Australian Brewing Student's Manual

Alfred Hasker
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THE AUSTRALIAN BREWING STUDENT'S MANUAL

By **GROVE JOHNSON, F. C. S.**

BY THE SAME AUTHOR:

THE STUDENT'S MANUAL OF YEAST CULTURE

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PREFACE

SEVEN years in Australia! It seems but seven months: but a pile of records of work done is convincing evidence of the truth. The time has been fruitful in experience and friendship. Arriving a stranger, I now count nearly everyone connected With the fermentation industries a personal friend.

We have worked together without being unduly serious, and laughed together at many old fashioned ideas daily becoming obsolete. An honest laugh has its value, just as a serious thought has, in its season.

Australia has been wonderfully liberal-minded with regard to modern ideas. The view that "our grandfathers must be right" is unknown, and progress is therefore easier and quicker than in older countries.

Take as an example of progress the "Abbot’s Lager," Melbourne. It is a wonderful achievement — the beer is second to none in the whole g world. We have also Messrs. Boag and Son, Tasmania, equally to be congratulated.

Valuable types of yeast have been isolated, and in every case have been used on a practical scale.

To facilitate reference, I have given each a number instead of a name. Pure cultures are propagated periodically.

Melbourne No. I. — Saccharomyces Cerevisia (high fermentation), isolated from the Ballarat Brewing Co. Pty. Ltd., now used almost exclusively throughout Australian Breweries.

Melbourne No. II. — Saccharomyces Cerevisiae, a wild type, used in the fermentation of bread. An exhibition of loaves at Christchurch (N.Z.) Hospital created a very favorable impression.

Melbourne No. III. — Saccharomyces Ellipsoideus, isolated at Messrs. Burgoyne’s Mount Ophir Vineyard, Rutherglen. The Burgundy fermented by this culture took the champion prize at Melbourne Royal Show.

Melbourne No. IV. — Saccharomyces Ellipsoideus, isolated from 1913 currants, at Irymple, Mildura. The type has proved invaluable for the fermentation of raisins for distillation.

Melbourne No. IV. — Saccharomyces Cerevisiae, isolated from the Abbotsford Brewery, Melbourne. It has very great attenuative power, and consequently is

valuable to distillers of grain spirit.

Melbourne No. VI. — Saccharomyces Cerevisiae (low fermentation), now in general use throughout Australia, wherever "Lager" is brewed.

Other types from vineyards, bakeries, breweries, rum distilleries, etc., have also been isolated and studied — but the six yeasts enumerated have severally special characteristics, rendering their application important.

The special advantage to be gained by the use of Melbourne No. I. is that, by its ability to ferment fifty per cent. of raw cane sugar, yeast weakness is overcome, and inversion (with the risk of arsenic) is unnecessary.- I hope to see this culture in general use in England when the War is over.

The pure culture system is now practically universal, and I know none who, having adopted it, would return to the dangerous practice of "changing" yeast.

In conclusion, a few words in explanation of my choice of subjects for this work may be acceptable.

The introductory Chapter (although part of a lecture delivered in- Melbourne) may help beginners to focus their ideas respecting the chemistry of brewing. In Chapters XIII. and XV. I notice, on passing the proofs for press, that the definition of specific gravity occurs in both; but, on consideration, I have decided to leave the text as it stands, as the details in both cases are essential to the arguments.

The remaining Chapters have all been written by request, and, I trust, may prove useful generally.

As an unnecessary amount of confusion has arisen owing to the variations of the Food Laws in the several States, I have collected all, as far as I am aware. The differences have been noted, and it is to be hoped that we may shortly have a common law for brewers in Australia.

Until that time, I think we may safely abide by the recommendations of the Commonwealth Conference, detailed in Chapter XVIII.

GROVE JOHNSON.
The Laboratory, Atlas Building,
Spring Street, Sydney,
February, 1917

CHAPTER I. FERMENTATION.

THE CHEMICAL ACTION OF THE INFINITELY SMALL IN NATURE.

Part of the Text of 3 Lecture delivered by the Author in Melbourne. June 23. 1913.

O the world of men in general the word "fermentation" would be associated with the brewing of beer, the raising of bread, the

fermentation of wine, and so forth; but the word has a wider use and meaning — literally to boil, and generally to describe commotion, heat, tumult, agitation movement.

Fermentation, again, is associated in some minds with definite cells or germs. In other minds fermentation is considered to be the action resulting from an essential substance of those cells to which the name enzyme has been given. Again, an enzyme can be elaborated by Nature apart from a germ. Thus we may look upon fermentation as chemical action set up by an enzyme, though all chemical changes resulting from enzymes are not necessarily fermentation.

I will endeavor to make this point clear as I proceed, and I propose considering the chemical action of an-enzyme apart from germ life, as well as fermentation, as it has a wider bearing on some points upon which I hope to hold your interest.

Before entering into details, I propose that we consider as briefly as possible what is actually meant by chemical action.

Every object, we know, is made up of one or more elements, e.g., gold, silver, carbon, oxygen, chlorine. An element is matter from which we can obtain nothing different from the mass. We can neither split it up into different substances nor change its qualities.

Compounds are substances composed of more than one element, and chemical-action is the rearrangement or the addition or liberation of an element or elements.

It may occur to inquiring minds how is one to know whether chemical action is due to living matter or matter that is inorganic.

In the first place one must inquire what are the essential differences between the organic and the inorganic worlds.

We have heard as children of the three worlds or kingdoms known as the animal,

vegetable, and mineral.

The first two — animal and vegetable said to belong to the organic world, and the last, the mineral, to the inorganic world. —

It is essential that all varieties of the animal and vegetable kingdoms exhibit the phenomena of life, growth, multiplication, and death.

But the mineral or inorganic world exhibits none of these phenomena unless a crystal can be said to grow. This, then, is the test — Can a thing live? Can it grow? Can it increase? Can it die? If the answer to these questions is yes, then that substance must belong to the organic world. The essential difference between the vegetable and animal kingdoms is this — that whereas the vegetable kingdom can build up its nutriment from carbon and mineral matter, the animal kingdom is unable to do so, and depends absolutely upon the vegetable kingdom for the preparation of its food.

Thus a bull eats grass and a man eats beef, but grass does not eat anything. No, it has the functions that animals have not — it can prepare its food from the chemicals in the air and soil.

Life can be destroyed by heat, as we all know, and if we have doubts in our mind as to whether or not chemical changes have been brought about by living matter, we can make the following experiments: —

We may take, two portions of a vegetable-substance, and one of them may be sterilized by heat, in order that germs may be destroyed; the other portion may be left without being sterilized, and if change occurs therein we may infer that the change is due to chemical action set in motion by the agency of living matter, or at least matter that was directly due to life; but, on the other hand, if changes occur in sterilized objects — that is, in matter in which life (if any) has been destroyed — we may reasonably argue that the chemical action has been due to inorganic matter, or, to put it the other way, to the mineral kingdom.

Now it is clear that chemical action is not confined to what are popularly called "chemicals." To the chemist everything in the heavens above, in the earth beneath, and in the waters under the earth, is a chemical. Chemical action is essentially a function of life, just as it is of inanimate things. Chemical action is not 11le visible to the naked eye, but the chemist has devised means whereby he knows it has been accomplished. To make chemical action a reality to you, I will cite examples probably well known to you, but to which you may not have assigned a reason.

The lime kiln is an object well known to everyone. The chemical action that takes

place therein is simply that limestone — calcium carbonate, or chalk — is compelled to give up, by heat, its carbonic acid. The remaining oxide 'of calcium is simply lime.

Here is an instance of chemical action in which the loss of a molecule occurs.

A seidlitz powder is another example of the loss by effervescence of carbonic acid, but in this case an exchange occurs — the acid present in the powder combining with the base.

Hydrolysis is a term often used amongst brewers. It means that water has been chemically combined with starch to form sugar. This can be effected by the agency of acids or by an active principle in malt termed diastase. Here, then, we have examples of chemical actions of identical nature achieved by entirely different means — the former by a substance belonging to the inorganic world, the latter to the organic world. Another example of chemical action belonging to the organic world is the splitting up of the glucose molecule into alcohol and carbon dioxide by the agency of a substance called zymase, contained in yeast. This chemical action is known to every- V one by the name of fermentation.

In the last example we have seen that the chemical action is due to germ life, an entirely different view to that adopted by the uninformed, whose outlook upon the changes in compounds might be that they could alone be altered by rusting, or burning, or explosion, for example.

Germ life, the conditions being favorable, increases in incredible numbers, the offspring of a single cell being calculated to the possibility of untold- millions of cells. They may reproduce by budding or by forming spores. I

True yeasts bud and sporulate, whilst some micro-organisms, similar in some respects, can bud, but cannot sporulate. Yeast is as much a vegetable as a mushroom is, though an infinitely small and undeveloped variety. To prove to ourselves that it is a vegetable and not an animal, we ask the question: Can it build up its food from inorganic — that is to say, mineral — compounds? The answer is — Yes. Pasteur proved that such was the case, and by doing so was able to study its habits and characteristics in a manner that would have been impossible until he had proved it.

In ordinary conversation we use from time to , time such sentences as these: "The meat has gone bad.". "The butter has gone rancid." "The haystack took fire." "The bread is sour." Has it ever struck you that definite germs have caused these changes in the several examples, and that had the specific germs been absent the things I have mentioned — badness, sourness, etc., — could not have happened?

Pasteur, I mentioned casually just now, is a name known to you all. Do you know that it was he who first placed bacteriology on the plane of an exact science?

His studies in fermentation are as interesting as stories from the Arabian Nights. They are more than that; they have shown the world how to prevent disease in a great number of cases.

The very Word "Pasteurized," used commonly in connection with food products, means simply that putrefactive germs have been destroyed.

You have heard of the Lister Institute in London. Do you know that Lord Lister was so impressed and influenced by Pasteur’s work that he reasoned that septic poisoning, often time arising from an operation, could be prevented by using antiseptics. This was so, and as a result of his reasoning we are spared all the horrors of the hospital, which unfortunately occurred before his wonderful researches.

Hansen is a name well known amongst bacteriologists. He it was who first demonstrated simple methods for the preparations of pure cultures. Of this subject I will speak later.

A wealthy Dane, Herr Jacobsen, of Copenhagen, amassed a vast fortune, and by his will it was devoted to science and art. Hence the finest laboratories in the world were built and endowed to allow Hansen the fullest scope for his genius.

Thus Copenhagen became the Mecca for bacteriologists, and the whole world paid tribute to the master who, by his inherent genius, rose to the highest eminence, although he started life in humble circumstances, and followed the calling of a painter.

The great names I have mentioned, Pasteur, Lister, Hansen, are no longer with us; but their works live, and afford for all time a splendid example of the reward of diligence.

I have suggested that we will consider an example of chemical action due to an enzyme apart from germ life. I propose, therefore, to use as an illustration the germination of a grain of barley. When seed is sown we say "it sprouts," or "it grows." Has it ever occurred to you that Nature has provided marvelous facilities for this sprouting or growing?

Have you ever noticed that beneath the outer skin of a grain of barley, on the back or dorsal side, there is a slight ridge near the base?. This ridge is caused by the presence of the embryo or immature plant, which is merely awaiting its chance to develop. You can take a grain of barley, strip the outer skin, and expose

the embryo to view. Immediately behind the embryo, and separating it from the major portion of the grain, is a very thin porous skin called the shield or scutellum. The major portion of the grain behind the scutellum consists of cells of starch. Now starch, as you are aware, is insoluble in cold water.

The grain of barley cannot obtain nutriment from the soil in its embryonic state, and, as I have said, starch is insoluble. Whence, then, does it derive its food — for there can be no growth or increase in the animal or vegetable kingdoms without nutriment?

At least two definite chemical actions commence directly the grain becomes moist in the soil.

Both of these chemical actions are directly due to enzymes, which brings us to the point of our illustration.

In the first place, starch cells may be compared to eggs with their shells. Just as omelets cannot be made until egg shells are broken, so must starch cells have their outer coverings dissolved or modified, as brewers would say, before the contents could be available as food.

Directly, as I have said, the grain becomes moist in the soil, an enzyme called cytase commences its solvent action of the shells or coverings of the starch cells. Directly this is accomplished, another enzyme called diastase commences its action, and converts the insoluble starch into soluble sugar. Now the soluble sugar, maltose, can pass through the shield or scutellum to the embryo or young, plant. The plant sucks it up and commences to shoot; it will continue shooting until the whole of the starch of the grain has been converted to sugar, and so absorbed.

Now attend a moment to the wonderful provision of Nature. Had Nature provided sugar ready formed in the grain it would be dissolved and distributed in the damp soil, and so be lost to the young plant. But by providing insoluble starch and the marvelous means of its conversion to sugar as required, surely compels our. admiration, and causes us to think of the wonders around us such wonders that only he who seeks may find.

Once the starch of the grain has been absorbed by the embryo, the little plant has to set out in life for itself. It thrusts its roots into the soil, from whence it draws moisture and mineral salts, and shoots forth the little green blades so familiar to us in the cornfields. As the little blades become greener and longer, they in their turn have to assist in the general scheme of enlarging the plant. The green coloring of the blades is due to a substance to which the name chlorophyll has been given.

This chlorophyll sets up another chemical action. It splits up carbon dioxide gas, always present in the atmosphere, to its component parts, Carbon and oxygen. The carbon is assimilated by the plant, and the oxygen is set free. Thus does the plant grow, and in due time gives forth its increase of grain.

CHAPTER II. HYDROLYSIS OF STARCH.

In the production of light beers, whether for non-alcoholic or lager, the essential condition is to make a weak beer tasteful; to achieve this result, it becomes necessary to have a clear comprehension of the principles involved in the hydrolysis of starch.

> Note. — In this chapter the author has drawn large from two papers published by the Institute of Brewing — "Brewing in Belgium and Belgian Beer," by G. M. Johnson (Vol. I, No. ii July, 1895). "Enzymes," by Dr. Harold Johnson (Vol. I, o. 1, January, 1904).

The ordinary British methods of mashing are quite out of the question for the simple reason that, within the first few minutes, the percentage of maltose and dextrin is determined according to the temperature of the mash tun and diastasic capacity of the malt. To give an example:

If, as in the case of a distiller’s mashing, the initial temperature of his mash tun is within the range of 142F. and the diastasic capacity of the malt is high, maltose will be produced in preference to dextrin, and maltose being directly fermentable, results in a mash of very low final gravity at the close .of fermentation. On the other hand, assuming it is required to produce the highest percentage of dextrin, we might conveniently employ an initial temperature of 165F. The question might naturally be asked, therefore, if this be so, why not mash with water hot enough to produce this initial temperature and have done with it? There are very full and sufficient reasons why this is not advantageous, as will be seen upon careful consideration of enzymic action, which includes, be it noted well, not merely hydrolysis of starch, but also proteolytic enzymic action.

The first point that should be thoroughly grasped is that Amylase or ordinary Diastase consists of two enzymes. One of these is called liquefying diastase and the other saccharifying diastase. The presence of the liquefying enzyme can be easily demonstrated by allowing a small proportion of malt extract to act on a thick starch paste at a temperature of 175F. In a few minutes the paste loses all viscosity, becoming liquid and transparent. It should be noted that at 175F the saccharifying enzyme is totally destroyed. In ordinary mashing operations, where malt is the only material used, the action of the liquefying enzyme is apt to be overlooked. The starch which has been partially prepared by the action of enzymes during germination is quickly liquefied and saccharified at temperatures between 142F. and 150F. When raw grain, however, is used, in which the starch granules are intact, it is found necessary to heat such material to a point considerably above 150F. in order to obtain its complete solution. Practical experience has proved that the most favorable temperature for producing the

liquefaction of raw grain, maize, or rice grits, is one of 175F, the quantity of malt required being about 20 per cent. of that of the raw grain.

Under the combined action of the heat and the liquefying diastase the starch cells are quickly burst and rendered soluble at a temperature of 175F.

If the matter is so far clear, it is obvious that in producing a wort composed of a proportion of raw grain with a view to obtaining a high final gravity, the digestion of the raw grain with 20 per cent malt at 175F. should be conducted in a separate vessel commanding the mash tun, in order that such a mixture may be introduced immediately the moment is ripe for its introduction. This ripe moment is considered later. Here a slight digression is necessary. It must be remembered that the main idea of wort production according to British methods must be forgotten for the moment. The principles at stake are so entirely different. Many brewers in Belgium mash cold, as little water as possible being used, but a large number mash with water at 118F. and in quantities sufficient to get an initial temperature of 108F, at which temperature the mash is generally left for half an hour, sometimes longer. At this temperature several things happen; the diastase is taken in solution and the starch-granules swell up. The proteolytic enzymes which act on the nitrogenous matter of the grain find their maximum activity at or near this degree. It might be useful at this stage to refer to the principal enzymes with which the brewer has to deal. Firstly, those met with in malted barley, and secondly, those secreted by yeast. In the first group we have Amylase (which has already been discussed). Peptase or the proteolytic enzyme, which digests and renders soluble vegetable albumin; Cytase, the enzyme which digests certain forms of cellulose; Oxidase, the enzyme which carries out the respiratory functions of germinating barley, and by whose medium the oxygen of the air is absorbed and carbon dioxide given off. In the second group — enzymes secreted by yeasts — we have Zymase, the ferment which splits up sugar into alcohol, and carbon dioxide; Invertase, which converts cane into invert sugar. Yeasts also contain other enzymes which are unimportant in the present discussion.

It will be noticed that it has been stated that at 108F. the proteolytic enzyme is most active, which means in plain English that the albuminous matters necessary for yeast food are digested and rendered soluble at this temperature. Compare this with the British brewer’s methods of mashing to obtain an initial temperature of 152F, for example. His proteolytic enzyme, if not destroyed, is certainly inactive, and he consequently loses the yeast food which he would have obtained in a soluble form by mashing to obtain an initial temperature of 108F. So much then for our initial temperature of 108F. It must be clear to the intelligent reader what a gulf there is fixed both in principle and practice between mashing at 108F. and 152F. We are now ready to consider the next stage in the mashing operation. What is technically known as a "thick mash" kettle is arranged in position beneath the mash tun. Above the mash tun plates a sluice valve is introduced into the side

of the tun. This enables a proportion (generally one-third) of the goods to be drawn off to the "thick mash" kettle. The mash tun rakes should be kept revolving as quickly as possible, whilst drawing off one-third of the goods. The proportion now in the thick mash — kettle is raised quickly to 165F, and this temperature is maintained until the wort becomes clear. It should be noticed that temperatures ranging between 108F to 165F. are avoided as much as possible; the reason for this will be explained later. It should be noted that at 165F we obtain our maximum of dextrin and also, be it noted well, this very temperature is closely approximating to the maximum of saccharifying diastasic action. It will be remembered that at 175F. the saccharifying diastase is destroyed though the liquefying diastase remains active. When the starch of the first thick mash is converted, in other words, when it has become clear it is boiled from 15 to 30 minutes, and then pumped back to the mash tun standing at present at 108F, care being taken by providing cold water that the initial temperature does not rise above 130F. and by the provision of boiling water to obtain this temperature (130F.) if necessary. After the goods have stood for (15 to 30 minutes, the sluice valve at the side of the tun is again opened and the rakes again revolved and again one-third of the goods is drawn into the thick mash kettle and again raised to 165F and then boiled, for the same reason as explained in the first thick mash. But here most important explanations and directions become necessary. It will be readily understood that a malt which has been soaking for half an hour or more at 108F undergoes (when subsequently warmed up either by addition of hot water or by a steam jacket) a very rapid and complete saccharification, directly at temperature is obtained at which starch is gelatinized. If, therefore, a mash which has been standing at 108F be gradually heated up to 140F and then on to 167F, a very thin beer will be produced, because it has already been shown that 140F. is the most favorable temperature for the formation of maltose. This undesirable result is easily accounted for; all the diastase that malt contains has been, by soaking at 108F, brought into play, and the transformation of the starch into sugars has not taken place at the high temperature that has been finally reached (167F), but at somewhere about 140F. The production of maltose is consequently excessive. This indeed constitutes the danger of digestive mashing, but brewers can avoid this danger by a very simple method. The. method is by any means to raise the temperature from 130F to 165F as quickly as possible, in order that the temperatures favorable to formation of maltose are avoided. If one would care to obtain evidence that this contention is based upon fact, and not hypothesis, a simple experiment, carefully conducted, will carry conviction. Let us assume that conversion is less possible at 130F (which we will call experiment "A") than at 140F (which we will call experiment "B"), and that if two mashes of 10 per cent. solutions are made at the respective temperatures for half an hour, and raised as quickly as possible to 165F, the final gravity of the worts after fermentation will be found higher in the case of "A" than in "B,"because in the case of "A" the critical temperatures for maltose, viz., 140-145F have been studiously avoided. We have jumped as quickly as possible to 165F, the most favorable for dextrin formation.

