ON THE PRESENCE OF FUSEL OIL IN BEER.


[Read before the Royal Society of N.S.W., November 2, 1887.]

The beverages we know so well as fermented malt liquors are so complex in their composition and so liable to change and decay, that until the last few years very little was known of their exact nature and internal constitution, still everyone was supposed to know all along the difference between good and bad beer. From the time of Falstaff to the present day, the beer drinker has always been a trifle suspicious of his brewer, and ever ready to exclaim with that fat and valiant judge of good liquor—"You rogue, here's lime in this sack," and he generally experiences a most lively satisfaction in changing his "barley bree."

It would help us to clearer views on this subject if we consider what beer really is, or rather what it ought to be, and what are the chemical and biological processes involved in its manufacture. I may therefore at once define beer as an alcoholic beverage made from malt, hops, yeast and water.

As briefly as I can describe it, the process of brewing ordinary beer is as follows:—Malt is crushed between rollers and dissolved in, or extracted by water at a temperature which is more or less a secret with the individual brewer—generally from about 140 or 145° to 150° Fah., by this means an infusion of malt is made, the operation being known as that of mashing: the vessel in which it is produced being termed the mash tun, while the product is known as the wort. The water found most suitable for mashing is one containing very little or no organic matter and a somewhat large proportion of sulphate of lime, which makes what is called a hard water; for porter brewing, however a softer water is used. By using a hard water certain albuminous matters contained in the malt are prevented from coming into solution; that is, the albumenoids are rendered much less soluble.

The chief object of the brewer in mashing is to convert the starch present in the malt into a peculiar variety of sugar termed maltose: this change being effected by the presence of a body known as diastase. A very small amount of this diastase is sufficient to convert an unfermentable body like starch into maltose. One part will transform 10,000 parts of starch into maltose—a sugar which is directly fermentable.
The next step is to boil the wort in a separate vessel termed the copper, together with a certain quantity of hops. The object of adding the hops is to impart the well-known bitter flavour—to endow the beer with narcotic properties, and finally to act as a preservative agent and so enhance the keeping qualities of the beer.* After boiling, the worts are rapidly cooled down to a temperature, varying from 58° to 62° Fah., and run into the fermenting "rounds" or "squares." Yeast is now added—or in the language of the brewer—fermentation is said to be "pitched" at a temperature varying with the locality, and the practice and ideas of the brewer.

Fermentation proceeds rapidly attended by a rise in temperature; and here comes one of the most critical parts of the process of brewing. It is after the worts have arrived at the fermenting tuns that the brewer's skill and experience comes in. I do not mean that any amount of skill in regulating the fermentation will ever remedy carelessness in mashing, because, if the wort is not perfectly sound on its arrival at the fermenting tuns, a perfect fermentation cannot be obtained; but only that, be they ever so satisfactory at this point, negligence or unskilfulness will be then even more fatal than at any other previous stage. Here it is that with a climate like that of Sydney, ice or artificial cooling machinery becomes absolutely essential for the production of good beer. Experience has shown, that fermentation should never exceed 70° to 72° Fah. When this temperature is exceeded no amount of after treatment or doctoring of the beer will ever remove its own inherent bad quality.†

What goes on in the act of fermentation will be better understood if we regard the wort merely as a sugar solution with some other albuminous bodies that may be more conveniently considered hereafter.

Alcoholic fermentation is the outcome of the life of a minute plant—a very lowly organism called the yeast cell or Saccharomyces cerevisie. The sugar solution is its arena, and ethylic alcohol is one of the products of its own life-decomposition, just as much as urea is one of the life-products of a man. As plants possess the faculty of changing the carbon dioxide of the atmosphere into starch, sugar, alkaloids and other products, so this little cryptogam lives upon the maltose of the brewer's wort changing it into alcohol and other compounds.

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* Hops are to the high fermentation brewer what ice is to the brewer of lager bier.

ON THE PRESENCE OF FUSEL OIL IN BEER.

