quantity of alcohol, and Proust has detected in it a portion of azot. Mr. Collier (Manchest: Trans. vol, 5,) has further shown, that in this gas, are contained all the requisites for vinous fermentation. He passed the whole of the gas from a ninety gallon fermenting tub into a cask of water, and divided the liquor thus impregnated into three parts, of which one being immediately distilled,

* If a clear saturated solution of pearl ash, be exposed in an open vessel, within a vat of fermenting liquor, beautiful chrystals of salt, formed of the alkali and acid or air, will be formed. From these the air may be again disengaged by vinegar or any other acid. These chrystals being thrown into a barrel of stale cyder, at the rate of not more than four ounces to a barrel, and the bung being replaced quickly will be found to diminish the acidity, and increase its briskness without injuring its salubrity.
afforded a small quantity of alcohol; to the second was added some yeast, by which a new fermentation was excited, and the subsequent product of distilled spirit was nearly doubled, and the third being suffered to ferment a longer time, produced vinegar.

The attenuation of liquors, or the diminution of their specific gravity by fermentation, is very striking. This is shown by the hydrometer, which swims much deeper in fermented liquor than in the same materials before fermentation.

Much of this attenuation is, doubtless, owing to the destruction of the sugar, which dissolves in water, adds to its density, and to the consequent production of alcohol, which on the contrary by mixture with water diminishes the density of the compound.

The tract or mucilage also appears to be in some degree destroyed by fermentation, for the gelatinous consistence of thick liquors is much lessened by this process: the destruction of this principle, however, is by no means so complete as of the sugar; many of the full-bodied ales, for example, retaining much of their clamminess and gelatinous density even after having undergone a very perfect fermentation.*

* This arises from their having more extract than there is water to decompose. The same paucity of water produces the same effects in the fermentation of syrup.
It has been doubted whether alcohol be the product of vinous fermentation, or of the subsequent distillation, by which it has always been obtained, or in other words, whether alcohol exists ready formed in the fermented liquor, or is the product of new combinations resulting from the subsequent application of heat in distillation. The proofs which have been brought forward in opposition to theory, are chiefly founded on the researches of Fabroni,* who attempted to separate alcohol by saturating the wine with dry sub-carbonate of pot-ash, but did not succeed, although by the same means he could detect very minute portions of alcohol which had been purposely added to the wine.

In favour of this opinion, that alcohol is formed by the process of fermentation, we have the experiments of Wm. Thomas Brande, Esq.;† and although we agree with him in opinion, we do not think his experiments decisive on the subject. Mr. Brande added one seventh part of alcohol to wine, and could not separate it by means of sub-carbonate of pot-ash, though Fabroni says, that by the same means he could separate one hundredth part when mixed with wine. But when Mr. B. added one fourth of alcohol to wine, the sub-carbonate of pot-ash would separate it in a very impure state.

In another experiment Mr. B. added four ounces

* Annales de Chimie, 31st vol. pa. 303.
† See Repertory of Arts, vol. 20, pa. 144. New Series.
of dry and warm sub-carbonate of pot-ash to eight-fluid ounces of port wine, which was previously as-
certain to afford by distillation 20 per cent. of alcohol (by measure) of the specific gravity of 0.825 at 60
deg. In twenty-four hours the mixture had separated into two distinct portions; at the bottom of the vessel
was a strong solution of the sub-carbonate, upon which floated a gelatinous substance, of such consist-
tency, as to prevent the escape of the liquor beneath when the vessel was inverted, and which appeared to
contain the alcohol of the wine, with the principal part of the extract tan and colouring matter, some of the
sub-carbonate and a portion of water; but as these ex-
periments relate chiefly to the spirit contained in the
wine, the other ingredients were not minutely exa-
 mined.

To seven fluid ounces of the same wine, were ad-
ded one fluid ounce of alcohol of 825, and the same
quantity of the sub-carbonate as in the last experiment;
but after twenty-four hours had elapsed, no distinct separation of alcohol had taken place.

If the spirit afforded by the distillation of wine was
a product, and not an educt, Mr. Brande conceived,
that by performing the distillation at different tempe-
ratures, different proportions of spirit would be ob-
tained.

The following are the experiments made to ascen-
tain this point. Four ounces of dried muriate of lime were dissolved in eight fluid ounces of Port wine, employed in the former experiments by this addition: the boiling point of the wine which was 190 deg. Farenheit, was raised to 200 deg.; the solution was put into a retort placed in a sand heat, and was kept boiling until four fluid ounces had passed over into the receiver, the specific gravity of which was 0.96316 at 60 deg. Farenheit.

The experiment was repeated with eight fluid ounces of the wine without any addition, and the same quantity was distilled over as in the last experiment, its specific gravity at 60° was 0.96311. Eight fluid ounces of the wine were distilled in a water bath; when four fluid ounces had passed over the heat was withdrawn. The specific gravity of the liquor in the receiver was 0.96320 at 60 deg. Farenheit.