In the case of "B," on the contrary, we have held our mash at 140F, the most favorable temperature for maltose in any method of mashing, but in this particular case more favorable than the British method because the preliminary mash of 108F. has taken into solution all the diastase, and further, has rendered the starch into a condition favorable to gelatinization, and consequently conversion, the moment 140F is reached.

To enter into further details respecting the experiments "A" and "B," it will be found that, after mashing both for half an hour at 108F, and in the several cases drawing off one-third of the goods and raising. to 165F. until clear, and then boiling, but in the case of "A," upon returning the mash, limiting the temperature to 130F, and in the case of "B", upon returning the mash, allowing the temperature to reach 140F, it will be found by an Iodine solution that complete saccharification takes place in the case of "B," but not in the case of "A," it being understood that the formation of the Iodide of starch is to be regarded as the indicator.

It will be remembered that in the early stage of this discussion it was mentioned that, when using raw grain digested with 20 per cent. of malt it must not be introduced to the main malt mash until the moment is ripe. If the argument has been followed carefully, and our intention is to produce a weak beer tasting full, it is most obvious that the ripe moment is when the main mash tun is as near 165F. as possible. We have, it must be remembered, the starch in our raw grain liquefied (the raw grain, together with the 20 per cent. of malt digested at 175F. must be reduced to 165F. before being run to the mash tun), and consequently capable of conversion immediately it comes in contact with diastase, and whether it produces the maximum of maltose or dextrin, is dependent absolutely upon the temperature of the mash tun. If we were distillers, our object should be to bring it to the mash tun not exceeding 140F, but as our whole reasoning and contention is the production of a weak beer tasting full, our object must be to introduce our liquefied starch at 167F. to our mash tun at the same and also the maximum temperature, in order that we may obtain the maximum of dextrin and yet not so high as to destroy saccharifying diastase.

In order that the student may have a clear comprehension of the significance of the arguments ad — advanced in the foregoing chapter, the following experiments are suggested and should be conducted: —

EXPERIMENT I.

Take 4 grams potato starch in an Erlenmeyer flask. Add 200 cc cold water and shake constantly. Have a small water bath ready at hand containing boiling water.

Introduce the flask to the boiling water, and continue shaking until the starch is gelatinized. Now adjust the temperature of the water bath and the flask to 175F. At this temperature add to the starch 1 gram finely powdered malt of a diastasic power of not less than 20 Lintner. Maintain the temperature at 175F. In a few minutes the starch will have become quite liquid. Confirm the presence of actual starch (that is, starch unconverted though liquefied) by iodine solution.

EXPERIMENT II.

Take 100 grams of finely crushed malt and mash with about 900 cc water at 160F. Maintain the temperature at 150F for 90 minutes. Filter. Boil 30 minutes. Cool to 60F, and adjust volume to a specific gravity of 1026. Ferment in a sterilized flask, plugged with wool, with any pure culture of yeast, having a range of temperatures favorable between 60 and 70F. At the close of fermentation note the final gravity and compare with the following : —

EXPERIMENT III.

(A) Take 70 grams of finely crushed malt of a diastasic power of not less than 20 Lintner, and mash with 700 cc of water at 168F, and maintain the temperature at 158F.

(B) Meanwhile take 20 grams of flaked rice or maize with 200 cc of water at 180F, and maintain the temperature at 175F. Now add 10 grams of finely crushed malt to the rice or maize, and maintain the temperature of 175F for 30 minutes. Now reduce the temperature to 158F.

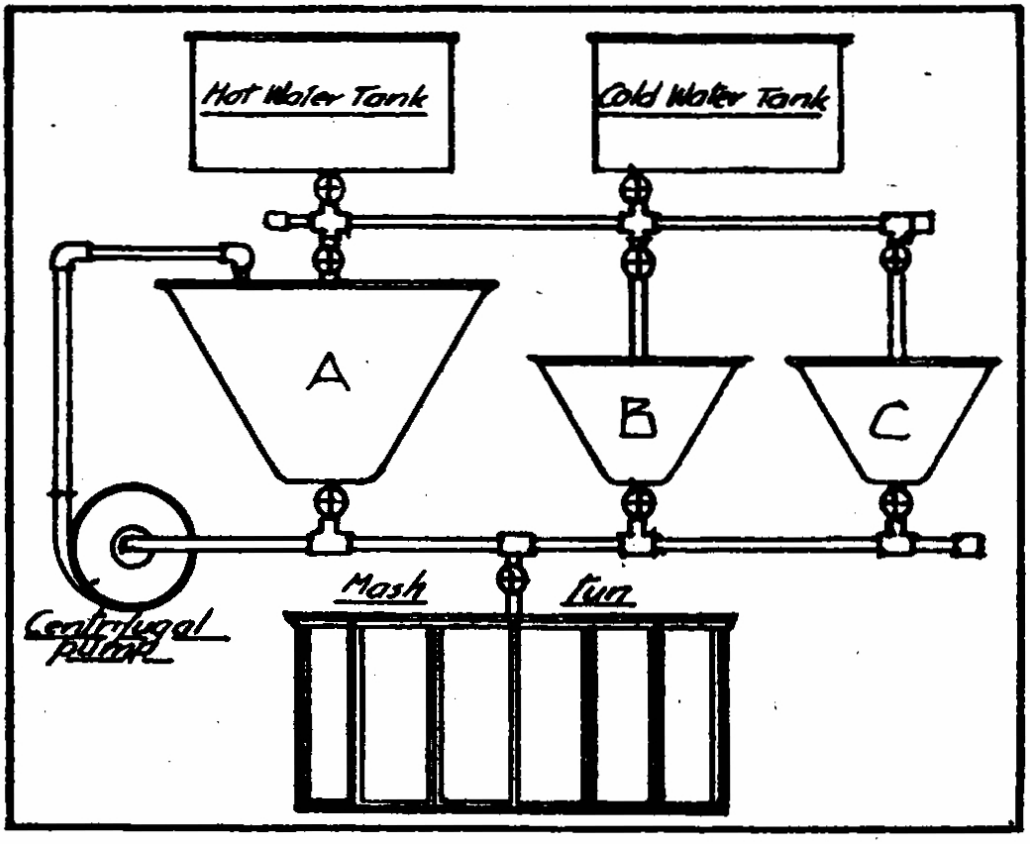
Next take the malt mash A at a temperature of 158F. Now mix in B at the same temperature, and hold the whole mixture at 158F for 1 hour. Filter, boil, and cool to 60F, adjust volume to 1026. Ferment with the same yeast as in Experiment II. The final gravity of the wort prepared according to the method of Experiment III. will be higher than the wort prepared according to the method of Experiment II.

EXPERIMENT IV.

Repeat Experiment III. with a malt of unknown diastasic capacity. Note well by iodine solution whether complete conversion takes place. If not, the inference is that the diastasic power of the malt is too low.

CHAPTER III. DECOCTION OR LAGER MASHING.

THE student having thoroughly grasped the I principles of digestive mashing and having performed the experiments recommended in the previous chapter, may now pass on to the consideration of an actual lager brewing we will say of 25 quarters of malt as an example. Experience has shown that mashing in an ordinary mash tun leaves much to be desired from the point of view of temperature control. Again, when returning. a boiled mash from the thick mash kettle to the mash tun, difficulty is often experienced in obtaining an even admixture of the goods. Part of the mash or the wort may be under the plates and can only be removed by underflow — in short, an equal temperature through the entire mash is difficult to obtain unless the plant is arranged to meet all contingencies. _ Frequently, however, many arrangements entail many complications. The following alternative is therefore suggested.



(See diagram herewith) A, B and C are cone shaped vessels provided with steam jackets and stirring apparatus. A is large enough to hold the whole mash. B may be half the size of A, and is to be used as a thick mash kettle. C is similar to B, and may be used for the raw grain liquefaction.

The mash tun below A, B and C is not used until the digestive mashing processes are complete.

The tanks of hot and cold water (the grist case and mashing machine are not shown in diagram) must command A where the mash proper is performed.

C might advantageously be arranged to withstand pressure in case it became advisable at any time to gelatinize starchy matter at a temperature higher than boiling point.

A, B and C are all provided with valves leading into a pipe, at the end of which is provided a centrifugal pump.

Now, if the vessels A, B and C are arranged with their bases on the same level and the mashing takes place in A, it is obvious that if the valves to A and B be opened simultaneously, B may be filled from A by gravitation. This object accomplished, both valves are again shut.

To return B to A merely requires the valve of B to be opened, when the goods will flow to the pump which (set in motion) returns the goods to A.

Now to consider actual details of the mashing process. The 25 quarters of malt should be mashed in A with about 60 barrels of water at about 115 to 110F. The object in view is to obtain a mash liquid enough to run easily to B. The initial temperature should be about 105 to 110F and the goods should be thoroughly stirred and remain in A for at least half an hour.

Now, about one-third of the goods is run as thick as possible to B. The contents of B are now raised as quickly as possible to 165F. and held at that temperature until clear. The goods are now boiled for about 15 minutes, when the valve of B is opened and-the goods immediately pumped back to A.

The boiling goods from B will naturally raise the temperature of A (now at 105F) considerably. A must be stirred meanwhile and care taken not to exceed a temperature of 130F. Hot water must be added to obtain this temperature if necessary, and cold water must be added if this temperature is exceeded: After the lapse of another 15 minutes or so, one-third of A is again run into B, whereupon B is again raised to 165F, and then boiled (as before) and then returned to A.

Now A is standing at 130F and B is boiling. Now we have arrived at the critical point. We want a complete admixture of A and B as near 165F to 167F as possible, and again we must have hot and cold water ready to assist us in obtaining this temperature without delay.

When A is thoroughly mixed at 167F it is allowed to drop into the mash tun and stand until conversion is complete and the wort runs clear — generally about one hour to one hour and a half. Sparging is then proceeded with, and the mush tun generally treated exactly on the lines familiar to every brewer. Water at 170F for sparging suffices.

So far no mention has been made of C, so we will imagine a brewing of 20 quarters of malt and live quarters of raw grain.

The five quarters of raw grain will be mashed in C, with one or two quarters of malt, to obtain an. initial temperature of 175F. This process should be accomplished before starting the malt mash proper in A. The remaining malt, 18 or 19 quarters, is then mashed in A, as already described.

When A is ready to be dropped to the mash tun, C (containing the raw grain-liquefied by digestion at 175F), is reduced to 167F by cold water, and is then run simultaneously with A to the mash tun, when the rakes are immediately started and run until a complete admixture has taken place.

Now, all this seems very easy, and so it is if all goes well, but a few words are necessary to caution the inexperienced.

Before attempting to mash on the decoction system, it is essential that the diastasic powers of the malts be determined.

We destroy in B one-third of our diastase on two occasions, and unless the diastase remaining is sufficient to effect conversion in the mash tun, a disastrous result must inevitably follow, especially when adding liquefied starch from C.

Experience shows that a diastasic power of at least 20 is necessary, and there are many brewers who prefer over 40. In Belgium (before the war) a large number of lager malts contained diastase of 40 and 45 Lintner.

A diastasic power of 10, so common in Australian malts, is likely to prove disastrous, while to use such a malt with raw grain is out of the question. A starchy wort would be the inevitable result.

Although stress has been laid on the importance of avoiding the temperature between 130F and 165F as far as possible, it must not be overlooked that our discussion started in Chapter II. by "How to make a weak beer taste full."

If, therefore, a decision is made to brew at a fairly high gravity, greater latitude in temperature control may be allowed than would be reasonable for the production

of a light gravity beer. The quantity of hops used in lager beer varies between 1½ to 2 per cent., the calculation being made on the weight of the grist. Thus 100 kilos of grist would require 1½ to 2 kilos of hops (approximately 4½ to 6 lbs. per quarter).

The amount of yeast required may be anything from 250 to 300 grams per hectoliter (about 1 lb. per barrel), according to the strength of the wort, temperature, etc.

CHAPTER IV. NON — INTOXICATING BEER.

THE time that has elapsed since the commencement of the War — with its inevitable consequence — the restriction of the sale of liquor — has brought about a wonderful improvement in the brewing of beers containing less than two per cent. of proof spirit by volume. Many years ago, although tee total beers were consumed by cranks and the fanatical members of the community (who presumably knew nothing of the flavor of real beer), they were so nauseating to the general public, their sale was necessarily limited. The majority of - them consisted of a solution of saccharin colored with caramel and flavored (save the mark) by hops generally described by merchants as "old olds." All this is now changed for the better, and Australia may proudly take credit for the definite progress that has not only been made but 'will also greatly influence the future. Nobody can now say non-intoxicating beer is nauseating, on the contrary, there are so many really excellent brewings the public has a wide range to choose from.

As with ordinary beer, so with our new brews, some prefer sweet, some dry, all palates are now considered, and a man who cannot select a brand that pleases him must be difficult to please indeed.

The great steps taken in scientific brewing have also been accompanied with vast improvements in chilling, aerating, filtering, drawing under pressure and through ice, so that really the public is now provided with a beverage that has actually been produced with all, the advantages of science and of art.

From the analysis of a great variety of Australian samples, it is clear that the following methods have been adopted: —

No. 1. Wort produced on lager methods. Sugar added in copper.

No. 2. Wort produced on lager methods, with methods, with or without added sugar.

No. 3. Wort produced by ordinary infusion methods, with or without added sugar.

There are of course endless varieties in addition, but the three examples given fairly represent the classes.

It is useless offering advice to a brewer respecting the method he should adopt the public taste in his district should be his guide, and the most successful man will be he who gauges public opinion accurately.

Let us consider the classes mentioned in their order.

No. 1 ANALYSIS

Apparent gravity	1014.000
Gravity of distillate, 50cc	49.922
.. liter	998.440
.. residue, 50Cc	50.710
.. liter	1014.200
Spirit indication	1.560
Alcohol by weight	0.85
Proof Spirit by vol.	1.87
Degrees fermented	4.80
.. unfermented	14.20
Original gravity	1019.00
.. Brewers, lbs.	6.90

This analysis is typical of several brewings gleaned from districts all over Australia, and by inference (the majority falling within this class) the most popular. The figures given represent the mean of beers brewed by six different breweries.

No. 2 ANALYSIS

Apparent gravity	1023.000
Distillate gravity of 50cc.	49.932
.. per liter	998.640
Residue gravity, of 50cc	51.125
.. per liter	1022.500
Spirit indication	1.360
Alcohol by weight	0.740
Proof spirit by vol.	1.630
Degrees fermented	4.280
Degrees unfermented	22.500
Original gravity	1026.780
Brewers, lbs.	9.600
Total unfermented carbohydrate, p.c.	5.830
Maltose, percent	3.830
Percentage of maltose on total of sugar .. content	65.600

In this case the figures are most significant, and if it were possible to present the student with a sample to drink, there could be but one opinion, viz., that the wort had been produced by decoction mashing, that the grist was probably composed of a proportion of raw grain, and that in all probability the yeast employed was of the low fermentation type.

It should be noted that of the total percentage of unfermented carbohydrate, 65.6, was composed of maltose, and 34.4 was composed of dextrin, or, at any

rate, some inert carbohydrate (the student should read from several text books, the significance of reducing and non-reducing sugars).

Contrast this with infusion mashing, the percentage of dextrin or other non-reducing carbohydrate would be considerably lower in the majority of cases, and in at least a few, nil.

The student is recommended to re-read the chapter on the hydrolysis of starch to guide him should he desire to produce the type of beer under discussion, and consequently the formation of dextrin.

CLASS 3. Of this little need be said — it is a brewing requiring little or no skill, and may be regarded as "antique." At the same time, it revives one's memory of a practice common in England, viz., the running of a final wort (as a separate brewing), fortified or not according to requirements by sugar.

This class of beer is called either "Harvest Beer," "Hay-makers' beer," "Table Beer," as well as a host of others. It is indeed most palatable, and drunk within a day or two of completion of fermentation, most refreshing on a hot day. The practice in England is to brew a Pale Ale of 20 lbs. gravity, for example, from a given grist, but instead of exhausting the grains for the Pale Ale, sufficient extract is allowed to remain in the goods to enable the mash tun to be sparged (generally until the mash tun is full to overflowing), the wort is then boiled with a few of the hops previously boiled with the pale ale, sugar is added according to the gravity required, and the copper is invariably cast into the hop back, containing all of the hops remaining from the pale ale. The cost of such a brew is practically nil — the hops cost nothing — — the extract would probably have remained in the Pale Ale goods; the cost of sugar is a mere fraction.

The flavor of such a beer has its own characteristics; without being sour, it has a very pleasant sub-acid flavor. Of course it is not expected to keep. Its alcoholic content is generally about 2 per cent. alcohol by volume. The author has a vivid recollection of the popularity of this beer amongst harvesters in East Kent, within a radius of 25 miles of Canterbury — surely a wide country district to judge popularity. It is curious to see this old idea revived in Australia. It might be — extended with advantage. The vast areas of country bearing wheat and hay ready for the sickle, with stalwart and thirsty manhood awaiting refreshment, need only enterprising distributors. This beer, carried to the parched and' arid districts would find a hearty welcome, and most ready customers, especially amongst those recently arrived from "home." This manner of brewing from "last worts" might be improved in the light of modern knowledge. For example, the final runnings from a lager mash present splendid prospects (fortified with sugar or not) for a non-alcoholic beer. Again, an ordinary infusion mash (after complete extraction) might be flooded with boiling water and boiled by steam if necessary; then reduced to

160F, for example, when a few bushels of ground malt could be added and raked in to convert the gelatinized starch resulting from the boiling of the grains. Such a brew would present the lager husky flavor so popular with light ale drinkers, and would cost nothing more than the few bushels of malt necessary to effect conversion.

CORDIAL FACTORY NON-INTOXICATING BEER.

As in so many cases cordial factories have no facilities for brewing, the best way for their proprietors to proceed is to use ready-made, so-called non-fermentable sugars, as well as a proportion of cane sugar instead of attempting to brew by rule of thumb.

Again, in country districts apparatus of all sorts is difficult to procure. It seems necessary therefore to consider a brewing where neither science or art is necessary for its production.

If we take the "sugars" mentioned, viz., Amyloin Syrup, Amyloid Syrup, Malto-dextrin, and a host of others, we find they will give an extract of about 34 brewers lbs. per cwt.

Cane sugar gives roughly 40 brewers lbs. according to purity, percentage of moisture, etc.

Suppose, then, we took I cwt. syrup (a class including the above mentioned "sugars," and half a cwt. of cane sugar, we could make approximately 10 barrels (360 gallons) of wort of 7 brewers lbs. gravity, or 20 degrees specific gravity. — The solution should be boiled with about 12 oz. of hops (more or less could be added according to taste), cooled to 60F if possible, and fermented until the original gravity of 20 degrees drops to about 16.

It should here be noted well that a reduction of five degrees of gravity during fermentation produces proof spirit to the amount of a fraction only below the amount allowed by law, viz., 2 per cent.

Everyone attempting to brew in this manner is recommended to buy a specific gravity saccharometer, marked from 1000 to 1025. After fermentation of five degrees, the beer should at once be chilled, filtered, aerated, bottled and Pasteurized at 145F to ensure suspension of further fermentation and consequently the further production of alcohol.

CHAPTER V. BREWING CALCULATIONS.

THE lack of Excise control, as understood in England, has led to a system in Australia which opens the door wide to allow neglect in obtaining the proper extract.

For example, in England a certain quantity of material entered (in the book furnished by the excise for the purpose) must yield by law a given extract on which duty has to be paid. If the expert brewer obtains an extract higher than that required by law, he pays on the higher yield; if he obtains less than required by law, duty is charged on "materials." —

An excise notice to directors that the monthly duty is calculated on materials — a "materials charge" it is called — is equivalent to censuring the brewer.

The English brewer calculates, then, how many barrels of beer he can make from a given quantity of materials. The extract is, as a rule, determined in the laboratory beforehand, and it is his duty to obtain an extract in the brewery as near the laboratory estimate as possible.

Compare this with the system so prevalent in Australia. A brewer will say, "I take so much malt or so much sugar to a hogshead." That this is a totally wrong and upside down way of looking at things should be self-evident, though an example may be useful.

We will say that the Australian brewer judges by general experience that one quarter of malt will give him five barrels of wort of 16 lbs. gravity. Then 100 quarters of malt will give him 500 barrels of beer of the same gravity — at least, so he would argue from his system. Now, live barrels of beer of 16 lbs. would mean an extract of 80 lbs. per quarter; but suppose the malt yielded 90 lbs. (quite within the range of possibility). he would be losing, if he mashed 100 quarters of malt, no less than 1000 lbs. of extract, or 66 barrels of beer of 16 lbs. gravity.

The figures given are not exaggerated; of course, they are unusual. They are, however, unfortunately gained by actual experience, though necessarily from smaller quantities of material, or the glaring discrepancy would have been discovered. At least, one should assume that the brewer should be given credit for having made the discovery.