The illustrious Pasteur found that 100 parts of cane sugar, first converted into the fermentable variety of sugar, will yield:

<table>
<thead>
<tr>
<th>Alcohol</th>
<th>Yield</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ethyl alcohol</td>
<td>48·40%</td>
</tr>
<tr>
<td>Carbon dioxide</td>
<td>46·60%</td>
</tr>
<tr>
<td>Saccharin acid</td>
<td>67</td>
</tr>
<tr>
<td>Glycerine</td>
<td>3·30</td>
</tr>
<tr>
<td>Cellulose fat &amp;c.</td>
<td>1·20</td>
</tr>
</tbody>
</table>

Now it is just at this critical stage of fermentation that other higher alcohols may be produced. Pasteur, Schützenberger, and Berthelot all recognize the fact of the simultaneous evolution of the higher alcohols under varying, or under abnormal conditions. Schützenberger says* :—"We may ask whether these secondary products, [i.e., fusel oil] which are relatively not very abundant, owe their origin to alcoholic fermentation properly so called, or to distinct concomitant fermentation having each a special ferment; or whether, in fact, it is better to attribute their appearance to special principles accompanying glucose in the natural saccharine juices. The actual state of science does not allow us as yet to answer these questions definitely."

Pasteur† mentions the production of butyl alcohol in irregular fermentation and its non-appearance in carefully conducted fermentation.

Before proceeding further it will be well to see what is the actual composition of properly brewed genuine beer, so far as it has been investigated by modern chemical research:

<table>
<thead>
<tr>
<th>Component</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dextrin</td>
<td>2 to 5</td>
</tr>
<tr>
<td>Albumenoids</td>
<td>2·2 to 3·4</td>
</tr>
<tr>
<td>Maltose</td>
<td>1 to 3</td>
</tr>
<tr>
<td>Lactic acid</td>
<td>0·02 to 0·05</td>
</tr>
<tr>
<td>Succinic acid</td>
<td>0·04 to 1</td>
</tr>
<tr>
<td>Glycerine</td>
<td>2·2 to 2·5</td>
</tr>
<tr>
<td>Colouring matter</td>
<td>1 to 1·2</td>
</tr>
<tr>
<td>Hop extract</td>
<td></td>
</tr>
<tr>
<td>Ash (mineral matter)</td>
<td>2 to 2·7</td>
</tr>
<tr>
<td>Total Extract</td>
<td>5 to 8</td>
</tr>
</tbody>
</table>

Alcohol (by weight) | 3·3 to 7
[Alcohol equivalent in Proof Spirit] | 7·4 to 15·1
Acetic acid        | 0·02 to 0·04
Carbonic acid      | 0·22 to 0·25

The origin of the enquiry which forms the subject-title of this paper, arose during the ordinary routine work in the Government laboratory. For several years, the examination of beers was somewhat a rare occurrence, but in the year 1881 a Mr. Waters from Melbourne created no small excitement by stating that the beers made in Sydney contained vitriol, aloe, bluestone and infusion of tobacco juice. The result of this alarming statement induced Mr. Barney, Chief Inspector of Distilleries to send a number of spirituous liquors to my predecessor—Mr. Charles Watt—for analysis. It appears from the enquiry then made that the chief interest centered in the quality of the rum, whisky, and brandy, however later on, in the following year some eleven samples of Sydney beer were examined.

During the four years from 1882 to the end of 1886 a very large number of samples were examined in the Government laboratory. The general results showed that the statement of Mr. Waters were without foundation. The methods of analysis usually included the estimation of the percentage of alcohol, ash and extract together with some statement to the effect that none of the articles mentioned in the Licensing Act had been found. In fine, the worst that could be said of the beers was that sometimes traces of lead or copper were found.