The same quantity was distilled at a temperature not exceeding 180°. This temperature was kept up from 4 to 5 hours for five successive days, at the end of which period, four ounces having passed into the receiver, its specific gravity at 60 deg. was ascertained to be 0.96314.

It may be concluded, from these results, that the proportion of alcohol is not influenced by the temperature at which wine is distilled; the variation of the specific gravities in the above experiments being even less than might have been expected, when the deli-
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cacy of the operation by which they are ascertained is considered.

Mr. B. says, he repeatedly endeavoured to separate the spirit from wine, by subjecting it to low temperatures, with a view to freeze the aqueous parts; but when the temperature is sufficiently reduced, the whole of the wine forms a spongy cake of ice.

After detailing all these experiments, we must say that they do not yield any positive conclusion on the subject.

The first experiment which comes nearest to proving the point is unsatisfactory. He says that the gelatinous substance which floated on the surface appeared to contain the alcohol, but he does not say what appearance it was that induced him to conclude that the spirit was in it. If he had thrown it on the still head and applied a blaze to it, and had found that it burnt much more strongly than an equal quantity of the wine from which it came; and if the liquid that held the sub-carbonate in solution had yielded no inflammable vapour when thrown on the still head, he would have come nearer to certainty on the subject.—But even this would not have satisfied his opponents. They require the separation of the spirit without changing it into vapour, because they allege, that it is produced either by the application of the heat, or when the fermented liquor is in a state of vapour. If the spirit had been contained in this gelatinous substance, we
would suppose, that by means of some of the various acids and alkalies or of strong alcohol, an agent might readily have been found capable of separating it. The latter experiments only show that spirit may be obtained in distilling with a low as well as high heat.

Our opinion that the spirit is formed by the process of fermentation, and not in the distillation of the vinous liquid, arises from observing the same intoxicating effects on the human body, from drinking fermented liquors, as from drinking the spirit distilled from them, the degree of intoxication being proportional to the quantity of spirit which the fermented liquors will yield on distillation, and because we hold it unphilosophical to conclude, until it has been proved by experiment, that the mere volatilization of this fluid changes its nature, contrary to what happens in volatilizing every other fluid that we know.

Hence we conclude that the production of alcohol is one of the last efforts, or the completion of the process of fermentation.

The atmospheric air seems to have no share whatever in vinous fermentation, for it will take place full as well in closed as in open vessels, provided, space is allowed for the expansion of the materials and the copious production of gas. Indeed Mr. Collier found by direct experiment that more spirit is produced by close, than open fermentation. In three separate experiments, in each of which an equal quantity of wort
and yeast were fermented, under circumstances precisely similar, with the single exception, that in one the vessel was open, and in the other closed, (the gas having no exit but through a tube dipped in water,) he found on distilling each fermented liquor, and drawing off the same quantity of spirit from each, that the liquor from the close vessel was constantly of less specific gravity, and therefore, richer in alcohol than the other. Where the spirit from the open vessel was twenty-four degrees below proof, that from the close, was fifty-six degrees; where the former was eighty-three, the latter sixty-five; and where it was one hundred and three, the other was ninety-three.

The results of Lavoisier’s experiments should not pass unnoticed, though it is obvious that much too great simplicity is attempted in the explanation of a process, which every circumstance shows to be very complicated. The simple points to which the experiments of this able enquirer tend, is (setting aside all other agents) to explain how sugar becomes converted into carbonic acid and alcohol, which after all, is the characteristic phenomenon of vinous fermentation.

The entire products of sugar, yeast, and water, fermented in close vessels, are stated to be carbonic acid, alcohol and water, together with a small portion of acetic acid; and from these facts the following theory is deduced: sugar is composed of eight parts hydrogen, sixty-four oxygen, and twenty-eight carbon, and the process of fermentation effects a change mere-
ly in the arrangement of the constituent parts of the sugar, converting one portion into carbonic acid, and the other into alcohol; and hence (as carbonic acid contains only carbon, with a large proportion of oxygen) the portion which is left must contain all the hydrogen, part of the carbon, and a very small portion of oxygen; or, in other words, by this new arrangement of the ingredients of the sugar, one portion, namely, the carbonic acid, is totally deprived of hydrogen, and overloaded with oxygen, while the other portion, namely, the alcohol, abounds in hydrogen, and is deficient in oxygen, the carbon being divided between the new products in nearly an equal proportion with regard to their respective qualities.*

Nothing more plausible than the above has, perhaps, hitherto been offered to the general phenomena of vinous fermentation, though it is very defective in many essential parts, and even does not correspond with the alleged composition of alcohol, given by the same chemist in another part of his inquiries.

The great question remaining to be determined by future inquirers is, what may be the substance or circumstance, which disposes sugar to ferment; for it has been proved that sugar will not of itself begin this

* Is it not more probable that the water is decomposed, its oxygen combined with the carbon of the sugar to form fixed air, and its hydrogen with the other constituent parts of the fermentable matter to form alcohol? This is the more likely as the extent of fermentation is exactly regulated by the quantity of water present.