The brewer in England forecasts his barrels obtainable from a given quantity of malt by calculating the maximum (laboratory) extract and making up his worts — generally in two lengths — accordingly.

Experience should tell the brewer whether his extract is likely to be less than the theoretical yield as soon as he has gauged and weighed his first copper. As results vary in every brewery, it is useless giving figures; but the student should make a careful note daily of the gravity and dip of his copper, comparing these figures with his daily experience. It will surprise him how significant these figures are in respect of higher or lower extract he expected, and for which he should have forecasted.

Generally speaking, heavy first worts lose 12 to 15 per cent. in bulk from the time of casting from the copper to collection in the fermenting vessel. Weak second worts lose from about 10 to 12 per cent. Contraction on cooling from boiling point to 60F, for example, evaporation on coolers and refrigerators, hop absorption, all have to be taken into consideration, and as these facts affect the gravity of the worts there is no reliable guide but experience, the experience varying in. every brewery and from day to day.

It is astonishing, but it is a fact, that a brewer of wide experience can gauge within a gallon or two, not merely the exact volume, but also the exact gravity required, even though he be brewing for the first time in a strange brewery.

Subject to the foregoing conditions of loss in volume and increase of gravity after casting worts from coppers, the following rule exactly fixes the volume of a second wort to be added to a first wort to produce any required gravity when the two worts are blended.

Example. — It is assumed that a wort of 18 lbs. is required and that the first wort collected is 27 barrels weighing 32.6 lbs. Set down the figures thus : —

	Barrels		lbs.	Total lbs.
1st Wort	27	x	32.6	= 880.2
2nd Wort		x	11.0	=
Average gravity required		x	18.0	=

The gravity of the second wort is 11 lbs. and the average gravity required is 18 lbs.

Rule 1. Multiply the difference between the gravity of the first wort and the gravity required by the number of barrels collected. Thus

```
32.6 gravity of first wort.
18. gravity required.
----
14.6 difference
x 27 the number of barrels collected.
----
1022
292
----
394.2
```

Rule 2. Deduct the gravity of the second wort from the gravity required and divide the difference into the above sum, viz., 394.2, Thus —

```
Gravity required            18
Gravity of second wort      11
Difference                   7

Divide 7 into            394.2

                       7) 394.2
                        -------
                           56.3
```

Fifty-six decimal three is the number of barrels required to bring the mixed worts to a gravity of 18 lbs. after blending.

Set down the figures thus and prove it —

	Barrels		Gravity		Total lbs.
1st Wort	27	x	32.6	=	880.2
2nd Wort	56.3	x	11	=	619.3
Total	83.3	x	18	=	1499.4

It will be noticed that the actual addition of the .total lbs. of the two worts is 1499.5 and that the multiplication of 83.3 by 18 is 1499.4, but this is occasioned by not carrying the calculations far enough, and is in any case unimportant.

Where the difficulty comes in, in large breweries, is not the calculation, which is simple, but to calculate by experience exactly how many barrels, and at what gravity, must be cast from the copper to yield the exact volume and exact gravity required when cooled and collected.

In a single brewing of 1500 to 2000 barrels this is not as easy as it appears. It must be borne in mind that the English brewer is trained to not only obtain the maximum gravity, but also that the maximum yield at the required gravity is obtained. He would not be employed in a large brewery unless he proved his ability in this respect.

It will be appreciated that there is a wide gulf between the foregoing and "mashing X bushels per hogshead."

CHAPTER VI. LOW FERMENTATION.

THE fermentation of Lager Beer is a matter I requiring much care and attention. As we have seen how the mashing process varies from British methods, so must we now grasp the differences between low fermentation and high fermentation methods.

In the first place the Worts should be cooled to 45F (many brewers prefer lower temperatures), one of the principal reasons (apart from the question of favorable temperature for a special type of yeast) being that a larger quantity of the gas carbon dioxide enters into solution with the wort at this temperature, compared with the higher temperature employed in high fermentation. It has been calculated that (see Roscoe’s elementary chemistry) one volume of water at 0 degrees dissolves 1.797 volumes of this gas, whilst at 20 degrees only 0.901 volume is absorbed.

The volume of this gas absorbed by water at the same temperature is found to remain the same under whatever pressure the gas may be measured. As the volumes occupied by any given quantity of gas measured under different pressures vary inversely as these pressures, it is clear that. the weights of carbon dioxide thus absorbed must be proportional to the pressures. In the excellent little work called "The Wanderings of Atoms," by Professor Pattison Muir of Cambridge, the solubility of carbon dioxide in water is also set forth very clearly, and it may be helpful to consider his statements. He says: —

"Carbon dioxide is soluble in water. The weight of the gas dissolved increases directly with the pressure. In other words, while one liter of water dissolves 2.346 grams of the gas when the pressure on the surface of the water and the gas is the ordinary pressure of the atmosphere, the same volume of water at the same temperature dissolves 2.346 x 2 = 4.692 grams when the pressure is doubled, and 2.346 x 3 = 7.038 grams when the pressure is trebled."

For some reason difficult to explain, there is an undoubted superiority in beer of natural gas condition, compared with artificial gas condition. The. successful production of lager beer depends, therefore, upon obtaining as much natural gas condition as possible.

Care must be exercised in running worts to storage (lagers) as soon as they are ready, in order that no unnecessary loss of gas is incurred. The question now arises: how is one to know when worts are ready?

We will suppose that a wort of an original gravity of 1050 has taken 10 to 12 days to attenuate to about 1022. By that time the fermenting wort should commence

depositing a solid cake of yeast on the bottom of the fermenting tun. It is not possible to say exactly when fermentation is likely to cease, unless one knows exactly, how the wort was produced, but as an example we will say that a wort of an original gravity was prepared with a view to obtaining the maximum of dextrin, such a wort should, therefore, have an attenuation limit of about 1018 degrees.

If yeast be well deposited in the fermenting tun and the wort looks dark, it should be immediately taken to storage. The gravity should be a few degrees above the attenuation limit, in order that the fermentation may continue in the "lager." Enameled steel tanks make the, best "lagers," and will withstand a pressure of 15 lbs. without danger.

Yeast wanted for subsequent brewings requires care in collection. When the wort is min from the fermenting vessel the yeast will be found in three layers resembling a sandwich — the top and bottom layers are rejected as far as possible and the middle layer is collected and stored (below 40F, if possible) until required.

The degrees remaining unfermented of the wort run to lager are not as a rule sufficient to produce enough gas pressure and condition by the time the beer is ready for sale. To obtain this necessary pressure the process of "Krausening" is resorted to. Krausen is new fermenting wort that has reached the "rocky head" stage in the fermenting vessel. The quantity of krausen necessary to be added to a given quantity of beer may be easily calculated from the facts already stated in regard to the solubility of carbon dioxide under varying conditions of temperature and pressure.

We will assume that if a liter of wort will absorb 2.346 grams of the gas at 60F, it will absorb 2.75 grams at 40F, at atmospheric pressure understood.

Now. the usual pressure at which beer is bottled is about half an atmosphere. It has been shown that by exerting a pressure of one atmosphere, the quantity of gas absorbed is double the quantity at atmospheric pressure — therefore, if we exert a pressure of half an atmosphere we shall add half the quantity of gas to the original quantity.

We have assumed that every liter of the wort in the lager has absorbed 2.75 grams of the gas at 40F at atmospheric pressure. It may therefore absorb r .375 grams more under a pressure of half an atmosphere. How much "krausen," then, should be added in order to obtain this weight of gas?

A wort of 1050 degrees original gravity and an, attenuation limit of 1018 has obviously 32 degrees capable of fermentation. As sugar splits up approximately into half alcohol and half carbon dioxide, the calculation is simple.

One per cent. of sugar in solution equals 3.86 degrees of gravity therefore 32 degrees of gravity equals 8.3 per cent. roughly, or 83 grams per liter.

This quantity of sugar, if fermented, would yield roughly 40 grams CO_2 per liter.

It has been shown that one liter of wort in the lager requires an additional 1.375 grams of gas, therefore one hectoliter will require 137.5 grams. of gas. If one liter of krausen can yield 40 grams of gas, then about three and a half liters of krausen will give the 137.5 grams of gas required. So much for the theory of the matter. Experience, however, has shown that leakage of gas in the original beer during storage, variation of temperature, incomplete fermentation, etc., have all to be taken into consideration. Krausen is, therefore, used in quantities varying between five and ten percent, according to requirements — smaller percentages, if the beer is to drink dry, such as Pilsener, and higher percentages if it is to drink full, such as Münchener.

The time to add the krausen varies between one and three weeks before the beer is required for racking or bottling. One week would be sufficient if incomplete fermentation is aimed at — the krausen in this case answers the purpose of "priming" as well as a means of producing gas — and three weeks if a dry beer with a maximum of gas is the objective.

Although a pressure of half an atmosphere has been suggested for beer at the time of bottling, care has to be exercised. Trouble may arise from the fact that too much gas causes beer to bottle "wild," which is not only wasteful, but results in some bottles being insufficiently filled. It is important before bottling a vat or tank of beer to note carefully the temperature, as well as the pressure, and if necessary release a part of the pressure if experience has shown that similar conditions of temperature and pressure have caused "overfoaming."

> Note. — The student should read the excellent articles on lager brewing by C. Rühl, "Journal of the Institute of Brewing," Vol. XVI., 1910, N05. 3, 4 and 6. He should also refer to "Southby on Brewing," page; 298 and 355.

CHAPTER VII. THE "SKIMMING" SYSTEM OF YEAST SEPARATION.

DIRECTIONS FOR DEVELOPING PURE CULTURES OF YEAST IN QUANTITIES FOR COMMERCIAL PURPOSES.

THE "skimming" system, as practiced in England, is probably the Oldest method, of yeast separation, but those who can look back a quarter of a century will remember that a wave of feeling displaced it in favor Of cleansing(with its many modifications), only to be replaced again later as knowledge became more exact and the opinions of faddists proved to be founded on insecure foundations.

It is not to be inferred from the foregoing remark that cleansing is merely a method of the faddist — as is usual in such cases, much can be said in favor of both sides — but in order to prove that it is not the panacea for all the ills claimed for it (years ago), breweries may be seen in the Burton district — the home of cleansing — where the skimming system is worked side by side with the Burton unions.

During the early nineties the writer had the two systems under control for three years at a brewery within the Burton district, and it can be said without fear of contradiction that an expert taster, no matter how delicate his palate may have been, was unable to say which of two beers had been skimmed or cleansed. Here surely, then, is ground for opposing the theory that cleansing of itself is endowed with any particular virtue so far as the final result is concerned.

The more experienced a man becomes, the less \ is be biased in any direction. He, however, judges a case not by one detail or another, but by a survey of all the circumstances.

It will be conceded in favor of the skimming system by those who have practiced it that it presents the following advantages : —

1. The fermenting wort is under better control, for the reason that it is kept in one volume, instead of being subdivided, as in the case of unions or cleansing butts.

2. Temperature is easier to control.

3. Cleaner pitching yeast can be obtained, for the reason that the first few heads can be neglected, and when clean yeast rises it can be skimmed into a separate wagon.

4. Troughs above and below unions, swan necks, mains, etc., the cause of

serious infection, are avoided.

5. Less waste is incurred. Experience, covering every conceivable and inconceivable condition, places the respective losses as follows: Skimming, 2½ to 3 per cent.; cleansing, over 3 per cent., and probably nearer to 5 or 6 per cent., according to the method of "topping up."

THE CHOICE OF YEAST SUITABLE FOR SKIMMING.

To conduct the skimming system in such a manner that success may be assured, it becomes of primary importance to give adequate consideration to the normal habits of the type of yeast employed. To make this suggestion clear, we will illustrate it by an extreme example Saccharomyces Thermantitonum and Carlsberg No. 1 do not rise to the surface of fermenting liquors at all, but at close of fermentation sink to the bottom of the vessel; Obviously, types such as these must be avoided if separating yeast by skimming be resorted to.

Some types of native Australian yeasts seem to have a decided tendency towards low fermentation species. To one who has studied the habits of various ferments from all parts of the world this is to be expected, for just as Australia abounds in eucalyptus trees, so in all probability the air is charged with yeast cells of low fermentation type, whose natural habitat seems to be the eucalyptus leaves.

The yeasts so far isolated from this source have been of the most marked low fermentation type, and are therefore most unsuitable for the skimming system.

Enough, then, has been said to illustrate the point that the first matter for serious consideration is to provide a yeast that rises with facility to the surface of fermenting wort at the close of fermentation.

MAXIMUM TEMPERATURES AND COURSE OF FERMENTATION.

Assuming that a type qf yeast has been selected, the next points to be considered are —

(a) The time it should occupy in reducing the gravity of wort to the required degree; and

(b) the temperatures most favorable from hour to hour during the course of fermentation; and

(c) the maximum temperature that should be permitted.

The following course of a fermenting wort is typical of a Burton or London skimming yeast. It does not follow at all, however, that the temperatures would be favorable to Australian types, probably acclimatize to higher temperatures.

Experience alone can settle the conditions favorable for individual cases:

Time	Temp	Gravity	Brewers Lbs
Monday, 6 pm	58	1.052	= 19
Tuesday, 6 am.	60	1.048	= 17.4
Tuesday, 6 pm	62	1.044	= 16
Wednesday, 6 am	64	1.038	= 14
Wednesday, 6 pm	68	1.030	= 11

At this period yeast commences to rise, and is skimmed off every four hours.

Thursday, 6am	70	1.012	= 4.6
Thursday, 6pm	69	1.011	= 4
Friday, 6am	66	1.011	= 4
Friday, 6pm	63	1.011	= 4

Most of the yeast should by now have been removed, but sufficient should be allowed to remain on the surface to protect the wort.

N. B. — The temperatures are controlled by an at temperator in the fermenting vessel. It will be observed that the reduction of gravity is greater as the temperature rises.

Saturday, 10 am, the beer should be racked into casks.

NECESSARY AUSTRALIAN MODIFICATIONS.

The fact that the exigencies of the Australian trade require that beer be sent out to the consumer in a bright condition, certain additions to plant (compared with English requirements) become necessary.

In parenthesis, it may be remarked that it is the custom in England to send out ale to the consumer with hops and finings in the cask. In rare instances — Bristol practice, for example — beer is dispatched to the customer racked fine from a vat; other cases could be cited, but they are exceptional, not the rule.

In order to comply, therefore, with Australian requirements, a fining vessel or vessels must be employed. Instead of racking the beer straight into casks (from either the fermenting vessel, as is customary in some breweries, or- from a

racking round in others), it must be conveyed to a fining vessel, preferably a covered vat, and there fined and allowed to clarify, and from, this vessel the trade casks must be filled.

The question has been hotly debated as to whether it is wise to skim in the fermenting vessel, or "drop" it at a certain gravity into a "dropping" vessel, and skim it there. Here, again, every faddist will urge some special reason for adopting one or the other method, but when one has tried all the modifications enumerated below, it ceases to have any serious importance.

The following are the usual variations of the skimming system. —

1. Collecting wort in fermenting vessels without attemperators, and allowing the temperature to "fly" to 70F within 36 hours. Then "drop," and attemperate and skim the "dropping vessel."

2. Collect, at temperate, skim, and rack, all from the same vessel.

3. Collect, at temperate, and skim in one vessel, and rack from another.

In the cases cited above, the final result being practically the same, no special advantage could be claimed for either of the methods enumerated.

SEPARATION OF BEER FROM YEAST IN YEAST WAGONS.

When yeast has been skimmed from fermenting wort, it commences, after a short interval, to separate from the beer that has passed over with it. In order to avoid loss in this direction yeast wagons should be provided with draw-off tubes. These we will consider for a few moments.

Draw-off tubes are simply copper pipes about one inch in diameter and three or four inches long, attached to the side of the wagon by flanges. They are usually placed at intervals of two inches, commencing from one inch from the bottom of the wagon.

They are never placed immediately above one another, but diagonally, the obvious reason being that the wagon should not be weakened along one line.

The draw-off tubes are provided with corks, and as the beer separates from the yeast, any cork may be withdrawn to allow the brightest beer to flow away. The beer is caught in a clean enameled bucket and returned to the fermenting vessel.

THE DEVELOPMENT OF PURE CULTURES OF YEAST IN COMMERCIAL QUANTITIES.

Although in The Student's Manual of Yeast Culture directions are given for development of yeast in cans of sterilized wort, Australian experience has proved that the following method cannot be improved upon. The student must refer to the work named for the exact conditions that must be complied with. Cans have proved difficult to clean and may be considered obsolete. Glass flasks are therefore preferred : —

1st Day. Inoculate a 100 cc flask containing 50 cc sterilized wort.

2nd Day (morning). Inoculate a three-liter flask, containing 1½ liters of wort, with the first day's yeast.

2nd Day (evening). Inoculate four more similar flasks from the foregoing.

3rd Day. Pitch about 40 gallons of wort in a freshly enameled hogshead with the above five flasks. Then cover with a clean linen cloth.

4th Day. Pitch twenty barrels wort with above.

5th Day. Pitch one hundred barrels with above and proceed to ferment. Cleanse or skim as usual.

Note well that no attempt is made to separate yeast until the volume of fermenting wort is the same as the full capacity of the brewery.

The method described is simple, clean and easy. Practice has proved that the risk of chance infection during the several transferences is negligible.

One other point of importance is this, viz., the provision of wort from day to day for the development of cultures.

There is no reason whatever why any quantity of wort may not be stored indefinitely, provided, of course, that the flasks are boiled for three successive days and care is taken to ensure that the cotton wool plugs fit the necks of the flasks properly.

CHAPTER VIII. THE TURN FERMENT. (SACCHARO BACILLUS PASTORIANUS)

DISINFECTION, CHANCE INFECTION.

A few years ago, M. Bekaert, director of the Brewing School at Ghent, contributed a paper to "Le petit Journal du Brasseur, Bruxelles."

> It has an important bearing on Australian brewing conditions in that the "Tourne" ferment, as it is known in France and Belgium, is generally to be found in wine-producing countries, or to put it another way, it is more likely to be a cause of trouble in wine-growing districts than in places without vineyards.

M. Bekaert throws out a few useful hints for combating the development of the turn ferment.

He asks why it is that the beers from a badlykept brewery often keep better than those from one where the most minute precautions are taken with regard to cleanliness, care in the choice of materials, etc., and other small details ? No satisfactory answer can be given to this question, except that the beers from certain breweries present a favorable field for disease ferments, whereas those from another brewery ofi'er extreme resistance.

There are other factors to be considered besides the mere presence of the ferment. The composition of the wort — that is, the medium in which the ferment grows — is also of importance.

If it were only a question of the bacillus in the case of infectious diseases, the majority of town dwellers would be consumptive, because the Koch bacillus finds its way into the lungs of nearly everybody. In certain organisms, however, it finds no field for development; in others, predisposed to illness, it develops rapidly. The case with beer is analogous. A curious fact mentioned by M. Bekaert is that the turn ferment is especially virulent during August and September (corresponding to February and March in Australia), as well as in the late autumn. This is primarily because both malt and hops have undergone deterioration during storage, and the wort produced from such materials forms an unstable medium which favors bacterial development.

The "turn" ferment, resembling bacillus subtilis in appearance, is rather peculiar in one respect, it has the ordinary rod shaped form (of a bacillus, but sometimes the cell will be, comparatively speaking, short (about the same length as the

diameter of a yeast cell), at other times it will be twice or three times this length, and occasionally it will even attain a size that is quite six times as long as an average yeast cell. The rods are generally quite straight when short, but nearly always bent on attaining a certain length. Occasionally they exhibit a very characteristic V shape.

It is easy to recognize beers which are "turned" without the aid of a microscope. In the first place, the beer has an acid taste somewhat like that of green fruit — unripe gooseberries, for instance; and secondly, a characteristic appearance of silkiness and formation of cloudy waves which rise from the bottom of a bottle containing turned beer when it is shaken.

Development of the ferment would seem to be encouraged by worts containing a high proportion of soluble nitrogen. The choice of sound malts is, therefore, one of the first considerations.

In the second place; mashing temperatures should be high enough to prevent over-formation of soluble nitrogen. A proportion of well-prepared and well saccharified raw grain, gives a greater power of resistance to beer, for the simple reason that the proportion of soluble nitrogen is reduced. Small barleys, such as Russians, Danubes, Moldavians, and certain Smyrnas, with high nitrogen content, must be avoided, unless raw grain is used in conjunction with them. These small barleys are always rich in nitrogen (and are chosen by distillers for this reason), which permits the production of malts very rich in diastase. They should, therefore, be avoided by brewers.

In a practical experiment which M. Bekaert made, it was found that of two beers brewed under identically the same conditions — one of all malt, and the other with 15 per cent. maize — a greater stability during forcing was possessed by the beer brewed with the maize. The deposit from the latter only contained a few "turn" ferments, while the deposit from the all-malt beer contained an enormous quantity of rods.