Early in the present year the question of artificial bitters and hop substitutes engaged the attention of analysts in England, amongst whom my friends Dr. Muter and Mr. Otto Helner were much interested in the subject. At the same time statements were frequently heard in Sydney to the effect that the brewers were in the habit of putting poisonous bitters into the beers instead of hops, and inasmuch as the police were constantly sending samples of beers and spirits for analysis, I wished to seek further satisfaction in the matter by carrying out a fuller and more extended investigation as to the nature of the bitter principle used in the manufacture of the local beer, with this object in view I requested that larger samples should be submitted for analysis.

These were all specially examined for strychnine, picric acid, cocculus indicus, and tobacco, as well as for quassia, gentian, chiretta, &c. In the case of all the brewers, it should be said to their credit that no poisonous bitter of any kind could be discovered not even after a most laborious and lengthy research.

During the course of analysis it was observed that the proportion of dextrin was unusually large, while the amount of maltose and albumenoids were extremely small. This might of course be attributed to great attenuation in the process of fermentation. In the course of mashing with malt, the proportion of dextrin to maltose goes on in very nearly a fixed ratio up to 140° Fah., when the maltose diminishes rapidly and the dextrin increases very
considerably. Therefore are we to account for the dextrin by high mashing heats? or would it not more likely be owing to the fact that large quantities of sugar are used in the brewing process? If this be so, why does the brewer use sugar, and if so what kind of sugar?

The object of the brewer in using sugar may be considered under two heads; firstly, his object is to reduce the proportion of the albumenoid matter in the wort; and secondly, to effect a saving in the price of malt, in other words, to use as little malt as possible, because barley is not grown here and has therefore to be imported; while sugar grows well as every body knows.

In the ordinary brewing process the reduction of albumenoids is mainly effected by the boiling of the wort after mashing; but it is also further considerably effected by the tannin of the hops, and by the employment of natural or else artificial waters, containing suitable saline bodies principally sulphate of lime, which renders some of the albumenoids insoluble.

Notwithstanding these various methods of reducing the albumenoids it is generally found by most brewers that a further reduction is necessary beyond what is attainable by these means. Now the addition of sugar effects this by the simple process of diluting the albumenous wort with a substance which is non-albumenous, but yet fermentable. These albumenous bodies, from a sanitary or dietetic point of view would prove of advantage to the beer consumer, inasmuch as these are flesh and tissue formers, being in fact the proteid matter from the grain. The reason why stout would be given to the invalid or the convalescent would be precisely on account of these albumenoids, which are studiously eliminated in the manufacture of Sydney beer. From the brewer’s point of view, he would say they were decidedly objectionable, since they would prove food for the yeasts cell, and for false or adventitious ferments. And still these albumenoids are essential for the healthy growth of the yeast, so that it is important that the brewer has a sufficient quantity in his worts for the yeast to live upon, as otherwise the S. cerevisiae would starve and die. The main object of the brewer is to conduct his fermentation without the introduction of the false ferments so-called—the lactic, acetic, and butyric ferments. A beer so made and afterwards kept from their contamination, would keep sound for an indefinite length of time.

Now, as to the why and wherefore of the use of sugar. The beer betrays its origin by its taste, albeit the demand may be for sweet ales, or sweet ‘running ales’ as they are sometimes termed. the sweetness may not be due to cane sugar: certainly not, since the sugar has undergone a change. If sugar crystals are used in brewing Sydney beer, and there is internal evidence from the beer
itself that such is the case, the brewer must first convert them into a fermentable variety of sugar; the sugar must be inverted as it is more correctly termed. Cane sugar of itself is unfermentable. This inversion may be effected in four different ways:

1. By malt extract in mashing at not too high a temperature.
2. By prolonged boiling with water.
3. By treatment with yeast and water.
4. By the action of sulphuric acid and after treatment with chalk.

The brewer is confronted with the question as to what sugar may be used, raw or refined crystals? If the former, other organisms besides the *S. cerevisiae* would inevitably be introduced: this would be followed by a high and uncontrollable fermentation: with refined crystals the sugar we have seen, has to be inverted. Another question then arose, were these beers brewed at an abnormally high temperature? Remembering that an eminent authority on brewing, Dr. Charles Graham, had found that a high temperature in fermentation means not only a rapid attenuation of the wort, but an increased loss of alcohol by evaporation, together with an increase in the higher alcohols—the fusel oils; reasoning upon this hypothesis the presence of fusel oil would therefore indicate to some extent the mode of manufacture of the beer. The question then resolved itself into this—does this beer contain fusel oil? Some difficulty then arose as to the process for finding out whether higher alcohols existed in beer. The methods in use which were applicable to liquids, such as brandy and whisky, failed when applied to beer. The method of fractional distillation was tried: the distillates from two litres of beer were placed in a flask fitted with a modified Hempel's column and the fractions collected separately, a current of steam being used to remove the last traces. As the boiling points of the different alcohols were not sufficiently marked from each other, the idea presented itself of converting the alcohols into their respective iodides, since the boiling points would be sufficiently removed from each other to enable a more complete separation to be effected.

However, these methods were afterwards abandoned, since it might be said that these higher alcohols might be generated in the act of distillation, an objection that I do not think carries much weight, as the alcohols are products of fermentation and are not likely to suffer changes in distillation. However, these methods were set aside for a process that would remove the higher alcohols from the beer itself, without distillation. The process I finally adopted—a modification of my own of Marquardt's—was based upon the fact that amylic alcohol is soluble in chloroform. I operated on a gallon of the beer in the following manner:

Some of the beer to be tested is placed in a capacious separator,
together with 50 cb. c. of chloroform; after repeated shaking, the liquid is allowed to subside, and the beer poured off without disturbing the chloroform. More beer is added until half the gallon has been so treated, when a further 50 cb. c. of chloroform is added together with more of the beer until about 5 pints have been used; a third 50 cb. c. is taken, making altogether 150 cb. c. of chloroform with which the remainder of the beer is thoroughly agitated. By this time the whole of the fusel oil will have been extracted. The next step is to wash the chloroform with water to remove traces of valerol derivable from the hops, and also to remove ethylic alcohol that may have been taken up into solution. The solution is then placed in a strong glass vessel with 5 grams of potassium di-chromate and 2 grams of concentrated sulphuric acid and oxidised under pressure for six hours at a temperature of 85° C. The oxidation having been completed, the liquid is now distilled, water added to the residue and the distillation continued. The distillate, which has a strong odour of valerianic acid is boiled for half an hour with some pure barium carbonate in a flask connected with an inverted Liebig condenser. After this the chloroform is removed by distillation and the residue filtered. The filtrate is then evaporated to dryness in a platinum dish, weighed and dissolved in water with a few drops of nitric acid. The solution is divided into two equal parts. In one the barium is estimated: in the other the amount of barium chloride. The weight of the latter is deducted from the residue. The total amount of barium salt, minus that existing as chloride, gives the amount of barium as barium valerianate and from which the amount of amylic alcohol is readily found.

The chloroform and the rectified spirit used throughout this research was carefully tested by blank experiments for the presence of the higher alcohols. Care was taken that only pure chloroform was used.

Another method for the estimation of minute quantities of amylic alcohol, and indeed for all the higher alcohols is that of Traube,* who employs a method based on the fact that butylic and amylic alcohols depress the capillarimetric column in a small tube. This process has in my hands been found more suitable for brandies and white spirits than for beer.

During the first experiments in working out this process, a somewhat unlooked for result was obtained; one giving positive indications that genuine hops had been used in the brewing of all the samples of Sydney beer; thus corroborating the results I obtained by the methods of Dupré and Allen used in my search for spurious bitters and hop-substitutes.