The author insists quite rightly on the importance of hopping. He states that beer brewed with old hops has no resistance against disease. In a special case, where the turn ferment was firmly established in a brewery, he noted that its effects were lessened immensely with the first application of new hops. After a few brews, it disappeared altogether. The author’s view in respect to tannin as a preservative agent are both interesting and instructive. The effect of tannin must be to precipitate a certain proportion of the albuminoid matters during the boiling of the wort.

Does this elimination do any good? M. Bekaert, on the whole, thinks not. He says that in many breweries where tannin is used, he has discussed this question with

the brewers, all of whom consider that the tannin did not act as a preservative.

He asked many of them to leave out the tannin in a few brews, and it was impossible to notice any difference in the beers produced with regard to their resistance to disease. His experience has led him to think that the advantage of tannin is a pure. illusion, and its effect, if anything, unfavorable.

In the first place, where tannin is used, a smaller proportion of hops is taken — a gigantic mistake, because the "tannin in itself has no preservative properties.

Secondly, the continual use of tannin causes the yeast to degenerate.

Where the turn ferment has got firmly fixed in a brewery, it must, of course, be eradicated by the complete disinfection of the whole plant.

HOW T0 COMBAT BACTERIAL INFECTION.

Practical experience has shown that the effects due to bacterial infection can be reduced to a minimum by paying proper attention to the following points :

1. Use dry malt, and if the malt is slack, re-kiln it.

2. Use only the best hops, and plenty of them.

3. Avoid undue exposure of wort in passage from copper to fermenting vessel.

4. Collect the wort (after boiling) in the fermenting vessels as quickly as possible.

5. Pay the greatest attention to the yeast.

6. Attemperate during fermentation, so as to _ keep down temperatures to the lowest point possible, without checking the yeast.

7. REGULARLY DISINFECT THE WHOLE BREWERY PLANT.

There is no need to discuss. points 1 and 2; no difficulty need be experienced in producing good hops and sound malt, or re-kilning it, if slack.

In regard to point 3. Should coolers be employed, there is little danger of contamination if precautions be taken to keep up the temperature of the wort to 180F. This can be effected in several ways. Perhaps the best way is to place three or four pipes across the whole length of the cooler at a depth of about half an inch

from the bottom, and pass spent steam through them during the whole period the wort remains on the coolers, so as to maintain a temperature of at least 180F. If the wort is then cooled immediately to 58 to 60F on the refrigerator, and the yeast is added to it at once, the degree of contamination due to air-borne organisms can be regarded as insignificant.

At the same time, the wort should not be exposed for too long a period on the coolers, even in the case where the temperature is kept up to 180F for, although bacteria cannot develop at this temperature, they are not always destroyed by it, and so remain in the beer, developing after fermentation if conditions are favorable. A temperature of 180F cripples foreign organisms, but does not entirely annihilate them.

It is a very dangerous plan in the case where two warts are exposed on the same cooler during one day to leave the remains of the first wort on the cooler until the second is brought up. If any time elapses between the bringing up of the two worts, the cooler should be well washed down with boiling water after the first wort has been drawn off, and boiling .water should also be passed over the refrigerator and through all the wort mains, the first washings, if they contain an appreciable amount of wort, being returned to the boiling copper.

It is scarcely necessary to add that on every brewing day, before the wort is sent to the cooler, boiling water should be passed from the copper to the hop back, through the wort mains to the cooler, and then over the refrigerator. Such precautions as these may seem almost too obvious to require mention, but, nevertheless, we have seen that endless difficulties frequently occur owing to their neglect. — Dealing now with the fourth point — that of rapid refrigeration — it is common knowledge that in many breweries the refrigerating plant is totally inadequate — either the refrigerators are too small for the number of barrels of wort to be treated, or else there is not a sufficient supply of cold water for cooling purposes. In the first case, the remedy is simple; the capacity of the refrigerating plant must be increased. The second case, however — want of liquor, or want of a supply of liquor cold enough to effect rapid refrigeration — is somewhat more troublesome to deal with. This latter difficulty is best met by cooling down the wort with the ordinary water supply to 70 to 80F and then completing refrigeration by means of an ice machine. There is no need to make any alteration in the existing plant beyond arranging for a supply of cold brine in the last dozen tubes of the refrigerator.

The objection is often put forward that ice machines are costly, but in reality a greater expenditure of fuel is entailed in pumping an endless supply of semi-tepid water through the refrigerator than in utilizing an ice machine for cooling down the wort through the last few degrees.

We have seen a very wasteful system adopted in one of our largest breweries in England, where the cold liquor supply falls short in summer. Here the whole of the supply was cooled down in a tank by means of brine pipes before passing it through the refrigerator.

This system, it is needless to say, is exceedingly — wasteful, because water at 70F is just as effective for cooling down wort from 180F to, say, 90F, as water taken at 50F. An ice machine, when used, should only be employed for cooling down the wort through the last 10 or 20 degrees.

The question of the regular disinfection of the brewery, although last in the list of precaution, is yet the most important of all. Calcium hypochlorite (commonly called chloride of lime) made into a very thin wash like lime-wash may safely be used in wooden vessels made from white cedar or fir, but not oak. The wash, after having been applied for six to twelve hours, should be rinsed from the vessels with boiling water. Then they should be finally dropped down with sulfurous acid or bisulfite of lime, when all traces of the smell of chlorine will disappear.

Caustic soda should be dissolved in a trough long enough to take any copper pipes in the brewery.

Steam should be provided to boil the caustic soda solution. After removal of the pipes from the trough, they should be scrubbed inside with suitable brushes, and then steamed before being re-erected in the brewery.

Formalin and potassium permanganate is a very useful mixture for disinfecting vats, Pfandler tanks and closed vessels generally.

The procedure is as follows : — First see that the vessels are sealed everywhere except the manhole. Place the permanganate of potash crystals in a pail or any suitable vessel; pour on the water, adding lastly the formalin. The formalin is added without waiting for the crystals to dissolve. Heat is evolved; the liquid boils, and the vapor is quickly set free. Close the manhole immediately the formalin is added. Leave closed for 12 hours.

The following quantities have proved sufficient for disinfecting purposes: — For every 2000 cubic feet of space, take 10 oz. potassium permanganate, 20 oz. water, and 20 oz. formalin.

It may be useful to mention that Australia suffers generally during the hottest months from a wild yeast, occurring as "chance infection." It has many properties similar to "Saccharomyces Thermantitonum," and is particularly persistent as a secondary, ferment in bottled beer, the ordinary pasteurizing temperatures leaving the germs unaffected, At the first sign of its appearance (it forms compact

granules in the bottled beer), the most careful overhauling of plant — particularly bottling plant — should be undertaken. Pipes, fillers, filters and pulp should all be thoroughly sterilized, without delay.

Before leaving the subject of chance infection, the student should bear in mind that both tannic acid and saponin (the essential ingredient in "heading") are glucosides, easily decomposed by acid forming bacteria, and consequently food for a host of undesirable organisms.

CHAPTER IX. HINTS ON THE USE OF THEMICROSCOPE.

THE microscopical examination of yeast appears to the inexperienced the easiest of operations, yet, like all things easy, a deal of practice is required to do it in exactly the right way; and although the importance of controlling the purity of the yeast is perfectly obvious to anyone acquainted with the rudiments of brewing, it remains an absolute fact that there are many scores of breweries in the country where the brewer does not avail himself of his microscope once in six months, although it may occupy a conspicuous place in the brewing room or laboratory.

The reason why the examination of yeast is not practiced regularly in every brewery is probably because, having used the microscope intermittently for some time, the brewer comes to the conclusion that things go on much the same whatever the yeast may happen to look like on any particular day.

In such a case we may be certain that the possibilities of the microscope have never been appreciated, and that the examination of the yeast has not revealed what it should do — the defects or the good features of a sample.

A few hints, therefore, on some of the points where the operator is most apt to go wrong may perhaps be serviceable.

The first thing in using a microscope is to study the peculiarities of the instrument. The brewer should discover the quickest way to get the right focus and the correct light, so that no time is lost in getting at the yeast itself. The reflector should never be pointed at the sun. A south (for Australia) aspect or a whitewashed wall, from which a bright diffused light can be obtained, give the best results. For everyday brewery work a one-eighth inch objective should be used. A test object, which can be supplied by any scientific dealer, proves very useful for determining if the microscope is perfectly adjusted. An object such as a diatom should plainly show the fine crossed markings of its silicious shell with a magnifying power of 500.

If a condenser is used, the light should only be admitted through a smallish diaphragm. With a one-eighth-inch objective a condenser is not really necessary, if the examination is made in the morning in a bright, diffused light. It is a common fault, when using a condenser, to get too much light into the instrument.

The correct dilution of the sample is the next point requiring attention. The presence of either too many or too few cells must be avoided. With a one-eighth-inch objective, 40 to 50 cells in one field constitute a fair average. As the microscope, when properly focused, will only show the cells in one plane, it is very necessary that the amount of liquid between the object and cover glass should be

limited so as to form a film that has practically no thickness at all. In practice this, of course, is not possible, but the thickness of the film can be reduced sufficiently to bring any object in the liquid into view, if not quite into focus. This is an important point, because small bacteria have a habit of coming to the top, while the yeast cells, being heavier, go to the bottom of the liquid, and if there is an excess of the latter between the glasses the bacteria may escape detection. A good plan to go by is the following: — Place a drop of the liquid on the object glass, of such size that when the cover glass is placed in position the liquid nearly, but not quite, reaches its circumference. To prevent air bubbles, both glasses should be kept quite free from grease. This can be done by keeping them in a weak solution of alcohol and caustic soda. A very good average sample of the yeast to be inspected must be obtained — say half a pound or so — which is beaten up with a jugful of clean, freshly drawn water. If the brewery supply is not free from bacteria, clean distilled water must be employed. A small quantity of the large sample thus prepared is taken on a clean spatula and diluted in a beaker of pure water. A drop of this is placed on the object glass by means of a platinum wire having a small loop at the end. A platinum wire is advised because the size of the drop is easily adjusted by making the loop larger or smaller. With a glass rod it is difficult to obtain a drop of just the right size owing to the influence of capillary attraction. If the number of cells in the field is too great or too small, the yeast in the beaker must be further diluted or more must be added, according to circumstances. With a little practice a correct number of cells is easily obtained the first time.

Supposing everything is now in order, the operator has to fix his attention on the following points: — The purity of the samples (freedom from disease ferments).

The appearance of the yeast cells. Ordinary brewery yeast does not, as a rule, contain a great variety of disease ferments. Those present can be classed as long rods, short rods, bacteria (small and of round form), mold fungi, and wild yeasts.

Mold fungi are practically never present in a brewery where any care is exercised, but there are very few yeasts altogether free from rods and bacteria.

Rods which are as long as the diameter of a yeast cell, or longer, consist of the "Saccharo-bacillus pastorianus," the turn ferment. The same species is also often present in the form of short , rods (about two-thirds the diameter of a yeast cell). These rods can be distinguished from the others by their thinness.

Short rods, about half the diameter of a yeast cell, occurring singly and in pairs, consist of lactic acid ferments.

Another common form is a short rod, with a slight strangulation at its center, giving the appearance of the figure 8. This is also an acid-producing species, and

in many works on brewing is referred to as a variety of bacterium termo.

The above three forms are those most commonly met with in yeast. Occasionally very small bacteria, not larger than a pin’s head, are found. These have a bright, black appearance, and are putrefactive bacteria, only found in yeast which has been stored.

Brewery yeast is invariably mixed up with hop resins, amorphous albuminoid matters, and small fragments of hop. The resins and albuminoid are sometimes diflicult to distinguish from bacteria, especially, as being very light, they tend to move about in the field.

A second examination of the yeast after rem0val of these impurities is therefore always advisable.

Hop resins and albuminoid matters dissolve in a weak solution of caustic alkali.

A second preparation is therefore made by placing one small drop of the yeast solution on the object glass and then mixing it with a drop of the same size of a 5 per cent. solution of caustic soda.

The number of bacteria in a field can then be easily counted, as a greater part of the unorganized impurities will have disappeared.

So far, nothing has been said about the appearance of the yeast cells. These should be of uniform size, with strong, thick cell walls. The protoplasm inside the cell should have a uniform appearance, and the vacuoles in a healthy sample should not be too large.

If the contents of the cell are granulated, this is a proof of weakness and age.

Should the brewer have the necessary time, one more examination should be resorted to after adding a drop of coloring matter to the sample.

This preparation is made as before, except that, instead of mixing the drop of yeast with caustic soda, a drop of I per cent. cosine solution is employed. Good healthy cells are scarcely affected at all by the color, but dead and weak cells are quickly stained a dark red.

When the examination is concluded, the brewer has to form an opinion on the value of the sample, and it is here that the real difficulty commences. In brewing manuals we find the authors stating that the ratio of bacteria to yeast cells should not exceed a certain fixed figure. It is impossible, however, to draw any hard and fast line.

In some brewery yeasts the percentage of bacteria appears appalling, but yet the beers remain remarkably sound. What the brewer should really aim at V is to reduce all impurities, if not to zero, at least to the lowest possible scale. It is true that the beers may not be banned by the presence of rods and bacteria in the pitching yeast, but at the same time the brewer is running risks.

If the percentage of the bacteria is anything over 1 to 2 per cent, the plant should be regularly disinfected, and the soundness of the materials inquired into.

Where the plant and materials are sound, and all proper precautions are taken, it is astonishing how pure the yeast can be kept, Wild yeasts cannot always be discovered in the pitching yeasts, but are easily detected in the deposit from the finished beers.

Curiously-shaped cells in a beer deposit are not invariably wild yeasts; but if the latter are present in excess, the beer is sure to fret, acquire an unpleasant flavor, or exhibit cloudiness.

If wild yeasts once get a real hold in the pitching yeast, the introduction of a pure culture into the brewery becomes a matter of prime necessity.

CHAPTER X. THE USE OF RAW CANE SUGAR IN AUSTRALIA.

THE NECESSITY OF SUPPLYING A SPECIAL YEAST SUITABLE TO THE CONDITIONS.

MELBOURNE No. 1 YEAST.

To an English brewer, accustomed to use only inverted sugars, it amounts almost to a shock to see the raw sugar used as it is in Australia. The first feeling of general surprise is that the brewings can be conducted successively successfully. Here and again one might think raw cane sugar might be used with impunity, but to do so in successive brewings is nothing less than amazing to an English brewer. It says much for the skill of the Australian brewer that he comes out of such an ordeal unscathed.

In all probability, in the early days of Australian history, beer was wanted at any price and by any method. Inverted sugars would probably be prohibitive on account of freight, and, possibly, duty (political readers could enlighten us on this latter point). What, then, could be more natural than to turn to an article ready at hand? Cane sugar would naturally be stocked in every country store. The brewer of the period laid his hands on this, and so probably the custom arose and eventually grew to its present dimensions.

It is the general custom in Australia to use 50 per cent. of sugar calculated on the basis of the original gravity of worts, and there are breweries where 60 per cent. is usual. One wonders that yeast weakness is not more prevalent.

In order to state as clearly as possible the essential difference between raw and inverted sugars, it becomes necessary to compare their chemical formula. Thus, cane sugar is represented by C_{12} H_{22} O_{11}, and the same sugar "inverted" or "hydrated" becomes, with the chemical attachment of a molecule of, water (represented by H_2O), C_{12}, H_{24} O_{12} or 2(C_6 H_{12} O_6). This slight difference in the percentage of water, it must be clearly understood, is not water in the sense of moisture, but an integral part of the molecule of inverted sugars. At first sight it might appear that such a slight variation in the composition of inverted and raw sugar could be of no account in practical brewing affairs, but, upon looking into matters more closely, a most important consideration becomes apparent.

Yeast has the dual power of inverting sugar by its enzyme invertase, and fermenting sugar by its enzyme zymase. Should raw sugar then be used, the yeast must of necessity exercise its inverting functions. The whole question of food suitable to yeast has been fully discussed in The Student’s Manual of Yeast Culture, and it is unnecessary to quote lengthy paragraphs here. At the same time readers may be reminded that there is no question Whatever "that in order to

keep certain types of yeast healthy it is not merely necessary to feed them, but also to provide them with something calling into the fullest action their inverting power. Apparently, food to easily assailable in some cases causes types to deteriorate, fermentation may become sluggish, beer may remain turbid, with the utmost persistence, flavors may be anything but agreeable.

"It would appear that such yeasts as the above require to ferment worts containing 5 or 10 per cent. of raw cane sugar in order that they may multiply successfully."

The foregoing paragraph was written without either knowledge or experience of Australian conditions; but the truth was forced upon the attention at the time of the discovery of Saccharomyces Thermantitonum. Note well that 5 or 10 per cent. of raw sugar was at that time suggested (1908). Who in their wildest dreams would have Suggested (without knowing Australia) 50 or even 60 per cent. regularly, year in year out, and in many breweries, without a thought of sowing a pure culture of yeast?

Yeast weakness on the author’s arrival in 1910 was distressingly prevalent. All sorts of mixed types had been tried — dried yeast from Burton-on-Trent — yeast in sealed tins of malt extract — American cultures — their name was legion, and the results, oftentimes bad, were as variable as the yeasts themselves. A very short experience (a few weeks ,merely) sufficed to show the pressing need of a yeast suitable to Australian conditions, climate, and the brewers’ amazing fondness of sugar.

There is no need to enter into the details of the vast amount of work accomplished before the type isolated and now known throughout Australia as "Melbourne No. 1" had proved itself the yeast every brewer was waiting for.

It has the ability to ferment worts of fifty per cent. of the gravity composed of raw cane sugar, without — the slightest sign of weakness; further, it is of such vigorous habit that pure cultures remain pure after resowing in" brews covering a period of months. In many breweries three or four new cultures per year have been sufficient to keep fermentations in perfect order — and if further evidence were needed there is scarcely a brewer of importance throughout the continent that has not written expressing his satisfaction and gratitude for the invariable good results following its use.

In parentheses it may be mentioned that the single cell culture is particularly applicable to Australian conditions. All bottled beer is chilled and filtered, all cask beer condition required, may be obtained by controlling the gravity before racking and secondary fermentation flavors are generally unpopular, and are not therefore provided for. Some of our very conservative friends in England may,

after the lapse of a few thousand more years — a thousand years is a mere fraction in English history — come to the conclusion also that single cell culture methods might present certain advantages to their conditions, especially respecting non deposit of yeast cells in bottled beers. But who can tell?

It is apparent the more and more one studies the subject that nature provides types of yeast whose properties were undreamed of until some abnormal condition — such as fermenting raw cane sugar — demonstrated them. It is safe to say, after seven years of Australian experience, that worts of fifty per cent. of raw cane sugar fermented by a suitable yeast are in every way as healthy as fermentations at Burton-on-Trent, where malt alone is generally used in brewing.

Candidly and honestly this would have been considered impossible in England, though not merely its possibility, but its actuality, has been proved by daily practice in Australia for a great number of years.

Several students have inquired for simple details to guide them in determining the "extract" per cwt. of sugar. One or two mention that they have gram weights and liter, ½ liter and 1; liter measures. Others say they have only oz. and lb. weights and pint and quarter measures.

Let us look at matters in this way. A brewer will say to himself, for example, 2 cwts. of sugar are equal to a quarter of malt. Another will say sugar should give 42 brewer’s lbs. per cwt. (raw cane sugar understood) — one cwt. of sugar if it yields 421bs. extract would make two barrels of syrup of 21 lbs. gravity each.

We will reckon out then small quantities, in the proportion of one cwt. of sugar dissolved and diluted to exactly two barrels.

```
Lbs.  Gallons.

112   to     72   (2 barrels)
1.12  to   0.72
0.112 to  0.072
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As 1 lb. equals 453 grams roughly, 0.112 of a lb. = 50.736 grams. As 1 gallon equals 4543 cc., 0.072 of a gallon equals 327 cc. Therefore, if we take 50.736 grams of sugar and dissolve and dilute it to 327 cc. it is exactly the same proportionately as one cwt. of sugar to two barrels.

In the same proportion if 38.78 grams of sugar are dissolved and diluted to 250 cc., we have an easy measure to make up and generally sufficient to weigh by a saccharometer.

CC.		CC.		Grams		Grams
327	:	250	::	50.736	::	38.78

As an example, 38.78 grams of sugar were taken and dissolved and diluted to 250 cc. The weight by the saccharometer was found to be 1056 degrees, or 20.2 brewer’s lbs. This figure, 20.2, multiplied by 2, equals 40.4 brewer’s lbs. extract per cwt. of sugar.

For the analysis of sugar the student is recommended to read Lawrence Briant’s Laboratory Text Book for Brewers.

Several opinions in respect of several varieties of sugar supplied to the Australian markets have been held by many brewers. Some prefer Mauritius crystals, others Java crystals, while the majority appear to favor the Queensland product. Various arguments have been advanced for the several preferences, and "ash" has been given as a special reason; but on analysis nothing has been discovered to establish any fact that could be regarded as important.

Possibly some "chance infection" might vary in different countries, but this can be determined by boiling flasks of syrup and noting whether spores develop into mature cells afterwards; and if so the nature of the cells could be noted. This possibly may be a reason for preference.

West Indian experiences call to mind an endless array of undesirable germs, infecting sugars of various qualities.

CHAPTER XI. HOPS.

The Brewing School of Ghent it is the custom to hold a yearly exhibition of the year’s products; but instead of merely placing samples of the harvest on view, comparisons are made with the products of former years, by a tabulated system of analysis. This system is specially useful in the case of hops, and forms a valuable guide to the brewer as a determining factor in regard to purchase price.

For weeks before the exhibition girls are employed in separating the hops into their component parts: —

Seeds.
Bracts or leaves.
Strigs.

The seeds and strigs, in the light of modern knowledge, are regarded as useless to the brewer, if not harmful, because they impart a harsh, astringent flavor to beer. Obviously, therefore, a sample of hops yielding a high percentage of these component parts is regarded with suspicion by the enterprising purchaser. The bracts or leaves yield tannic acid, and certain nitrogenous matters, which serve as yeast foods.

The lupulin contains the essential oil of the hop. To give a general idea to the Australian brewers of the value of determining the percentages of bracts, seeds, and strigs, three samples of hops are tabulated below. At a glance it is easy to decide which sample represents the highest value. No cursory examination, according to the usual method, could disclose the true state of affairs so definitely .

	Seeds Per cent.	Bracts Per cent.	Strigs Per cent.
Nelson, N.Z.	17.18	68.71	14.06
Tasmanian	29.46	58.38	12.15
Californian	11.02	74.51	14.46

The figures given should also be considered in conjunction with the percentage of resins soluble in petroleum .ether, and sulfuric ether. Neither should ash and moisture be disregarded. Here are further instructive figures: —

	Soft Resins soluble in Petroleum Ether	Hard Resins soluble in sulfuric Ether	Ash	Moisture
Nelson, N.Z.	5.43	7.33	8.7	10.66
Tasmanian	10.066	3.63	7.6	10.59
Californian	--	14.28	8.26	10.68

sulfuric ether can take into solution the hard and soft resins. Petroleum ether is capable of dissolving the soft resins only. In the ease of the Californian hops, no separate determination of the soft resins was made. The figure given (14.28) as resins soluble in sulfuric ether includes the soft and hard resins. The method of determining the hard and soft resins is as follows: — A Soxhlet extractor of about 100 cc capacity is taken, and about 3 grams of hops are placed in the filter paper cone. The flask below the tube should be filled to about half its capacity with petroleum ether and then be immersed in a hot water bath, care being taken that the temperature does not rise above 155F.

The ether should be circulated several times during 24 hours. At the end of this time the petroleum ether will have extracted the soft resins. The flask is now detached from the tube and the contents are transferred to an accurately weighed beaker. Care must be taken not to evaporate the ether near a flame.

When the ether has evaporated, the beaker containing the soft resins is carefully dried in the oven, cooled in desiccator, and weighed until constant.

The flask is again taken, this time with sulfuric ether, which is circulated several times during 12 hours, care being taken that the hot water bath does not exceed 135F.

After the expiration of the 12 hours the flask is detached, containing the hard resins, and the same procedure followed as described for soft resins.

The soft resins are generally regarded as "preservative," the hard resins as "non-preservative."

An ingenious machine has been designed in Belgium for the purpose of separating hops into three essential parts, viz. : —

1. The Bracts.
2. Lupulin.
3. Seeds and strigs.

The extraction of tannin from the bracts necessitates a long period of boiling, and is hampered "by the fact that the leaves in the whole hop cone clog together, and thus imprison between them a quantity of wort, which circulates slowly. This difficulty is entirely overcome by the separation of the bracts from the strigs.

The lupulin of the hop is volatile, and is therefore driven of by a prolonged period of boiling; "but if separated from the bracts it may be introduced into the copper a quarter of an hour or so before "turning out." By this method a far better aroma can be expected in the finished beer. From the foregoing remarks it would appear that the method of using hops whole is neither rational nor economical; therefore it seems but logical to adopt the method proposed by M. Rounberg, the Belgian engineer.

It has been stated in Bruxelles that a certain brewery has effected a saving in their hop consumption by no less than 15 to 20 per cent. by the adoption of the means under discussion — a notable economy.

There is yet another and even greater advantage to be obtained by separating hops. —

The process permits of a long preservation of the most valuable constituents. The lupulin, which represents on an average some 10 per cent. by weight of the cones, can be placed in small receptacles, and can be stored in cold storage.

The leaves can be compressed, and if kept in a dry place will not undergo any appreciable deterioration within one or two years.

Mr. Chapman F. I. C., F. C. S., has shown that it is an error to suppose that tannic acid suffers a reduction per cent. during one or two years. Again, M. Bekaert, of the Brewing School of Ghent, has demonstrated that an unwarrantable appreciation of tannic acid has held the field too long.

CHAPTER XII. THE PRINCIPLES AT STAKE IN THE MALTING PROCESS.

IN the introductory chapter it is mentioned I that grain when sown in the soil undergoes certain changes — enzymes are formed — in order that starch may be converted to soluble sugar for the sustenance of the young plant.

The maltster, taking advantage of Nature’s methods, soaks the grain in cisterns filled with water instead of sowing it in soil. After soaking the grain for a number of hours. ranging from 24 to 80, according to the climate, type of barley, temperature of the steeping water, and so forth, it is spread over the malting floors, turned to prevent over-heating, sprinkled to assist the growth, and finally withered to suspend the growth of the embryo.

After withering the grain, it is conveyed to the kilns and then dried.

It should be unnecessary to discuss the malting process in detail here; every brewery student should endeavor to see the process carried on, and refer to his text books for further enlightenment. The principles at stake, .however, are important, and it is as well to consider them shortly.

In the first place, it is clear that as the embryo must necessarily feed on the starch of the grain — it is merely a question of time before the seed would no longer contain starch, but would consist of embryo (young plant) husk and rootlet.

Again, should the embryo grow insufficiently, the grain would still resemble barley, rather than malt, sufficient diastase will not have been produced to effect the conversion of starch to sugar in the mash tun.

The experienced maltster therefore has to decide:

1. Whether the embryo has developed sufficiently, which also indicates that sufficient diastase has been formed.

2. Whether the embryo is over-grown, which would mean an unnecessary loss of , starch.

3. Whether the grain is sufficiently "withered" before loading the kiln.

It may be stated generally that much of the bad malt is due to lack of appreciation of the foregoing considerations.

If germination has developed insufficiently, either from lack of steeping long enough, or from lack of watering on the floors, or for lack of sufficient "flooring,"

hard ended steely malt will be the invariable result, and this of course means loss of extract. Steely malt indicates that the important role of cytase has not had fair play; its function is to "modify" the starch, by which is meant that the cell walls of the starch granules are partially dissolved and rendered therefore capable of rupture (gelatinization) at a temperature far lower than boiling point.

A well "modified" grain results in a fine friable malt, mealy and malty to the palate; an ill modified malt possesses the reverse of these characteristics.

The art of "withering" at the right time is also of the greatest importance. For example, sufficient moisture should be in the grain to assist the growth of the embryo to the length required, and no further, so that when the time arrives for loading the kiln, the grain should be "hand dry," as maltsters would say.

The kilning should now be conducted with the greatest caution, a very gentle warmth only being permitted, until the malt becomes dry. The diastase so necessary to the brewer is destroyed by heating in the presence of moisture, but once the moisture is expelled by the gentle warmth, "firing up" may safely be commenced, though caution here is necessary also. It may be taken as a fairly safe statement that every five degrees of kiln temperature above 180F, reduces diastasic power "two Lintner."

During many years of experience in malting this fact has become prominent. Given, we will say, that a malt yields "twenty-five Lintner" when dried at 180F, another kiln malted from the same sample of barley and treated in identically the same manner (except for" the fact that 220F, was permitted as a maximum kiln temperature) would yield in all probability "Ten Lintner."

It must be recognized, therefore, that high dried malts, although so desirable for rich malty flavor, must also be suspected of being low in diastasic power.

The following list is interesting. It represents the analysis of fifty kilns. The ten examples are the average figures from five analyses of each variety

MALT ANALYSES.

AVERAGE CALCULATED FROM FIVE SAMPLES OF EACH VARIETY.

	Kiln Dried at	Extract	Moisture	Diastasic Power Lintner
Chevalier				
A	180	84.37	2.5	32
B	210	87.66	1.03	1.5
C	180	85.65	3.33	29
D	190	83.03	3.39	24
E	200	86.28	2.28	12
Chilian	200	90.56	0.83	20
Cape				
A	180	82.27	3.97	14
B	180	79.12	3.41	16
C	180	80.84	3.29	15
D	200	84.29	1.16	12

The student is urged to read "A Grain of Barley," by Horace T. Brown, F. C. S., F. C. S., F. I. C. Nothing on the subject comparable to it has ever been printed in the English language. Extracts from the work appear in nearly every text book published since it was written, but all lose the charm engendered by reading the paper in its entirety.

The whole conception of the reasons for the growth of the grain, the chemical actions ensuing, the opening wide of Nature’s wondrous book (so feebly hinted at here), all are set forth in a manner one would expect from a man of wide learning and vivid imagination.

The pamphlet is not merely a scientific work it is a work of art.

Dr. Wyatt, of New York, has also done much work for the guidance of students. His practice is to publish periodically average analyses of all brewing materials. The following example, culled from a pamphlet published by- his "National Brewers’ Academy," should prove instructive to Australian students : —

TYPE or BARLEY FOR MALTING PURPOSES.

	Per cent.
Moisture	11.00
Total albuminoids	11.00
Fat	2.00
Fiber	4.25
Ash	2.40
Starch, sugar, etc.	69.40
Weight of 100 kernels	4 grams
GERMINATING CAPACITY	96
Black-ended corns	none
Broken corns	none
Color	pale gold
Odor	sweet
Foreign seeds	none
General physical appearance	excellent

The prevailing characteristic of Australian malts is their low diastasic power (unless one has the control of the malt-house). This is a matter of secondary importance when brewing mild beer from highly dried and very friable malts, but as Lager beer is unquestionably the beer of the future, the

subject of diastase will require the most careful attention. In the event of public taste demanding exceedingly light, raw grain beers (there is a pile of evidence in the author's possession indicating this trend), the attention of the maltster will not only have to be given to this subject, but the brewer will be wise in specifying his diastasic requirements in his malt contracts.

CHAPTER XIII. METHODS OF MALT ANALYSIS.

> Note. — In July, 1914, I had the opportunity of a consultation with two gentlemen prominent in the Australian brewing industry — Mr. T. Nation (of Adelaide) and Mr. Barrett (Melbourne). Amongst other things, we gave careful consideration to Iandard methods of malt analysis, with the result that I was asked to publish (in the general interest) details upon which I invite criticism from anyone interested in the subject. While fully admitting the excellence of the methods adopted by the Council of the Institute of Brewing, London (fully reported in the journal of the Institute, Vol. KIL, No. a, January, 1906, and reprinted in " The Australian Brewer's Journal" for November, 1906, I have decided that certain modifications are permissible.

My object has been to establish a. standard in Australia that may be reliable within reasonable limits, rather than to insist on certain details of apparatus, which might be procurable with difficulty in Australia.

During one of my several visits to assist my brothers in Bruxelles, I was much struck with Dr. Harold Johnson’s modification of the Lintner diaatasic capacity method.

It has such obvious advantages if put to the test that I believe it will be acceptable to anyone giving it a fair trial. It is at once simple and reliable, and I think far easier than the original method.

In the several recommendations of the Council of the Institute of Brewing, prominence is given to the preparation of soluble starch for the Lintner process. It is, of course, obvious to anyone accustomed to malt analysis that the subject is of great importance. Here, again, however, it is not with a view of minimizing the importance of the recommendation that I suggest an alternative, but simply and solely to facilitate matters for brewers already fully occupied with multifarious duties.

I suggest, then, that instead of preparing starch as described, pure potato starch be employed. Personally, I have used it for many years, and have never found any variation of importance.

So far, then, for preliminaries. I hope I have made myself clear — that in suggesting the methods following I have been guided by my desire to make things as simple as possible, without, however, departing from essentials.

MOISTURE IN MALT.

Spong’s coffee mill is obtainable in Australia, and answers the purpose of grinding malt admirably. It can be adjusted to any degree of fineness, the parts are easily detachable; it is quite inexpensive, and, moreover, greatest advantage of all — it can be easily cleaned.

A practice should be made of cleaning the mill before grinding every sample.

A few grains of malt are passed through the mill, and the grist is rejected.

Then a small, shallow vessel, carefully weighed, is taken, and about 5 grams of finely ground malt are placed in it. A watch glass of about 3 inches in diameter will serve as a drying vessel if nothing else suitable is obtainable.

A water oven is heated to boiling point — the vessel and malt are placed in it, the temperature being maintained for five hours. After the lapse of five hours, the malt is to be taken from the oven, and placed to cool in a desiccator.

It is then weighed. Again it is placed in the oven for one hour, replaced in the desiccator to cool, and then re-weighed.

If necessary, the process is to be repeated until the weight is constant. The loss in weight is due to expulsion of moisture, and is to be calculated on a percentage basis.

To make all clear. let us take an example:

Malt, plus watch glass	10.451
Watch glass	6.451
Malt taken	4.000
After five hours heating:	
Malt, plus watch glass	10.230
Watch glass	6.451
Malt	3.779
Malt before heating	4.000
Malt after heating	3.779
Loss	0.221

If, therefore, by simple proportion 4 grams of malt lose 0.221 in weight, 100 grams of malt lose 5.52 — that is, obviously, 5.52 per cent. It might be mentioned to the inexperienced that such a percentage of moisture is far too high; but actual figures obtained from a melt sent for analysis are given.

DIASTASIC CAPACITY (LINTNER).

MODIFICATION BY HAROLD JOHNSON, D.Sc.

In the first place, potato starch solution is to be prepared, and note well it is to be prepared upon every occasion — that is to say, whenever a malt analysis is to be conducted. Solutions of starch are easily decomposed, and are, therefore, unreliable after the lapse of a few hours. —

Weigh 2 grams pure potato starch, add 100 cc cold, distilled water- in a quarter liter flask. Place the flask in boiling water, and shake constantly to prevent lump formation. After gelatinizing, let the flask remain in the water bath five minutes. Cool to 60F. Leave volume as it is.

Place the solution on one side until required.

Next prepare.

COLD EXTRACT OF MALT.

Weigh out carefully 10 grams of finely-ground malt, add 200 cc tap water, and place flask (about 300 cc capacity answers well) in a water bath for five hours at 68F. Stir occasionally — filter. Of the filtrate take 1 cc by means of a pipette, and add it to the 100 cc of starch solution already described. Allow the solution to remain one hour at a temperature of 77F.

Meanwhile, prepare a mixture of Fehling’s solutions — half of each. Details of these solutions are given further on. Place the mixed Fehling’s solutions in a burette, and have clean and ready at hand a jam pot full of test tubes.

In the first tube take it 0.5 cc Fehling; in the second, 1 cc; in the third, 1.5 cc; and so on, increasing half a cc in each tube up to 4 cc.

Mark the tubes with stamp edging thus: — 0.5 cc, 1.0 cc, 1.5 cc, 2.0 cc, 2.5 cc and so on.

After the lapse of the hour during which the diastase (from the cold mash solution) has acted upon the starch, take the starch solution, and by means of a pipette transfer 10 cc to every test tube containing Fehling. Next transfer the test tubes to a boiling-water bath, and keep them in it for ten minutes.

After the ten minutes, the tubes are withdrawn, and placed in a slanting position, their heads testing on an office ruler, for example.

It will be noticed that some of the tubes remain blue, while others are red or yellow.

Suppose, for example, tube containing 1.5 cc Fehling loses all trace of blue, but 2 cc is distinctly blue, then we should say the diastase reduces the 1.5 cc tube. Every 1 cc Fehling equals 20 of diastasic power; therefore, if 1.5 cc is reduced, the diastasic power is 30.

Observations should be made generally after the lapse of twelve hours or so, as the red copper Oxide is held in suspension for some time, thus obscuring the unreduced blue copper sulfate.

Diastasic results should be completed by five o'clock in the afternoon, and the tubes left until early the following morning for observation.

Fehling's solutions, to which references have been made, are prepared in the following manner: —

Copper Sulfate Solution. — 34.64 grams of chemically pure copper sulfate are dissolved in warm distilled water and diluted to about 250 cc Then 0.5 cc of pure concentrated sulfuric acid is added, and the solution is cooled to 60 F and made up to half a liter with distilled water (at 60 F understood).

Alkaline Tartrate Solution. — 175 grams of crystallized Rochelle salts (sodic potassic tartrate) are dissolved in 350 cc of distilled water, and the solution is to be filtered if not clear. It is then added to a clear solution of 50 grams of caustic soda in 100 cc of distilled water. The volume of the above mixture is then made up to half a liter at 60F. It is to be clearly understood that both the copper sulfate solution and the alkaline tartrate solution are to be stored in separate bottles. The mixing of the solution is to take place immediately before requirements, and the volume of each solution is to be taken equally and in such quantity as may be slightly in excess of the requirements of analyses in hand. At the end of the day's analyses any mixed Fehling's solution remaining in excess of requirements should be poured to waste. —

THE DETERMINATION OF THE EXTRACT OF MALT.

Weigh roughly 55 grams of malt, and then setting the mill to grind finely, pass the malt through, taking care to reject the first gramme or so. Of the fine grist weigh carefully and accurately 50 grams, and without loss transfer it to a 500c.c. flask, and add about 400 cc cold tap water. Now place the flask in a water bath and raise the temperature to 114F. Leave three-quarters of an hour. Next raise temperature as quickly as possible to 150F, and leave for another three — quarters of an hour, Next raise to 167F, and leave again three-quarters of an hour.

Shake occasionally during the several periods. Now cool the flask to 60F, and make up to volume with tap water at 60F. Add an extra 15 cc (carefully measured) of cold tap water. It is assumed universally that the insoluble part of 50 grams of malt displaces a volume of 15 cc. It follows, therefore, if all is clear, that our total volume is to be 515 cc, not 500 cc The contents of the flask may now be transferred to a beaker or any suitable vessel, and must be thoroughly mixed. It is not an easy matter to effect a perfect mixture whilst the mash remains in the flask. When thoroughly mixed, a clean, dry funnel, dry beaker, and dry filter paper are taken, and the filtration of the mash is proceeded with. The specific gravity of the wort is then taken in a specific gravity bottle, preferably of 50 grams capacity. It will be noted that we are dealing with a lo per cent. solution. Fifty grams of malt are mashed in 500 cc of water. No notice is taken of the extra 15 cc mentioned. We will assume that the 50 cc specific gravity bottle filled with the filtered wort weighs 51.205. It follows that 100 cc would weigh 102.410, and that a liter would weigh 1024.1. Obviously, therefore, 1024.1 is the specific gravity, taking, as is generally the case, the liter as the unit. In parenthesis it may be well to give the definition of specific gravity to assist those whose knowledge on the subject may be nebulous f Specific gravity is the weight of a substance compared with an equal volume of water at 60F. Thus a liter of distilled water weighs 1000 grams, but a liter of the malt extract under discussion would weigh (as has been demonstrated) 1024.1. Whether the actual liter be weighed or calculated from a 50 cc bottle matters nothing, neither would it matter if we took an ordinary saccharometer cylinder and filled it with wort and weighed it with the saccharometer. We would arrive at precisely the same result. The saccharometer would. register (if accurate) a shade over 1024. It is this "shade over," however, that compels the use of the specific gravity bottle; the saccharometer is not fine enough to reveal gravities between single degrees. But to resume. Our wort in a 10 per cent. solution has been shown to be 1024.1. We neglect, for purposes of calculation, the 1000, and say 24.1., We divide 24.1 by 3.86, the reason being that 1 per cent. of maltose in solution gives a specific gravity of 3.86 degrees.