Hops contain about $7\frac{1}{2}$ parts in a thousand of an essential oil. This oil consists of a terpene isomeric with turpentine oil ($C_{10}H_{16}$) and a stearoptene termed valerol ($C_6H_{10}O_7$); the first, being a very volatile ethereal body, is entirely dissipated during the process of brewing and gives that pleasant aromatic odour often noticed in the brewery; the second consists of a mixture of the stearoptene valerol and resin. The valerol is easily oxidised by ordinary atmospheric oxidation into valeric acid, which may sometimes be observed in the peculiar cheesy smell of old hops.

Valerol being soluble in ether and in ethylic alcohol would therefore be found in the crude chloroform extract; hence the necessity for a prolonged washing with water to remove both the valerol as well as the ethylic alcohol before proceeding further with the process. If the impure and unwashed chloroform residue be oxidised the valerol would become oxidised into valeric acid along with the amyllic alcohol. The presence of the hop oil of the hops may therefore be recognised if the chloroform residue be divided into two parts: one of which is thoroughly washed and oxidised by chromate. If oxidation yields valeric acid in the one case and none in the other, then it follows and, I think proves conclusively that hops have been used in brewing the beer.

The process, therefore has a double value and significance; namely, in determining first, whether the beer has been really flavoured with hops, and secondly if the higher alcohols are present.

To remove all doubt as to whether the fusel oil really existed in beer, I took two litres of beer and removed the whole of the ethylic alcohol by slow and careful evaporation; the liquid was made alkaline by sodium hydroxide treated with ether in a separator and the valerol thus removed. Acetic acid was then added to neutralise the soda and the chloroform process, as before described and carried out. The result was that barium valerianate was produced as before. This was dissolved in water with a few drops of nitric acid, the barium estimated as sulphate and the amount of fusel oil found and expressed in terms of amyllic alcohol.

Four and a-half litres of beer (=1 gallon) gave 530 grain of barium sulphate, equal to 4 grain of amyllic alcohol per gallon.

One gallon of another sample gave on analysis 324 grain of barium sulphate, equal to 245 grain of amyllic alcohol per gallon.

In another instance, one gallon of a beer gave 1.18 grain of barium sulphate equal to .89 grain of amyllic alcohol per gallon, this being the largest proportion found. The amount therefore of fusel oil ranged from $\frac{1}{4}$ grain to nearly 1 grain [2.45 to .89] per gallon.

Molecular weight of $C_6H_{11}HO = 88$

ditto $C_6H_9O_2 \Pi = 102$
ON THE PRESENCE OF FUSEL OIL IN BEER. 241

Molecular weight of \((C_3 H_9 O_2)^2 \cdot Ba + 2 OH_2 = 375\)

1 part of ditto = \(3.41 \cdot C_3 H_{11} \cdot HO\)

1 part of \(Ba SO_4 = 753 \cdot C_3 H_{13} \cdot HO\)

In the case of Marquardt's process for brandies and whiskies:

1 part of \((C_3 H_9 O_2)^3 \cdot Ba\) contains \(4513 \cdot Ba \cdot O\)

Whereas

1 part of \((C_2 H_5 O)_2 \cdot Ba\) contains \(674 \cdot Ba \cdot O\)

Fusel oil or fousel oil, Fr. *Huile de pommes de terre*, Ger. *fuselol*
derived from the Greek *phuo*, I produce, alluding to its production or generation in and during the act of distillation and not merely to its evaporation or mere separation from a liquid in which it is already present. I may say that I have very strong grounds for saying that this is not so, and that fusel oil is not a mere creature of the distilling process; but that it existed in the wash before distillation took place. However that may be, I will give a short description of what fusel oil is and would refer my hearers to the many published accounts of this liquid.

The compound known as fusel oil is a complex oily liquid possessing a powerful sickly odour, producing nausea, coughing, irritation and headache when inhaled, and having a biting fiery taste. It occurs in the residues, the faints, of the distillation or rectification of all kinds of spirit, such as cane spirit, brandy, potato, rye, maize, and other grain spirit, from the marc of grapes and from the fermentation of sugar and glucose.