```
3.86) 24.10 (6.24
      23.16
      ------
        .940
         772
       ------
         1680
         1544
```

From the above calculation it will be seen that in a 10 per cent. malt mash solution 6.24 grams have passed into solution. It follows, therefore, that if 10 grams gives 6.24 soluble parts, 100 grams give 62.4 soluble parts, or, as we should say in brewers’ language, "the malt gives an extract of 62.4 per cent."

There is another way of calculating the percentage of the extract from the specific gravity. Every degree of gravity (above 1000 understood) is due to 2.6 grams of cane sugar per liter. Thus supposing our gravity is 24.1, as already demonstrated, and that this gravity is multiplied by 2.6 —

```
  24.1
   2.6
------
  1446
  482
------
62.66
```

it will be seen that except for a trifling fraction, which is of little consequence, we arrive at the same conclusion that we obtained by our other method.

We will now consider the further details necessary to enable the brewing student to calculate extract on the basis of brewers’ lbs. per qr.

In the first place, let us turn to page 43, Professor Adrian Brown’s "Laboratory Studies for Brewing Students." "As 50 grams of malt were mashed, the extract from this weight of malt is contained in 500 cc of the wort. Hence the extract from 10 grams of malt is present in 100 cc of the wort."

In our experiment our wort — 10 per cent. solution — was found to be 1024. It is self-evident that 100 cc of this wort would weigh 102.4. Now this volume of wort contains the extract from 10 grams of malt. It is obvious that the extract from 10 lbs. of malt must be 2.4, and from 190 lbs. of malt 24. An Australian quarter of 320 lbs. is obviously 3.2 hundreds.

If, therefore, we multiply our extract per 100 lbs. — viz., 24 x 3.2 — it amounts to 76.8. This, then, is the extract per qr. in brewers’ lbs.

There is yet another method devised for students which obviates all calculations, or nearly so. It is based on the assumption Of a laboratory quarter of malt extracted in four barrels of wort.

Follow this reasoning, and all will become clear : —

320 lbs. extracted in 4 barrels equal 144 gallons, therefore 32 lbs. give 14.4 gallons, therefore 3.2 lbs. give 1 .44 gallons, therefore 0.4 lb. gives 0.18 gallon.

0.4 lb. multiplied by 453.59 grams equals 181.436 grams. 0.18 gallon multiplied by 4543.4 cc equals 817.812 cc

If, therefore, 817 cc require 181 grams, 100 cc will require 22.2 grams.

A convenient measure for weighing by a saccharometer is 250 cc; therefore 250 cc require 55.5 grams of malt.

If my readers have followed me, 55.5 grams of malt extracted in 250 cc is precisely the same thing proportionately as 320 lbs. malt extracted in four barrels.

RULES. — Mash the 55.5 grams of malt with 200 cc of water at 165F, and maintain at 152F for two hours. Cool to 60F, make up to 250 cc, grains included. Add 15 cc for displacement of insoluble part of grains (fully explained previously), filter and weigh. We will assume the filtrate weighs 20 brewers lbs. It must be remembered that Our volume of 250 cc represents four barrels of wort. Therefore we obtain four barrels, weighing 20 lbs., or 80 lbs. in all. This, then, is the extract from a quarter of malt of 320 lbs.

> Note. — The author has omitted to mention the Kjeldahl process for the estimation of nitrogen. Firstly, because it is a little beyond the scope of the ordinary student; secondly, because it is so fully described in the majority of text-books, and thirdly, that as it is customary in Australia to use fifty per cent. of sugar, excess of albumin is unlikely, and deficiency of albumin is being gradually but surely overcome by cold mash peptonisation.

CHAPTER XIV. AUSTRALIAN WATERS

THEIR CHARACTERISTICS, AND SUGGESTIONS FOR TREATMENT.

The prevailing characteristics of the town supplies of water in Adelaide, Melbourne and Sydney are extreme softness, traces only of free ammonia, absence of nitric acid; and albuminoid ammonia varying with the seasons, just above and just below the limit considered safe by Wanklyn. Mineral matter is generally 4 or 5 grains per " gallon — chiefly sodium chloride.

The waters are in effect rain waters pure and simple, and consequently lend themselves to a great variety of treatment.

The preposterous idea that pale ale can only be brewed at Burton-on-Trent and that stout can alone be brewed in Dublin is to the younger generation nothing but a myth on a par with changes of yeast as a panacea for every ill (often times dangerously infected) and other wonder-working miracles.

If evidence were required of the myth of Burton-on-Trent, take Lichfield as an example. Here, within 12 miles of one another, we have Burton with 100 grains of solids per gallon, mostly gypsum (Burton waters vary considerably): and Lichfield

City with 21 grains, of which 5 only are gypsum, or Lichfield City Brewery artesian well with 18 grains, of which 1.5 only are gypsum.

No critic, be he ever so expert, could say if given two pale ales (one brewed in either town) which town brewed the one or the other. It is cus — tomary in Lichfield to raise the mineral matter artificially to the "Burton standard," and the result is precisely what might be expected — no difference whatever in the finished product.

Of course a water containing little or nothing in the way of mineral matter that has been used in its natural state will produce a beer totally different to a beer brewed from water containing much mineral matter.

To put the case concisely, a water containing little or nothing can be made up artificially to nearly anything desired, but the reverse of this cannot be done. Dublin in all probability could brew ale just as good as Burton-on-Trent, but the reverse, viz., Burton-on-Trent brewing Dublin stout, would be an admitted impossibility.

The vast majority of Australian waters examined by the author resemble the chief city supplies in that they all contain little or nothing in the way of mineral matter.

An artesian well at Adelaide is an exception, and luckily for the proprietors represents the highest standard of purity, and in every respect conforms to the standard recognized by experienced brewers as desirable for producing the finest ales.

A prevailing feature of many Australian wells is the extraordinary amount of nitric acid. Eight grains per gallon (N_2O_5) is not uncommon, yet in spite of this amount good beers are produced — pure yeast cultures introduced at regular intervals being of course the invariable rule.

From time to time various suggestions are put forth bywriters in many countries respecting water treatment, but nothing more lucid and (by experience) accurate can be found than the late Mr. Southby's chapter XIV.

The student is recommended to give serious attention to this chapter. Surely a copy of Southby on Brewing may be found in every Australian brewery.

In a great measure water treatment has been regarded by many analysts the world over as a sort of secret — not perhaps quite so secret as alchemy, but a subject not to be entirely disclosed to the vulgar mind.

"Be sure you in no case exceed 20 grains of gypsum," advises one. "If you do not have at least 30 grains gypsum, how can you expect to brew?" cries another. There is a touch of mystery in these several amounts, creating an atmosphere of deep learning, hidden causes producing wonderful effects. In truth the whole thing may be summed up in the schoolboy phrase, "Bosh !" Of course there are limits to everything, but a grain more or less of mineral matter in a gallon of water is of no consequence whatever. At the same time it should be remembered that excessive gypsum in brewing water is favorable to the development of "ropy" fermentation — luckily almost unknown in Australia.

For Australian waters generally, experience has shown that for Pale Ales the following amounts of mineral matter — natural and artificial — have proved suitable : —

	Grains per gallon
Gypsum	25
Sulphate Magnesia	7
Calcium Chloride	8
Common Salt	5
Total	45

For, mild Ales the following have given good results: —

	Grains per gallon
Common Salt	25
Sulphate Magnesium	14
Calcium Chloride	8
Total	47

Note. — The Mg. SO_4 mentioned contains the water of crystallisation.

For Stout something similar to Dublin water cannot be improved upon, for example : —

	Grains per gallon
Gypsum	5
Sodium Chloride	25
Calcium Chloride	5
Magnesium Carbonate	5
Total	40

Most of the carbonate of magnesia is precipitated on boiling, leaving a balance of 35 grains only per gallon. This would probably be the minimum for producing a good full stout. Many authorities suggest as much as 60 grains per gallon, and kainit is constantly recommended.

But as kainit consists chiefly of magnesium sulfate and sodium chloride, there cannot be any special advantage in using it. Another point against kainit is this: By its use the sulfates are unduly increased, thus rendering the water unsuitable for stout brewing — the, main fact requiring recognition being that chlorides, not sulfates, produce smooth full drinking black beers.

Doubtless there will be plenty of criticism respecting the wide liberality of margin herein suggested for water treatment — but 33 years experience in practical analysis of an inconceivable number and Variety of wells has forced the conclusion that the whole subject of "grains per gallon" has been grossly exaggerated. If an example were needed, Burton-on-Trent waters vary from 60 to 160 grains per gallon, yet who stops to consider whether Bass has 60 or Worthington 100? Truly Lichfield water is largely used in Burton for blending with excessively gypseous waters, but nobody takes the trouble to limit the amount to any definite figure; or, to put the case another way, nobody tries to do precisely

as his neighbor — yet all brewings are Burton Ale.

Unfortunately there are many wells in Australia containing more than traces of organic matter and considerable albuminoid ammonia.

A very simple test for country districts is to evaporate about a pint of water to dryness (even a tin pannikin will do), and then note whether the residue blackens when heated by the spirit lamp or Primus stove, or whatever else is handy for heating.

"Blackening on ignition" proves organic matter present, and before proceeding to brew, the water should at once be sent to the analyst.

In a great many cases filters made from empty hop drums packed alternately with sand and animal charcoal have proved effective. Very bad waters might be passed through a series of six drums — three of sand and three of charcoal, and if this should prove insufficient the following device might be tried with advantage.

At the highest point in the brewery the water is caused to issue from several ordinary gas jets fitted in the delivery pipe. The finest of fine sprays will be the result. The jets should be directed towards a supply tank high enough to control the filters. A good plan is to run a water pipe around a tank and place a gas burner at intervals of every foot or even 6 inches. After the oxidation process and subsequent filtration a water should generally be greatly improved, as analytical results would reveal. There are several breweries that have adopted this system with very beneficial results.

In the event of the student wishing to learn practical water analysis, he cannot possibly do better than follow the late Professor Wanklyn’s directions. If the original work is unobtainable, the details are given in so many text books that it is unnecessary to repeat them here.

The following few observations on mineral matter may be useful to the student.

Gypsum should pass a 100 mesh if it is to dissolve readily. It is more soluble in cold than hot water. Many samples of Australian gypsum are Superior to the imported, both in purity and solubility.

Plaster of Paris is gypsum with a proportion of its water of crystallization driven off, and is quite insoluble and therefore useless to the brewer. Calcium chloride. The commercial quality generally in use for "brine," suffices. Magnesium sulfate is generally sold with its water of crystallization (roughly half its weight); on the other hand, it is not unusual to buy it with water of crystallization expelled. Care must be taken when buying, on account of economy as well as for weighing the

amount required.

Kainit varies considerably, particularly in percentage of moisture. Arsenic also has been detected in kainit. Caution is therefore necessary.

Salt of the greatest purity is obtainable all over Australia. Crystals from a salt lake near Adelaide proved to be chemically pure.

From the foregoing remarks at least some home industries should be supported.

The student after deciding upon the amount and varieties of mineral matter he intends using should remember to dissolve 'each salt separately, and "rouse" each solution separately into his brewing tank. No proper distribution of mineral matter can be obtained by any other method.

It must be remembered, also, that certain salts exchange acids and bases when mixed together, and, in order to facilitate such exchange, a perfect distribution over the entire volume of water to be treated becomes a matter, not of expedience merely, but of necessity.

CHAPTER XV. SPECIFIC GRAVITY.

DEFINITION & METHODS OF DETERMINING.

THE specific gravity of a substance is its weight compared with an equal volume of water at 60F.

In all brewing calculations the liter, 1000 cc and consequently 1000 grams, is taken as the volume for comparison, so that when we Say that a wort has a specific gravity of 1050 degrees we mean that, if we weigh a liter flask of it, it will weigh 1050 grams. The specific gravity saccharometer is so designed that whatever degree it floats at, it registers the weight per liter in whole figures; that is to say, grams per liter.

In the event, for example, of the instrument floating between 1050 and 1051 we might assume the weight per liter to be 1050.5; but this rough calculation is not fine enough when determining, facts from an analytical point of view. Consequently it is customary to take a 50 cc specific gravity bottle and weigh its contents on the balance and calculate the weight to 1000 cc Thus —

Weight of 50 cc	53.464
Weight of 100 cc	106.928
Weight of 1000 cc	1069.280

By this ,method we obtain the exact gravity, 1069.28, that is to say, to the second place of decimals. No saccharometer is likely to register such a degree of fineness as this.

The 50 cc specific gravity bottle, when clean and dry, must have a counterpoise that exactly balances it. When the bottle is filled with distilled water at 60F, it should weigh exactly so grams. The counterpoise balancing the empty - bottle overcomes the necessity .of calculating its weight.

It is rare to find a 50 cc bottle that weighs exactly 50 grams when filled with distilled water at 60F. In such a case the actual weight must be found.

For example, suppose that the water in a reputed 50 cc bottle only weighs 49.954; we must compare the weight of the liquid whose gravity we require to determine with this figure instead of 50.

Thus, if a bottle full of the liquid weighs 50.975, we make the following calculation: If 49.954 weighs 50.975, what will 100 weigh ?

```
 49.954 : 100 :: 50.975
            50.975
             x 100
          ----------
49.954) 5097.5000 (102.043
          4995.4
          ----------
             102100
              99908
          ----------
               219200
               199816
          ----------
                193840
```

Thus, having found the gravity of 100 cc to — be 102.043, a liter (1000 cc) would weigh 1020.43.

As there are liquids lighter than water, such as spirit (just as there are solutions, such as sugar or wort, that are heavier than water), we must expect the gravities per liter of such liquids to be less than 1000 — how much less depends upon the amount of spirit, for example, contained in the liquid. Absolute alcohol weighs 793.8 grams per liter. Proof spirit weighs 919.84 grams per liter.

Proof spirit is defined by Act of Parliament as such that 1 volumes of it are equal in weight to 12 volumes of water at 51F, and as having a specific gravity of 919.84 at 60F. It must contain 49.24 per cent by weight, or 57.06 by volume, of absolute alcohol.

If 100 volumes of rectified spirit be mixed with 60 volumes of pure water, both at 60F, 156 volumes of proof spirit will result, a shrinkage of four volumes taking place.

The expression "under proof" = "UP" and "over proof" = "OP" can best be explained by examples: 25UP means that 100 volumes contain 75 volumes of proof spirit, while 25OP means that 100 volumes of this spirit, when mixed with sufficient water, will yield 125 volumes of proof spirit.

The foregoing definition is provided for the benefit of those having to comply with British law.

But what more does one want to know than the percentage of alcohol by volume? Here is something tangible and easily grasped, and moreover adopted by the majority of countries.

Alcohol is determined the world over by its gravity, and such gravity is expressed in terms of alcohol by weight or alcohol by volume. If one wants to know the relationship between alcohol by volume and proof spirit, the factor 1.7525 is employed, thus:

```
    4.62  per cent alcohol by volume
x 1.7525
--------
    2310
    924
  2310
 3234
 462
--------
8.096550  = proof spirit.
```

The alcohol tables provided by the excise authorities are substantially the same as those in general use to-day. Later tables, however, may be found in No. 7, Vol. xx., 1914, and March, 1915, Journal of the Institute of Brewing. By these tables all. percentages of alcohol and water are given side by side with their specific gravities; it only remains, therefore, to determine the gravity of a mixture of spirit and water with accuracy and refer to the table to discover the percentage of alcohol by a weight and also by volume.

In addition to solutions containing "alcohol", (lighter than water) and solutions containing sugar (heavier than water), the brewer has to consider , a solution containing both alcohol and sugar, viz., beer. How is one to determine the gravity of each when both are present?

It is oftentimes the case that alcohol and sugar are so evenly balanced that a liter of the solution weighs exactly 1000 grams — the same as water. The Green Chartreuse is a case in point, yet this liqueur contains 54.66 per cent of alcohol by volume and 22 per cent of sugar.

By weighing Green Chartreuse either by the liter or by floating a saccharometer and reading off the specific gravity at 1000 and then assuming it to be water, would obviously be fallacious.

In all liquids containing both sugar and alcohol the alcohol must be separated by distillation, and this is known as determining "original gravity" in the case of malt

liquors, wines, etc. In the case of spirits we speak of determining the percentage of spirits either by volume or weight or "proof." Sugar, if present, is spoken of as obscuration.

To determine the original gravity of beer, a flask of one liter capacity suffices for the purpose of a still. A well fitting rubber stopper, bored with one hole in which is fitted a bent glass tube, is the means of conveying the steam (when the flask is boiled) to the condenser. The end of the tube entering the condenser is also fitted with a rubber stopper. Corks are unreliable — apt to leak, and consequently cause error in the weight of a distillate.

One hundred cc of beer is accurately measured from a sample previously filtered to liberate gas. It is then poured into the liter flask and about 70 to 75 cc of water is added and the whole shaken. The tube is then connected to the flask and condenser, care being taken that leakage is impossible. The flask is then placed over a Bunsen flame and distillation is continued until 100 cc of distillate is collected. The 70 odd cc remaining in the distilling flask is called the residue. This residue is transferred to a 100 cc flask, and water containing the rinsings added until exactly 100 cc is collected. Note well that the volumes of both distillate and residue must be exactly 100 cc at 60F.

Care also must be taken before weighing that a proper mixing takes place in the several cases. A good practice is to take a clean, dry beaker of a little more than 100 cc capacity, and then pour the distillate out from the flask. Pour it back again until adequately blended. The same procedure Should be followed with the residue.

Now it will be clear that we have obtained 100 cc of solution free of sugar, and 100 cc of solution free of alcohol, each volume representing the sugar and alcohol contained in the beer taken, but separately, not collectively.

Now both may be weighed. The distillate will weigh less than water; the residue will weigh heavier than water.

These weights are obtained from the 50 cc specific gravity bottle and calculated to the liter. Thus