I desire it to be stated that I am not the first discoverer of fusel oil in beer, and that a paper appeared in the Comptes Rendus 96 [19] 1368—1370 by J. A. Le Bel, who shows that amylic alcohol is a product of the fermentation of beer. It has also been shown in Germany that when impure saccharum was used in brewing, that fusel oil was developed. In the Rep. Anal. Chem. 5, 188, a case is cited where a brewer was fined for allowing fusel oil to appear in his beer, and where it is stated that the fusel oil “may under certain circumstances prove injurious to health.”

**Toxic action of fusel oil.**

The administration of a quantity estimated at not more than \(\frac{1}{3}\) grain kills frogs. One minim sufficed to kill three blow flies. One minim killed a minnow. Two minims was found fatal to guinea pigs. Sixty grains of fusel oil was given to a dog. The effect was instantaneous, producing muscular paralysis of the hinder legs with drunkenness, giddiness and stupor. In a few minutes the animal was quite unable to stand on its legs and rolled about on

* Faints contain over 60 per cent. amylic alcohol.
† Named amylic alcohol by Cahours, from amylum starch.
DISCUSSION.

In ten minutes the muscular tremors came on recurring with perfect regularity. In twenty minutes there was foaming at the mouth. In thirty minutes the muscular tremors came on in paroxysms, especially at each inspiration of the lungs, amounting to what Dr. Ashburton Thompson better described as a spasm. The tremors continued for some time. In three hours the dog was in a state of coma, the twitching going on all the while regularly. At this stage violent headache and nausea was experienced by myself and two other observers. The dog was seized with a most violent fit of vomiting about five hours after, and partially recovered in 24 hours from the time of administration.

In conclusion, these results may be summarised as follows:

1. That traces of certain other alcohols besides ordinary ethyl alcohol exist in most of the beers brewed in Sydney.
2. That these may be derived either from the temperature at which the fermentation is allowed to take place; or from the excessive use of saccharum, glucose, or sugar crystals, or from both.
3. That the presence of even traces of fusel oil is quite undesirable and most probably injurious to health, since it is known that small quantities of fusel oil act as a poison on the animal system.

Mr. W. A. Dixon F.C.S., said that it seemed to him that too much attention had of late been given to minute analysis of foods. Since Mr. Hamlet's first report had been published he had given a good deal of attention to this matter and had himself carried out some experiments. From these, as far as he had gone, he concluded that the glycerine formed during fermentation was extracted by the chloroform, and in the process used by Mr. Hamlet this was oxidised to formic acid and determined as valerianic acid and hence as amylic alcohol. Mr. Hamlet appeared to have only examined beers manufactured in Sydney. He (Mr. Dixon) had examined beer brewed at home and found as much amylic alcohol as in any beer brewed here. It seemed to him that amylic alcohol was always produced more or less in fermentation; and that its production was not well understood. It is only known that it is produced in largest quantity from roots, next from raw grain, and generally when the yeast was in bad condition, and the temperature high. He did not think the temperature of fermentation here was carried much higher than at home, not much beyond 76° or 78° F. at the outside. If much amylic alcohol was produced the beer would be very distasteful. What was essential at one time was not so at another, thus at one time beer was brewed without hops at all; in the reign of Queen Elizabeth very stringent regulations were laid down.
against the use of hops in beer, but the use of hops has so grown that the use of beer without is now almost unknown. Beer was a complex liquid containing various ingredients which made it palatable, some of them affected the sense of taste and others the sense of smell, these were called sapors and odours and together flavor. The bitter of hops and the salt affected the taste, some people liked more of the latter some less, but the quantity present could scarcely produce thirst. The ingredients which affected the organs of smell were, the oil of hops and the small quantities of those higher alcohols which were present, and if these were left out the beer would be undrinkable. What Mr. Hamlet had said with regard to the water here being particularly soft, and therefore taking up a large quantity of albuminous matter, was perfectly correct, and the brewer got rid of that difficulty by the use of sugar, as otherwise the beer would never be bright. The waters used in the brewing of some of the English beers contained besides the sulphate of calcium mentioned, sulphate of potassium, and both these were absent in Sydney waters. British beers contained from 200 to 300 grains of inorganic matter per gallon, which was more than in Sydney beer. With regard to the intoxicating effects of amyllic alcohol, he did not think much dependence would be placed upon experiments made on animals. The effect of experiments made on different men might be very different, and the difference might be still greater between experiments made upon a man and a dog. For example, give a glass of rum to a blackfellow and he would be hopelessly drunk, but on most white men it would have no effect one way or the other. Various people had given different accounts of the effects of amyllic alcohol; some said that it was fifteen times as intoxicating as ordinary alcohol; others said three grains produced decided effects. He knew of a case in which a man took a jar of fusel oil, thinking it was brandy and took a mouthful of it: it made him drunk but he soon got over it. Even if beer contained one grain of fusel oil per gallon, he did not think that was sufficient to condemn it, but he had not found nearly as much. As a chemist he thought that too much importance was often attached to minute chemical analysis and in a general way he considered that what would pass his sense of taste and smell was good enough.