```
Distillate, 50 cc       weighs 49.62
Distillate, 100 cc      weighs 99.24
Distillate, 1000 cc    weighs 992.40
Residue, 50 cc          weighs 50.91
Residue, 100 cc        weighs 101.82
Residue, 1000 cc      weighs 1018.20
```

The difference between the weight of a distillate per liter and a liter of water, viz.,

1000, is called the "spirit indication."

The following table, furnished by the excise authorities, sets forth the specific gravity lost by fermentation, corresponding to spirit indication : —

Original Gravity Tables

Spirit Indication, with corresponding Deg. of Gravity lost in Wort by the "Distillation Process."

For use with Filtered Wort

Indication	.0	.1	.2	.8	.4	.5	.6	.7	.8	.9
0	.00	.42	.85	1.27	1.70	2.12	2.55	2.97	3.40	3.82
1	4.25	4.07	5.10	5.52	5.95	0.37	0.80	7.22	7.05	8.07
2	8.50	8.94	9.88	9.82	10.20	10.70	11.14	11.58	12.02	12.40
3	12.90	13.34	13.78	14.22	14.66	15.10	15.54	15.98	16.42	10.86
4	17.30	17.75	18.21	18.66	19.12	19.57	20.03	20.48	20.94	21.39
5	21.85	22.80	22.70	28.21	28.07	24.12	24.58	25.08	25.49	25.94
6	26.40	26.86	27.32	27.78	28.24	28.70	29.16	29.62	30.08	30.54
7	31.00	81.40	81.98	82.89	82.80	83.82	98.79	34.25	34.72	85.18
8	85.05	80.11	80.58	87.04	87.51	87.97	88.44	88.90	39.87	89.88
9	40.30	40.77	41.24	41.71	42.18	42.65	43.12	43.59	44.06	44.53
10	45.00	45.48	45.97	46.45	46.94	47.42	47.91	48.39	48.88	49.36
11	49.85	50.35	50.85	51.35	51.85	52.35	52.85	53.35	53.85	54.35
12	54.85	55.30	55.87	50.88	50.89	57.40	57.91	58.42	58.98	59.44
13	59.95	60.46	60.97	61.48	61.99	62.51	63.01	63.52	64.03	64.54
14	65.10	65.02	66.14	66.00	67.18	67.70	68.22	68.74	69.20	69.78
15	70.30	70.83	71.36	71.39	72.42	72.95	78.48	74.01	74.64	75.07
16	75.60									

If we set our figures down as follows all will be clear : —

Weight of water per liter	1000.0
Weight of distillate per liter	992.4
Difference is called "spirit indication"	7.6

According to the table, 7.6 is equivalent to 33.79 degrees; of gravity lost by fermentation.

To find the original gravity of a beer the degrees lost by fermentation are added to the degrees of the residue, thus:

Degrees fermented	33.79
Degrees unfermented	18.20

Original gravity 51.99 or, as expressed per liter, 1051.99, equal to 18.7 brewers pounds.

The following table shows the relationship between saccharometer pounds per barrel and specific gravity

Lbs/ Bri.	Specific Gravity	Lbs/ Bri.	Specific Gravity	Lbs/ Bri.	Specific Gravity	Lbs/ Bri.	Specific Gravity
0.2	1000.55	9.2	1025.55	18.2	1050.55	27.2	1075.55
0.4	1001.11	9.4	1026.11	18.4	1051.11	27.4	1076.11
0.6	1001.66	9.6	1026.66	18.6	1051.66	27.6	1076.66
0.8	1002.22	9.8	1027.22	18.8	1052.22	27.8	1077.22
1.0	1002.77	10.0	1027.77	19.0	1052.77	28.0	1077.77
1.2	1003.33	10.2	1028.33	19.2	1053.33	28.2	1078.33
1.4	1003.88	10.4	1028.88	19.4	1053.88	28.4	1078.88
1.6	1004.44	10.6	1029.44	19.6	1054.44	28.6	1079.44
1.8	1005.00	10.8	1030.00	19.8	1055.00	28.8	1080.00
2.0	1005.55	11.0	1030.55	20.0	1055.55	29.0	1080.55
2.2	1006.11	11.2	1031.11	20.2	1056.11	29.2	1081.11
2.4	1006.66	11.4	1031.66	20.4	1056.66	29.4	1081.66
2.6	1007.22	11.6	1032.22	20.6	1057.22	29.6	1082.22
2.8	1007.77	11.8	1032.77	20.8	1057.77	29.8	1082.77
3.0	1008.33	12.0	1033.83	21.0	1058.33	30.0	1083.33
3.2	1008.88	12.2	1033.88	21.2	1058.88	30.2	1088.88
3.4	1009.44	12.4	1034.44	21.4	1059.44	30.4	1084.44
3.6	1010.00	12.6	1035.00	21.6	1060.00	30.6	1085.00
3.8	1010.55	12.8	1035.55	21.8	1060.55	30.8	1085.55
3.0	1011.11	13.0	1036.11	22.0	1061.11	31.0	1086.11
4.2	1011.66	13.2	1036.66	22.2	1061.66	31.2	1086.66
4.4	1012.22	13.4	1037.22	22.4	1062.22	31.4	1087.22
4.6	1012.77	13.6	1037.77	22.6	1062.77	31.6	1087.77
4.8	1013.33	13.8	1038.38	22.8	1063.38	31.8	1088.33
5.0	1013.88	14.0	1088.88	23.0	1063.88	32.0	1088.88
5.2	1014.44	14.2	1039.44	23.2	1064.44	32.2	1089.44
5.4	1015.00	14.4	1040.00	23.4	1065.00	32.4	1090.00
5.6	1015.55	14.6	1040.55	23.6	1065.55	32.6	1090.55
5.8	1016.11	14.8	1041.11	23.8	1066.11	32.8	1091.11
6.0	1016.66	15.0	1041.66	24.0	1066.66	33.0	1091.66
6.2	1017.22	15.2	1042.22	24.2	1067.22	33.2	1092.22
6.4	1017.77	15.4	1042.77	24.4	1067.77	33.4	1092.77
6.0	1018.83	15.6	1043.33	24.6	1068.33	33.6	1093.33
6.8	1018.88	15.8	1043.88	24.8	1068.88	33.8	1093.88
7.0	1019.44	16.0	1044.44	25.0	1069.44	34.0	1094.44
7.2	1020.00	16.2	1045.00	25.2	1070.00	34.2	1095.00
7.4	1020.55	16.4	1045.55	25.4	1070.55	34.4	1095.55
7.6	1021.11	16.6	1046.11	25.6	1071.11	34.6	1095.11
7.8	1021.66	16.8	1046.66	25.8	1071.66	34.8	1096.66
8.0	1022.22	17.0	1047.22	26.0	1072.22	35.0	1097.22
8.2	1022.77	17.2	1047.77	26.2	1072.77	35.2	1097.77
8.4	1023.33	17.4	1048.33	26.4	1073.33	35.4	1098.33
8.6	1023.88	17.6	1048.88	26.6	1073.88	35.6	1098.88
8.8	1024.44	17.8	1049.44	26.8	1074.44	35.8	1099.44
9.0	1025.00	18.0	1050.00	27.0	1075.00	36.0	1100.00

The following original gravities of Australian Lager, Ale and Stout represent a fair average based on a great number of samples : —

LAGER. Apparent gravity 1014.

Degrees fermented	26.4
Degrees unfermented	19.7
Original gravity	1046.1
Alcohol by volume, per cent	4.52
Proof spirit, by volume	7.91

ALE.

Apparent gravity	1011.0
Degrees fermented	29.2
Degrees unfermented	14.9
Original gravity	1044.1
Alcohol by volume, per cent.	4.9
Proof spirit, by volume	8.57

STOUT.

Apparent gravity	1014.0
Degrees fermented	34.3
Degrees unfermented	22.0
Original gravity	56.3
Alcohol by volume, per cent	5.7
Proof spirit, by volume	9.97

The following table, showing the specific gravities of solutions of water and alcohol from 5.77 per cent. of alcohol by weight to water containing no alcohol (water = 1), will be useful.

To calculate the weight of water as 1000 obviously requires. the removal of the decimal point three places to the right. —

If further calculations are necessary, from absolute alcohol to plain water, the table generally ascribed to Gay Lussac, the great Chemist, should be consulted.

Gravity 60F	%ALC /WGT	%PROOF /MSRE	Gravity 60F	%ALC /WGT	%PROOF /MSRE	Gravity 60F	%ALC /WGT	%PROOF /MSRE
0.9900	5.77	12.01	0.9934	3.67	8.05	0.9968	1.73	3.81
0.9901	5.70	12.40	0.9935	3.61	7.92	0.9969	1.67	3.68
0.9902	5.64	12.33	0.9936	3.55	7.79	0.9970	1.61	3.54
0.9903	5.58	12.20	0.9937	3.49	7.66	0.9971	1.56	3.43
0.9904	5.51	12.05	0.9938	3.43	7.53	0.9972	1.51	3.32
0.9905	5.45	11.92	0.9939	3.37	7.40	0.9973	1.45	3.19
0.9906	5.39	11.79	0.9940	3.32	7.29	0.9974	1.40	3.08
0.9907	5.32	11.64	0.9941	3.26	7.16	0.9975	1.34	2.95
0.9908	5.26	11.51	0.9942	3.20	7.02	0.9976	1.29	2.84
0.9909	5.13	11.22	0.9943	3.14	6.89	0.9977	1.23	2.71
0.9910	5.12	11.38	0.9944	3.08	6.76	0.9978	1.18	2.60
0.9911	5.07	11.09	0.9945	3.02	6.63	0.9979	1.12	2.47
0.9912	5.01	10.96	0.9946	2.91	6.39	0.9980	1.07	2.36
0.9913	4.94	10.81	0.9947	2.85	6.26	0.9981	1.02	2.25
0.9914	4.88	10.68	0.9948	2.74	6.02	0.9982	0.96	2.12
0.9915	4.82	10.55	0.9949	2.70	6.18	0.9983	0.91	2.01
0.9916	4.76	10.42	0.9950	2.68	5.89	0.9984	0.85	1.87
0.9917	4.70	10.29	0.9951	2.62	5.76	0.9985	0.80	1.76
0.9918	4.64	10.16	0.9952	2.57	5.65	0.9986	0.74	1.68
0.9919	4.57	10.01	0.9953	2.51	5.52	0.9987	0.69	1.52
0.9920	4.51	9.88	0.9954	2.45	5.39	0.9988	0.64	1.41
0.9921	4.45	9.75	0.9955	2.39	5.25	0.9989	0.58	1.28
0.9922	4.39	9.62	0.9956	2.34	5.14	0.9990	0.53	1.17
0.9923	4.33	9.49	0.9957	2.28	5.01	0.9991	0.47	1.04
0.9924	4.27	9.36	0.9958	2.22	4.88	0.9992	0.42	0.93
0.9925	4.20	9.20	0.9959	2.17	4.77	0.9993	0.37	0.82
0.9926	4.14	9.07	0.9960	2.11	4.64	0.9994	0.32	0.71
0.9927	4.08	9.94	0.9061	2.07	0.52	0.9995	0.26	0.57
0.9928	4.02	8.81	0.9962	2.05	4.51	0.9996	0.21	0.46
0.9929	3.96	8.68	0.9963	1.99	4.38	0.9997	0.16	0.35
0.0930	3.90	8.55	0.9964	1.94	4.27	0.9998	0.11	0.24
0.9931	3.84	8.42	0.9965	1.89	4.16	0.9999	0.05	0.11
0.9932	3.78	8.29	0.9966	1.83	4.03	1.0000	0.00	0.00
0.9933	3.73	8.18	0.9967	1.78	3.92			

CHAPTER XVI. VOLUMETRIC DETERMINATION OF ACIDITY.

Norm — The Student is recommended to grasp the following reasoning very thoroughly, for herein is found a reliable basis from which all normal solutions may be prepared. As in so small a manual it is impossible to give all details, the student knowing nothing of chemistry should seek the advice of any master or student of the subject, who will readily explain the facts to him.

ET us reason out the relationship between sulfuric acid and the alkali, potassium hydrate, KHO.

The following equation expresses the change that follows upon adding potassium hydrate to sulfuric acid : —

$$H_2SO_4 + 2\ (KHO) = K_2SO_4 + 2(H_2O)$$

If we look at the atomic weights in the following manner, we find that 98 parts of sulfuric acid neutralize 112 parts of potassium hydrate: —

H_2 = 2	K = 39
S = 32	H = 1
O_4 = 64	O = 16
98	56 x 2 = 112

It is usual, however, to take one molecule of our alkali, = 56, and compare it with half the weight of sulfuric acid, viz., 49, the reason being that sulfuric acid, being diabasic, requires as a necessary consequence two molecules of a monobasic compound, whose base is a monad element — KHO, for example. To make all clear, it must be obvious that if it requires two molecules of KHO of a weight of 56 each to combine with 98 of sulfuric acid, one molecule of KHO of a weight of 56 will combine with 49 of sulfuric acid. —

The question that now arises is: How are we to prepare a solution of KHO of a composition strictly normal — that is to say, 56 grams per liter? It is not possible to obtain KHO in such a state of purity that by merely weighing 56 grams and diluting it to a liter, it could be called strictly normal. No; we have to consider something more accurate; and carry our reasoning a little further. There is no trouble in obtaining Iceland Spa, or crystallized calcium carbonate in a state of absolute purity, whose composition is strictly Ca C03. This compound is readily decomposed by hydrochloric acid, according to the equation —

$Ca\ CO_3 +_2(HCI) = Ca\ Cl_2 + H_20 + C0_2$

Or, to look at it another way, 100 parts of calcium carbonate equal 73 of hydrochloric acid —

Ca =	40	H =	1
C =	12	Cl =	35.5
O_3 =	48		====
	===		36.5 x 2 = 73
	100		

Suppose, then, we take 10 cc of a solution of hydrochloric acid of unknown strength and drop into it a carefully weighed crystal of — Iceland Spa, a loss in weight of the crystal must follow until the whole of the Hydrochloric acid has entered into combination with the calcium. As calcium chloride is soluble, the undissolved crystal can’ easily be be washed (free of Ca C12) in distilled water, and carefully dried. It is then reweighed, and the loss in weight is equivalent to the hydrochloric acid taken in the 10 cc of solution of unknown strength. (Note that the crystal should remain in the acid 24 hours.) An example will perhaps make all clear. A crystal of Iceland Spa, weighing 1.25 grams is placed in a beaker with 10 cc. hydrochloric acid solution for 24 hours. It is then taken out, washed and redried and reweighed. Its weight is now 0.63 — a loss of 0.62. The following .sum in simple proportion clearly shows the quantity of hydrochloric acid there was in the beaker: —

$CaCO_3$		$CaCO_3$		Hcl		HCl
100	:	0.62	::	73	:	0.4526

But a solution of hydrochloric acid, to be normal, should contain 0.365 HCl in 10 cc Thus

1000 cc = 36.5 HCl
100 cc = 3.65 HCl
10 cc = 0.365 HCl
1 cc = 0.0365 HCl

We have now to consider means of bringing our hydrochloric acid solution (of which we should have prepared at least half a liter before taking the 10 cc for the purpose of assaying its value) to such a strength that it becomes strictly normal.

We have shown that 10 cc of the solution contains 0.4526 HCl. A sum in simple proportion shows us how to dilute 'it to our requirements. If 0.365 HCl should be contained in 10 cc, then 0.4526 HCl should be contained in 12.4 cc Therefore, to every 10 cc of the HCl solution must be added 2.4 cc distilled water, the solution then being normal, as required.

We now have to make our alkali solution KHO to neutralize our HCl, volume for volume, according to the equation —

$$KHO + HCl = KCl + H_2O$$

That is to say, a liter of KHO must contain 56 grams of KHO. Any proportion of this solution used in estimating an acid can easily be calculated. If 1 liter contains 56 grams, obviously 1 cc must contain .056, Supposing that, in estimating the acidity of a sample, 2.3 cc of KHO would be employed, the equivalent would be 2.3 cc, H_2SO_4, and the quantity of H_2SO. in every cc would be 0.049.

Twenty-five cc of beer are placed in a porcelain dish and diluted to four or five times its bulk with distilled water. Then a few drops of phenol phthalein are added, which is colorless in the presence of acid, but in alkaline solutions turns bright crimson. Directly the sides of the liquid acquire the slightest pink color by titration with decinormal alkali solution, the acid is neutralized and the reading is taken from the burette. The acidity is calculated as acetic acid. The following equation expresses the reaction: —

$$KHO + CH_3\ COOH = CH_3\ COKO + H_2O$$

The molecular weight of KHO is 56, and that of CH_3COOH 60; therefore 56 parts by weight of the alkali equals 60 parts by weight of acetic acid.

Example : 25 cc of beer took 10.2 cc $\frac{N}{10}$ KHO therefore 100 cc of beer would take 40.8 cc T $\frac{N}{10}$ KHO.

One cc $\frac{N}{10}$ KHO = 0.006 acetic acid, therefore 40.8 cc KHO = 0.2448 acetic acid — that is to say, the percentage of acetic acid in the beer.

CHAPTER XVII. VINEGAR.

IN many country breweries in Australia, the strange sight of a number of casks in the back yard, with shives out and empty beer bottles turned upside down in the bung holes would attract attention. Upon inquiry, the stranger would be informed "that old beer was being converted to vinegar." How or why such an extraordinary arrangement should make vinegar would puzzle the wisest. It might make "sour" beer. There are several reasons, however, why it should not make vinegar — at any rate, vinegar containing the 4 per cent. of acetic acid required by law.

Again, molds and putrefactive bacteria of all sorts being abundant — especially in a brewery yard — would probably consume the acid as quickly as produced.

Will it be believed that a vinegar during acetification — if the plant is badly infected — can lose 50 per cent. of its acetic acid in about 48 hours — yet this is actually the case.

Vinegar "brewed" by the brewery yard method described .would certainly be regarded as infringing the law by any honest analyst, unless it contained 4 per cent. of acetic acid, which is most unlikely, and the wonder is the "process" has not been condemned ages ago. ,

In two cases at least casks have been turned out for inspection, and a more evil smelling concoction would be impossible to imagine. Decayed yeast — lumps of mold — "mother of vinegar" like jelly fish and so forth, together suggested a sort of "witch’s broth" most nauseating to the senses of smell and taste.

If any brewer desires to make vinegar — it is not difficult — but there are certain conditions that have to be complied with —

1. That as the law requires 4 per cent. of acetic acid, the beer for acetification must contain enough alcohol by weight to produce it. Although, according to the equation, 4 per cent. of alcohol should produce more than 4 per cent. of acid, there is always a loss in practice, as volatile ethers and aldehydes are also formed.

2. Beer must pass to the acetifier in a brilliant condition.

3. During acetification, a careful note must be taken respecting (a) loss of alcohol, (b) gain of acetic acid, (c) loss of acetic acid, if any.

Let us look at the equation and see how readily the exchange occurs between alcohol and acetic acid.

Alcohol – CH_3CH_2OH
Acetic Acid – CH_3COOH

It will be observed that the only difference between the two is that H, in the alcohol is replaced by O in the acid, and this exchange is effected by the agency of acetic bacteria.

Again, vinegar is easily decomposed, and its decomposition completes Nature’s cycle from carbon dioxide to carbon dioxide. Let us consider this statement. The carbon dioxide in the air may be decomposed by chlorophyl in green leaves to carbon and oxygen. In the case of grain plants - starch producing plants - the carbon is used to build up the starch granules.

Starch can be converted to sugar, maltose for example. Maltose can be converted to alcohol, as every brewer knows.

Alcohol can be converted to acetic acid according to the equation given. Acetic acid can be split up by a variety of micro-organisms, with carbon dioxide as a product.

Thus at the finish we are exactly where Ewe started; Nature's cycle is complete. Unfortunately for the vinegar brewer, it is too easy for him to complete Nature’s cycle, leaving him nothing but a little colored water for his trouble. Therefore he must learn how to prevent the completion of the cycle and so conserve the acetic acid after having obtained it.

Students should refer again to the chapter on acidity and the method of preparing normal potassium hydrate solution. It must be carefully noted that 56 parts by weight of the alkali will neutralize — 60 parts by weight of acetic acid, thus -

K	39		
H	1	CH_3	15
O	16	COOH	45
	56		60

In titrating the acid, phenol phthalein may be used for an indicator, and a measure of five cc of the vinegar suffices for the experiment.

The following table has been worked out to save trouble in calculation. Figures in the first column (0.1 cc for example) indicate the volume of the normal alkali

employed.

Figures in the second column (0.12, for example) indicate the amount of acetic acid per cent., it being understood when operating upon 5 cc of vinegar. —

cc.	Pct	cc.	Pct	cc.	Pct	cc.	Pct	cc.	Pct
0.1	0.12	1.0	1.20	2.0	2.40	3.0	3.00	4.0	4.80
0.2	0.24	1.1	1.32	2.1	2.52	3.1	3.72	4.1	4.92
0.3	0.80	1.2	1.44	2.2	2.04	3.2	3.84	4.2	5.04
0.4	0.48	1.3	1.50	2.3	2.70	3.3	3.90	4.3	5.10
0.5	0.00	1.4	1.08	2.4	2.88	3.4	4.08	4.4	5.28
0.6	0.72	1.5	1.80	2.5	3.00	3.5	4.20	4.5	5.40
0.7	0.84	1.0	1.92	2.0	3.12	3.0	4.32	4.0	5.52
0.8	0.90	1.7	2.04	2.7	3.24	3.7	4.44	4.7	5.04
0.9	1.08	1.8	2.10	2.8	3.30	3.8	4.50	4.8	5.70
		1.9	2.23	2.9	3.48	3.9	4.08	4.9	5.88

If the student will now take paper and pencil and draw as he reads, the acetifier, as it is called, and the method of acetifying will become clear.

Draw a Vat slightly tapered between bottom and t0p. The top has a manhole easily removable and as large as possible.

Draw a section of the above vat and about mid — way between top and bottom fill in a "stage" of strong but light lattice, supported by a post at the center and a fillet at its circumference.

Upon the "lattice" vine or willow chips are packed closely until the vat (the acetifier) is nearly full.

The lower half of the vat is void, except for the post supporting the lattice. Between the top of the vat and the top of the willow chips, space is left for a sparge to revolve.

At intervals of every few inches around the vat holes are bored about one inch in diameter, and at a level above the stage, but not ab0ve the highest level of the willow chips.

In the lower half of the vat a manhole must be provided, either in the side or the bottom; it must be large enough to admit a man and conveniently placed in order that perfect cleansing may be conducted without difficulty. (Note. the author has known cases where great loss has been incurred for the lack of this most necessary provision).

In the bottom of the vat is placed a tap which by hose may be connected to a gunmetal centrifugal pump. The said pump is to be placed conveniently for the purpose next following.

Above the vat is placed the receiver or reservoir (supplied by the pump mentioned), which is arranged to supply the sparge already mentioned in the vat. The capacity of the reservoir is to be the same as the void half of the acetifier. At any convenient place on the floor level a "pumping well" is provided. To the well is conducted either the fermented wort or the old beer, and from the well a hose leads to the pump.

Now our diagram is complete. We can therefore discuss operations.

The beer is pumped from the "well" by hose to the reservoir. The tap- in the pipe between the reservoir and the sparge is then turned on and sparging is to be conducted slowly. Thus the beer passes over the willow twigs in fine spray. The twigs are infected with pure cultures of acetic bacteria.

In time the whole of the beer will have run through the twigs into the void half of the acetifier. When this is accomplished the pump is connected to the tap below. the vat and the whole lot is returned to the reservoir.

Heat is generated as acetification progresses. Attention must be given to opening or closing the holes mentioned, and provided for the purpose of admitting oxygen. Experience only can dictate a rule for this.

At intervals of every few hours the acidity must be determined and the moment the acetification is complete the circulation of the vinegar must be stopped, or a loss of acid will surely follow.

After every "brewing" the manhole in the lower half of the vat must be opened and all slime- removed. All hoses must be cleaned and scalded, and the holes in the sparge arms must be cleared from the bacteria. If possible a strainer should _ be fixed in the reservoir to prevent the slime (always formed during acetification, commonly called mother of vinegar) entering the sparge arms and so blocking the holes. The vinegar should be at once filtered and sterilized and then run to casks or bottles.

It is a wise precaution to pasteurize bottled vinegar (as well as sterilizing in bulk), for of all liquids it seems to be. very susceptible to decomposition. Molds and "vinegar eels," as well as a whole host of bacteria, find acetic acid a suitable "food."

CHAPTER XVIII. THE PURE FOOD ACTS OF AUSTRALIA.

THE report of the Commonwealth and States of Australia Second Conference on Uniform Standards for Foods. and Drugs (Melbourne, 27th June, 1913), published at Sydney by the Government Printer, price 1/6, includes the recommendations of representatives of all the States, for uniform standards for Malt Ale, Malt Beer, and Non-excisable Fermented drinks. They are defined as follows : —

MALT ALE OR MALT BEER.

(1) Malt ale or malt beer containing not less than two per centum of proof spirit is ale or beer brewed from barley malt and hops exclusively.

(2) Ale, beer, porter, or stout containing not less than two per centum of proof spirit shall be produced by the alcoholic fermentation of a mash of malted and other grain and sugar with hops and other harmless vegetable bitters.

(3) Malt ale or malt beer, ale, beer, porter, and stout shall not contain strychnine, cocculus indicus, picric acid, lead, or other harmful substance.

Preservative.

(4) Malt ale or malt beer, ale, beer, porter, or stout shall not contain more than three grains per gallon of salicylic acid, or alternatively not more than two grains of free sulfur dioxide, or more than five grains of total sulfur dioxide per gallon.

NON-EXCISABLE FERMENTED DRINKS.

(1) Non-excisable fermented drinks shall be composed of potable water with vegetable extractives or infusions, and sugar, with or without the addition of harmless vegetable flavoring substances, citric or tartaric acid, and harmless coloring matters. They shall not contain more than two parts per centum of proof spirit.

(2) The addition of saccharin to non-excisable fermented drink, in proportion not exceeding two grains to the gallon, is hereby permitted.

It will be noted that arsenic is not mentioned. A strange oversight, if the foregoing recommendations have passed into law for the whole Commonwealth.

As far as can be ascertained, the laws passed by the several States are still operative. They are as follows : —

N.S.W. —

(1) Malt ale or malt beer containing not less than two per centum of proof spirit shall be ale or beer brewed from barley, malt, and hops exclusively;

(2) Ale, beer, porter, or stout containing not less than two per centum of proof spirit shall be produced by the alcoholic fermentation of a mash of malted and other grain and sugar, with hops or other harmless vegetable bitters;

(3) Malt ale or malt beer, ale, beer, porter, or stout shall not contain strychnine, cocculus indicus, picric acid, lead, or other harmful substance.

Preservative.

(4) Malt ale or malt beer, ale, beer, porter, or stout shall not contain more than three grains per gallon of salicylic acid or alternatively not more than two grains of free sulfur dioxide, or more than five grains of total sulfur dioxide per gallon.

Here, again, we find (in the N.S.W. regulations) no mention of arsenic.

QUEENSLAND. — Clause Nos. 1 and 2 are practically identical with N.S.W., but Clause 3 recites as follows: —

(3) Malt ale, malt beer, ale, porter, and beer, shall not contain strychnine, cocculus indicus, picric acid, lead or other harmful substance, nor more than one-hundredth of a grain of arsenic, calculated as arsenious oxide, nor more than two grains of free sulfur dioxide, or more than five grains of total sulfur dioxide per gallon.

Salicylic acid is not mentioned.

VICTORIA. — Beer shall not contain strychnine or cocculus indicus or picric acid, or lead, and shall not contain more than one hundred and fiftieth part of a grain of arsenic ($As_2 O_3$) per gallon, and not more than two grains per gallon of sulfurous acid, calculated as sulfur dioxide (SO_2). sulfurous acid or sulphites may be added to beer as a preservative substance in such proportion that the total content of preservative substance, calculated as sulfur dioxide (SO_2), shall not exceed eight grains per gallon. Salicylic acid is not mentioned, neither is there any reference to the qualities of beer as defined in Clauses 1 and 2 of N.S.W. SOUTH

AUSTRALIA. — The Central Board of Health, Adelaide, wrote (upon inquiry) as follows: , — "I have the honor to inform you that, so far as can be ascertained, the only legislation at present in force in this State is under the Commonwealth control, and no doubt those authorities in your State (Victoria) will furnish you with particulars."

WEST AUSTRALIA, 1914. —

(1) Malt ale or malt beer containing not less than two per centum of proof spirit is ale or beer brewed from barley, malt and hops exclusively;

(2) ale, beer, porter, or stout containing not less than two per centum of proof spirit shall be produced by the alcoholic fermentation of a mash of malted and other grain and sugar with hops and other harmless vegetable bitters;

(3) malt ale or malt beer, ale, beer, porter,_ and stout shall not contain strychnine, cocculus indicus, picric acid, lead or other harmful substance.

Preservative.

Malt ale or malt beer, ale, beer, porter, or stout shall not contain more than three grains per gallon of salicylic acid or alternatively not more than two grains free sulfur dioxide or more than five grains of total sulfur dioxide per gallon.

Arsenic is not mentioned.

TASMANIA. —

(1) Malt ale or malt beer, containing not less than 2 per cent. (two per centum) of proof spirits, shall be ale or beer brewed from barley, malt and hops exclusively.

(2) Ale, porter or beer, containing not less than two parts per centum of proof spirit; shall be produced by the alcoholic fermentation of. a mash oi malted and other grain and sugar with hops and other harmless vegetable bitters.

(3) Malt ale or malt beer, ale, porter and beer shall not contain strychnine, cocculus indicus, picric acid, lead, or other harmful substance, nor more than one hundredth of a grain of arsenic, calculated as arsenious oxide, nor more than two grains of free sulfur dioxide, or more than five grains of total sulfur dioxide per gallon.

Salicylic acid is not mentioned.

To summarize, we find1 arsenic mentioned by Tasmania, Queensland, and Victoria, and Western Australia, 1912, regulation -(one hundredth of a grain of. arsenic calculated as arsenious oxide), but not by the Commonwealth report, or N.S.W. or Western Australia, 1914. South Australia apparently follows the Commonwealth. Salicylic acid is allowed by Commonwealth Report to the amount of 3 grains per gallon (alternatively to SO_2). N.S.W. has the same regulation, and so has West Australia; it is not mentioned by Queensland, Victoria yor Tasmania. South Australia apparently follows the Commonwealth.

CHAPTER XIX. ARSENIC IN BEER.

WANKLYN'S RESTORED MARSH'S PROCESS.

THE method of arsenic determination prescribed by the late Professor Wanklyn should be of the greatest interest to the brewing fraternity, for they know (or should know) the grave risk they are running should traces of arsenic be found in their brewings. Before describing or criticizing Wanklyn's method, let us consider the essential difference between his and other methods.

By reference to the text books it will be found that the majority of arsenic experiments are based on calculations from 50 cc of the sample operated upon. Wanklyn, on the other hand, employs one liter.

It is obvious to anyone accustomed to dealing with minute traces of matter that the larger quantity (in reason) operated upon must bear results more reliable than the lesser. The essential requirements consist of a glass cylinder of a capacity of about two liters — such a cylinder as required for a battery, for example — and a bell jar capable of fitting the cylinder nicely, though not tightly, the said bell jar being stoppered at the top with a rubber cork. The bell jar, when placed in the cylinder, answers all the purposes of an ordinary gasometer. Care must be taken in choosing a light bell jar, for if too heavy, instead of rising easily in the cylinder, as the gas is generated, the gas may be forced outside the bell jar. An illustration will make this clear.- Supposing we place a liter of beer, water, etc., in the cylinder. Next we place the bell jar (with cork out) in the cylinder. We now drop zinc in the cylinder, through the cork hole of the bell jar, and now hydrochloric acid. The cork belonging to the bell jar is now placed in position tightly, a little clean water is poured around its side (that is, between the bell jar and the cylinder — exactly on the same principle as water around a coal gas gasometer) to prevent escape of gas.

Obviously the moment the zinc and hydrochloric acid come in contact, hydrogen is generated according to the equation —

$$Zn + (H\ Cl)_2 = Zn\ Cl_2 + 2(H)$$

The bell jar should rise easily in the cylinder as the pressure of gas increases; but if the bell jar be too heavy, the gas, instead of forcing it (the bell jar) up, finds its way underneath, and consequently outside, and is so lost.

Now, the whole point of Wanklyn's reasoning is this: If hydrogen be generated in a solution containing arsenic, arseniuretted hydrogen is produced, and this

anseniuretted hydrogen, if passed into solutions of mercury perchloride $HgCl_2$ or silver nitrate $AgNO_3$ causes a slight coloration if small, or a precipitate if large. The principles governing the determination of the exact amount are identical with the principles of his ammonia determinations — to be brief — by matching the colors obtained from the experiments with colors obtained by operating on known quantities.

Let us, then, reason out how we may prepare a solution whereby we may obtain a color test from a known quantity of arsenic for comparison with a color from a sample of beer containing an unknown quantity of arsenic. In parenthesis, it may be mentioned that the question of "mirrors" does not interest us, though, if mirrors should be wanted, they could be formed from the precipitates or colors by suitable means. colors or precipitates furnish all the facts required, as will be shown.

To resume, it is required to prepare an arsenical solution of known strength. Obviously it would be well, therefore, to make a solution that has reference to a fact required to be ascertained. What fact Could we take more suitable to our requirements than the quantity of arsenic limited by law? Western Australian law; recites: "Beer shall not contain more than one one-hundredth of a grain of arsenic ($As_2 O_3$) per gallon."

Now, a gallon contains 70,000 grains, therefore the arsenic allowed by Western Australia is one one-hundredth part in 70,000 parts.

As gallons and grains are quite out of the question so far as analytical methods are concerned, we must seek an equivalent in the metric system. Seventy cc contains 70,000 milligrams, therefore the quantity of arsenic allowed would be 0.00001 grams in 70 cc But as 70 cc is too small a quantity to operate upon according to Wanklyn’s method, we take 700 cc., and consequently this volume may contain 0.001 grams $As_2 O_3$ according to Western Australian law.

The foregoing is mentioned for the benefit of readers in those States setting the aforesaid standard; but as Victorian readers, with a different standard, must be considered, we will discuss an arsenical solution to compare with the limits imposed by the Victorian Act, viz., one one-hundred and fiftieth grain per gallon of $As_2 O_3$, that is to say, one one-hundred and fiftieth part in 70,000 parts.

The equivalent of the one-hundred and fiftieth part expressed in decimal fractions is 0.006.

That is to say, expressing the whole requirements of the law according to the decimal or metric system, 0.006 parts in 70,000 parts.

But, as before mentioned, 70,000 parts, or 70 cc, is too small to operate on. We take, therefore, 700 cc, or 700,000 parts, the equivalent in arsenic being 0.06 parts in 700,000 parts.

We make, then, a solution of As, 0,, containing 0.06 parts per cc — that is to say, 0.06 of a milligram per cc.

To make a liter of such a solution we require to multiply 0.06 milligrams by 1000 — that is, 66 milligrams, or 0.066 grams. We take, therefore, 0.066 grams of $As_2 O_3$.

Wanklyn in his original description recommends bicarbonate of soda to be added to standard arsenical solutions in the proportion of 7 grams of soda to 1.32 grams of $As_2 O_3$. According to this standard, we require 0.35 grams of soda to 0.066 grams of $As_2 O_3$.. The salts are to be dissolved separately and then mixed together and diluted to one liter.

If all is now clear, if one cc of this solution be taken and added to 700 cc of pure water, the water contains arsenic $As_2 O_3$ in the exact proportion of one, one hundred and fiftieth grain per gallon.

To quote Wanklyn "If this solution be operated upon in the apparatus — that is, if the hydrogen be generated in presence of the solution — the escaping hydrogen will carry off the arseniuretted hydrogen produced by the $As_2 O_3$ present." The gas led into a volume of solution of mercury perchloride will furnish a standard liquid for color comparisons.

We have now to consider the preparation of mercury perchloride solutions and means of arresting traces of sulfuretted hydrogen, which could lead us to false conclusions, and which is invariably present in small quantities in most fermented liquors.

We have also to consider the exact details necessary to perform the experiment properly. It should be noted carefully that some practice is necessary before one can be satisfied absolutely that the results obtained represent the facts.

The preparation of mercury perchloride solution, to which reference has been made, is accomplished as follows : —

Mercury perchloride $Hg Cl_2$, commonly known as corrosive sublimate, is soluble in the proportion of one part of the salt to sixteen parts of cold water. To prepare a liter of such a saturated solution, 62 grams of the salt should be taken in a beaker with about half a liter of distilled water, and warmed until the salt dissolves. It should then be transferred to a liter measure, the volume adjusted, cooled to 60F,

and readjusted.

Sulfuretted hydrogen is generally present in beer in minute traces, and if arseniuretted hydrogen be generated in the arsenic apparatus, both the sulfuretted hydrogen and the arseniuretted hydrogen escape together. sulfuretted hydrogen, however, combines with lead acetate; arseniuretted hydrogen does not.

If, therefore, filter paper soaked in a lead acetate solution and dried is packed closely in a suitable tube or separating funnel, and the mixed gases he passed through, the sulfuretted hydrogen is caught on the lead acetate paper and the arseniuretted hydrogen escapes.

Now that the various details have been described, we will recapitulate the details of the method and the general principles guiding us in the erection of the apparatus.

The bell jar, which must rise and fall in the cylinder easily, is fitted at the top with a closely fitting rubber cork. Through the cork is fitted a separating funnel provided with a tap, and the bulb is packed closely with the lead acetate papers. Above the bulb is fitted another rubber cork, and a glass tube passes through it. The tube is bent over (letter U upside down), and one end dips into a 50 cc cylinder filled with the saturated solution of mercury perchloride.

Now we will make an experiment. 700 cc of beer are placed in the gasometer, and 50 cc of hydrochloric acid are added and thoroughly mixed together. The bell jar (without its cork) is now placed in the gasometer. The zinc (2.9 grams free of arsenic) is next dropped in through the cork hole of the bell jar. Immediately the rubber cork fitted with the separating funnel is placed in V position, care being taken that the gas tap is turned off.

Next the gas delivery tube is fitted to the top of the separating funnel, and one end dips into the 50 cc cylinder of mercury perchloride. Next, about 250 cc clean water is poured around the outside of the bell jar, thus forcing any beer between the gasometer and bell jar into the bell jar. Hydrogen is slowly generated by the action of the hydrochloric acid on the zinc.

The gas tap in the separating funnel is now cautiously turned on,. and the gas is allowed to pass, bubble by bubble, through the lead acetate papers in the bulb, and then into the solution of mercury perchloride. After 18 hours or so a careful examination of the tip of the gas delivery tube will reveal corrosion, due to the action of arseniuretted hydrogen on the mercury perchloride.

The quantity of arsenic may be judged by comparing the gas tube with another

one belonging to an experiment in which the; quantity of added arsenic is known.

Wanklyn states that so small a proportion of arsenic as one milligram in one liter of beer would give a weighable precipitate. It must be remembered, however, that the allowance of arsenic according to Victorian law — viz., 0.06 parts in 700,000 — is equivalent to 0.085 parts per million, less than one-tenth the quantity mentioned by Wanklyn as giving the precipitate. We cannot, therefore, expect a weighable precipitate, but we can compare the corrosion on the tips of the gas delivery tubes with experiments in which the quantity of arsenic is known.

It must be perfectly obvious to anyone performing the experiment that minute care must be taken to make certain that neither the acid nor the zinc nor the water contains arsenic. With this end in view, distilled water should be taken with arsenic free zinc, and hydrochloric acid of an unknown quality. If arsenic appears from this combination it must obviously come from the acid. Equally, if water and acid be free of arsenic, and zinc of an unknown quality be employed, and arsenic appears in the experiment, it must obviously come from the zinc. Professor Wanklyn, it will be remembered, mentions that a solution of silver nitrate may he employed for receiving the gas tube just as satisfactorily as a solution of mercury perchloride. There is a chance, however, of corrosion due to hydrochloric acid in the gasometer vaporizing and coming in contact with silver nitrate, thus leading us to erroneous conclusions. There is no chance of this happening between hydrochloric acid and mercury perchloride.

> Note. — The student should also refer to an article on arsenic by G. E. Dowzard, F. C. S., Journal of the Chemical Society, 1901, No. 79, Part 2.

CHAPTER XX. TO DETERMINE SALICYLIC ACID IN BEER.

ANALYTICAL METHODS FOR THE DETERMINATION OF SUBSTANCES MENTIONED IN THE PURE FOOD ACTS OF AUSTRALIA.

IT will be remembered that Wanklyn in his water analysis recommends 70 cc to be taken, for the reason that 70 cc contains 70,000 milligrams, and a gallon 70,000 grains.

Thus proportionately every milligram found in 70 cc corresponds to grains per gallon.

To commence the experiment, 70 cc of beer are taken and evaporated in a porcelain basin to a syrup and allowed to cool. The syrup is then transferred to a flask of about 100 cc capacity, and then about 50 to 75 cc of sulfuric ether is added, and the whole thoroughly shaken up. The salicylic acid enters into solution with the ether. After a few moments the ether will become clear, the syrup having settled to the bottom of the flask.

The clear ether is now to be decanted into a beaker and allowed to evaporate. , Care must be taken not to evaporate over a flame; an outside window sill generally answers the purpose admirably. If salicylic acid be present it remains as a residue in the beaker. The residue is now dissolved in boiling water and transferred to a 50 cc Nessler tube standing on a white tile. A drop of ferric perchloride is added. when a violet coloration is instantly produced.

To find the amount of salicylic acid from the 70 cc of beer taken for the experiment, another Nessler tube is taken, filled with distilled water and a drop of ferric perchloride. A standard solution of salicylic acid is then added until the color corresponds to the color of the experiment.

The standard solution of salicylic acid is prepared by dissolving 0.5 grams in distilled water and diluted to 1 liter. Every cc therefore contains 0.0005 acid.

Thus —