The Rev. S. Wilkinson said he had been enabled to make some observations of the evil effects of fusel oil. There was one part of this colony in which wine was very extensively produced and to his certain knowledge considerable quantities of very coarse sugar was used in fermentation in order to produce the wine; that he knew to be a fact, and it was a certainty from that fact that a considerable quantity of fusel oil is generated by fermentation to produce the wine he alluded to. But what was the result of it?
DISCUSSION.

He had been talking to a very trustworthy man in the Police of that district, who had large experience of the men who had got drunk upon that wine, and his answer was, “Sir, they are not drunk, they are mad.” He observed the difference between the men who got drunk on spirits and those who got drunk on the wine produced largely by the use of sugar, and these latter became perfectly mad with it. He was fully persuaded in his own mind, that the larger the quantity of fusel oil found in beer or elsewhere the more deleterious were the effects, and therefore he thought that the results arrived at by our Government Analyst after skilful examination were most important, and shewed that this oil was to be avoided by every possible means. He had not drunk any beer for a quarter of a century, but had observed the effects upon others. He was very pleased that Mr. Hamlet had not discovered any of those deleterious ingredients that are put in some of the beers in other countries, such as grains of paradise, cocculus indicus, copperas and other baneful metallic substances.

Mr. Smith said the point seemed to have been lost sight of as to the amount of amylic alcohol necessary to produce any toxic effects. The authorities of the present day give 3 of a grain as the quantity required to produce toxic effects on the human system. Mr. Hamlet had shewn that colonial beer contained on an average .05 grains to the gallon: therefore to get enough amylic alcohol to produce any poisonous symptoms a man must drink six gallons before it would produce any effect. It had been suggested that it might remain in the system over a period of time and eventually the amylic alcohol produced toxic effects upon the system. Delirium tremens had been attributed to fusel oil, but was in no way caused by it. Mr. Dixon had spoken about the analysis of foods; and had rather cried down the analysing of food substances. With all due deference to Mr. Dixon he thought the paper read that night proved that there was a use in analysing food substances. Again, Mr. Dixon had made the remark that anything which would pass his nose and palate he thought good enough to take. He (Mr. Smith) while in England studying chemistry, on one occasion had been appointed to go over one of the works where potted meats were largely manufactured. The course of inquiry was with reference to poisonous salts found in the meat, and this necessitated going through the whole process, and during the examination of the manufactory he certainly saw some things which had entirely prevented him for some years past from eating potted meats. The filthy way in which the meats were prepared would prevent many of the members here present from eating them again; it was only by analysis that we could find out and put a stop to unhealthy products being put on the market. Again from a medical point of view, there were many diseases which could not be found out
either by nose or palate; there are various species of tape worm that cannot be found out by chemistry, but they can by microscopical examination.