```
1000 cc = 0.5
100 cc = 0.05
10 cc = 0.005
1 cc = 0.0005
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But as 1 cc equals 0.5 milligrams acid, it also equals 0.5 grains per gallon when

employed to match the color from the 70 cc beer. Thus, supposing 4 cc of the standard solution are required to match the color, the equivalent is 2 grains per gallon of salicylic acid in the beer.

TO DETERMINE LEAD AND COPPER IN BEER.

Standard solutions of lead and copper are first prepared as follows : —

Copper. — If a solution of copper sulphate be taken containing 0.395 Cu SO_4 + 5 H_2O in one liter, every cc corresponds to 0.1 milligram Cu.

Lead — Dissolve 0.1831 lead acetate and dilute to one liter. Every cc corresponds to 0.1 milligram Pb.

To determine lead or copper, 70 cc of beer are evaporated to dryness in a porcelain basin, and the residue ignited until a grey white ash alone remains. The ash is then moistened with a drop or two of HNO_3, and distilled water is added to about 40 cc AmHo is then added to excess, when the whole solution is filtered, boiled to expel excess AmHo, and the volume adjusted to so cc in a Nessler glass.

A glass rod dipped in S.Am_2, is then taken, and the contents of the tube are stirred with it. If lead or copper be present a slight brown tinge will be produced.

HCl is then added, when, if copper be present, the color will be enhanced; while, if lead be present, the color will be reduced.

In very delicate experiments more elaborate methods have been devised, but for the ordinary routine work of the brewery the method outlined suffices, for if there remains a doubt as to whether the coloration be due to Pb or Cu, it matters little, for in either case the sample would be condemned according to law.

The actual quantity of Pb or Cu present is determined by matching the colors with the standard solutions according to the same line of reasoning disclosed under "Salicylic Acid."

The reaction between iodine and very dilute sulfurous acid may be represented by the formula —

$$SO_2 + I_2 + 2H_2O = 2HI + H_2SO_4$$

The standard solution of decinormal iodine is prepared by taking 12.7 grams of resublimed iodine and 18 grams of potassium iodide and dissolving them without warming, and finally diluting to one liter.

The standard solution of decinormal sodium thiosulphate is prepared by taking 24.827 grams of the salt ($Na_2 S_2 O_3 + 5 H_2O$) and dissolving and diluting to one liter.

Equal volumes of the foregoing solutions, if strictly decinormal, should be quite colorless upon being mixed together.

It will be obvious that upon titrating a liquid such as beer with iodine solution, it would be impossible to know the end reaction without an indicator.

A solution of potato starch (about 3 grams per liter) answers well.

To perform the experiment, 70 cc of beer is mixed with a few drops of the starch solution, and is then titrated with the decinormal iodine. The instant the SO_2 in the sample is satisfied according to the equation, the blue iodide of starch appears. In the USA. methods for food analysis, it is pointed out that minute traces of sulfides affect the reaction just as do sulfites. Every cc of iodine employed equals .0032 SO_2, or 3.2 milligrams.

SALICYLIC ACID IN BEER.

Supposing, then, upon titrating 70 cc of beer, 0.5 cc iodine is required, we have the following : —

3.2
x 0.5
———————
1.60 = 1.6 grains per gallon SO_2

Note. — For the estimation of combined 80,. the student is recommended to consult Lawrence Bryant’s Text Book.

For the unusual substances (rather beyond the student’s capability) "Squires" Companion to the British Pharmacopoeia will prove helpful.