Mr. W. A. Dixon wished to refer to the incident mentioned by Mr. Wilkinson where men had been reported to be mad by the policemen as the result of drinking certain wine. He (Mr. Dixon) wished to point out that the effect of fusel oil in those cases in which it had been administered had been to produce coma and not madness. A man would be reported dead drunk but would not be reported mad by the average policeman if the effect were due to fusel oil. As for potted meats they never passed his palate.

The Chairman said he was perfectly aware that many ingredients were put in foods although with no intent to cause injury; he was very glad to find that the samples of beer examined by Mr. Hamlet did not contain those injurious things which had been alleged. He certainly thought from what he knew of the brewers here, they would not put in deleterious things; he felt assured that it was not the brewers but the people through whose hands it passed afterwards who adulterated the beer. Chemical analysis was very valuable, and Mr. Hamlet's investigations proved that fusel oil was there, although not in large quantities; but can it be produced without fusel oil? (Mr. Hamlet:—Yes, it can). He was very pleased, and had been instructed by what he had heard that night and wished that more of their members would come forward with papers. Before sitting down he would mention a fact that just occurred to his mind through reference to hops, and it was this:—that nearly all plants twine from right to left, but the hop is an exception; it twines the reverse way and it was the only plant he knew that did so. He would tender on behalf of the Society a cordial vote of thanks to Mr. Hamlet for his paper.

Mr. Hamlet in acknowledging the vote of thanks, said that he considered that any one who had an interest in the State as a citizen, should do all he could to investigate such matters rightly. He did not bring forward his paper to "rob a poor man of his beer," as the popular saying goes, but he simply stated what he found to be the fact—that fusel oil was contained in beer. He concurred very much in what Mr. Dixon had stated about the residues in British beers being higher than that in Sydney beer. He did not think that adding salt had any great deleterious effect nor did he think the amount of common salt that Mr. Dixon referred to, had any great effect, having regard to the fact that most people took a considerable quantity of salt in twenty-four hours. It had been remarked that a man must take a large quantity of beer before the fusel oil takes any effect. That might be so, but it was no so much that, as the cumulative effect of amyllic alcohol. If he were going to be dosed with minute doses.
for six months it would accumulate in his system much in the same way as small doses of lead. If you took small doses of lead it would not produce any immediate effect; but not being eliminated it would be stored up in the body and by and bye produce very alarming results, and it was quite possible that the toxic action of fusel oil would act much in the same way. The men about the streets were not to be compared with the ordinary drinker who takes an occasional glass; those poor creatures that we saw standing about the corners of the streets were imbibing it all day. They are members of the State, and we had, it was to be hoped, some degree of interest in mankind so as to enable them to get as pure an article as possible. Mr. Dixon had suggested that he should have tried experiments on men and not on animals; that had been a great difficulty with him. He should like very much to have experimented on human subjects, and he had hinted as much, but of course it was an impossibility. He only knew from these effects upon himself, that it was a very irritating disagreeable noxious liquid. With regard to the incident mentioned by Mr. Dixon of the man who took a gulp of fusel oil, he could only think it must have been largely diluted. The latest authorities on the subject, considered that 1/60th to 1/15th of a grain produced intoxicating results. The effect on animals was very distressing to see.

In reply to a question of Dr. Leibius, Mr. Hamlet said there were no recorded experiments of the cumulative effects of fusel oil, but it was inferred from the innate properties of fusel oil that it was so. Of course, he did not compare it with lead, but merely mentioned lead by way of illustration, and it would not be fair to compare it with lead.

WEDNESDAY, NOVEMBER 2, 1887.

CHARLES MOORE, F.L.S., &c., Vice-President in the Chair.

The minutes of the last meeting were read and confirmed.

The certificate of one new candidate was read for the third time, and of two for the first time.

The ballot for the election of the candidate whose certificate had been read for the third time, was postponed to the next General Meeting in consequence of a quorum not being present.

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