

ONE YEAST OR TWO? PURE YEAST AND TOP FERMENTATION

RAY ANDERSON

The origins of pure yeast culture

Production of beer using a single strain of yeast, as opposed to a mixed population, was first performed at the Gamle (Old) Carlsberg brewery in Copenhagen in November 1883. The instigator of this radical departure from custom and practice was Emil Christian Hansen, head of the Physiological Department at the Carlsberg Laboratory. Hansen's original conception of the idea of pure yeast was that such cultures should be free from 'disease yeast species'. It soon became apparent to him, however, that there were different strains of 'good brewery yeast', with different flocculating and attenuating characteristics, which gave beers of different character. The use of only one of these good yeasts i.e. 'that best suited to the brewery in question' was the sense in which the term 'pure' became adopted.¹ Hansen's technique was to isolate a single yeast by serial dilution of liquid medium and grow up a culture from this. In November 1885 the first purpose built pure yeast culture plant designed by Hansen and Søren Anton van der Aa Kühle, technical manager of Gamle Carlsberg, was commissioned.² Within a few years pure yeast cultures were being employed in breweries across the world. In his book *Practical Studies in Fermentation* published in English in 1896, Hansen lists 173 breweries in 23 countries which had installed the pure yeast culture apparatus.³ The majority of these breweries employed bottom fermentation, but installations were also recorded in 19 top fermentation breweries in six countries, with a single use reported from England. In addition to these plants, Alfred Jörgensen was by then supplying 66 other breweries with pure yeast from his laboratory in Copenhagen, the experimental station in Nuremberg was sending out more than 100 samples of pure yeast annually to small Bavarian breweries and the Wahl-

Henius was providing a similar service to more than 60 North American breweries.⁴ Thus pure culture yeast met with widening application in both bottom and top fermentation breweries. Only in Britain did the system stumble and meet with mixed fortune. For two decades following Hansen's innovation an at times heated public debate ensued at meetings of the Laboratory Club and its successors over the applicability of the principle of pure yeast to the production of top fermentation beers.

A stall in progress

Hansen himself spoke in London in May 1889 on his system⁵ and a number of papers generally favourable to the technique were given at meetings over the next few years.^{6,7,8 & 9} Brewers from Combe's brewery in London (the single English example Hansen had given for use of his culture plant) and Chester's brewery in Manchester were particularly enthusiastic. In the former case two strains of pure yeast were used; one for porter and stout brewing the other for pale ale. Of their nature negative results seldom get published, there is however evidence of dissent amongst the audience in the discussions of these papers. Some brewers complained of difficulty in obtaining condition in their beers with a single yeast and also of lack of flavour. It was in order to overcome these objections that in 1894 Henri Van Laer of the Ghent brewing school promoted the use of 'pure mixed culture' or 'composite culture' as it was variously termed,¹⁰ i.e. a culture containing a defined mixture of two different strains of *Saccharomyces cerevisiae* - one for the primary and another for the secondary fermentation. Soon afterwards The British Pure Yeast Company was established in Burton-on-

Trent, with van Laer as technical director, in order to supply suitable cultures.¹¹ This move met with opposition from Hansen, who had already rejected the idea on both philosophical and practical grounds, and outright hostility from Alfred Jørgensen, Hansen's principle acolyte. As both Jørgensen and Van Laer were in the business of supplying yeast to breweries their disagreement over matters of science may also have been tempered by commercial considerations. In a paper published in 1894,¹² Jørgensen did, however, make the valid point that Van Laer's system: 'is not able to preserve the constancy of ratio between the species of which it is composed, but has to be renewed continually if wanted to keep unaltered.'

Jørgensen returned to the attack in another paper given in March 1899,¹³ in which he lamented the 'stall in progress' in the application of pure yeast in Great Britain and attributed it to what he stated to be the mistaken belief that English beers required a 'particular species of yeast ... to carry through fermentation'. He asserted that he had long ago shown that this was not the case and that all that was required was to select the correct primary yeast to achieve good results. The clear inference from his paper is that British brewers were just incompetent. Obviously stung by this, George Harris Morris, who as we shall see presently had devoted considerable effort in trying to make pure culture work, spoke critically of Jørgensen's paper during the discussion, noting that pure culture had received 'a great check' and was no longer making progress in England.

In April 1899, in an attempt to cool the situation, Albert John Murphy, proprietor of a firm specialising in the supply of brewery processing aids (then known as the Vanguard Chemical Company and still extant as Murphy & Son Ltd.) delivered a paper¹⁴ in Leeds entitled: 'Some aspects of the pure yeast question'. He noted the pure yeast 'storm' and how the technique had been 'severely assailed by most English scientists of brewing'. He went on to observe that

both sides claim to have established their views by the results of very numerous and varied experiments on a practical and commercial scale as well as in the laboratory.

Whilst dismissing Van Laer's dual yeast system as impractical, he refers to secondary fermentation as a 'vexed and complex question'. His own results led him

to believe that a single yeast could give sufficient attenuation and condition, but that sometimes there was failure for no accountable reason. He seemed to tend towards the view that these failures were due to some deficiency in the condition or nutrition of the yeast rather than the absence of the correct yeast culture. To support this he reported that failures seemed mainly to be associated with Burton, whereas success had been achieved in London, Manchester and Bradford. He tentatively suggested that this was due to a lack of potassium and/or phosphorus in Burton yeast. He concluded that

this paper ... may be taken as a plea for further investigation into the influence which inorganic elements may have upon the formation and action of enzymes, and particularly the influence of phosphorus when organically combined.

It is clear that Murphy was seeking a biochemical rather than a microbiological explanation for the conflicting evidence so far presented on the efficacy or otherwise of pure yeast.

Problems in Burton

Murphy's diversion was not followed up and instead Hansen himself returned to the fray in support of the views expressed by Jørgensen. In a letter¹⁵ to the *Journal of the Federated Institutes of Brewing* published in January 1900, characteristically peppered with references to 'my pure cultivation system' - Hansen was very possessive of his achievements - he rehearsed the arguments and evidence in favour of pure yeast from both continental and British sources. He blamed the lack of penetration of his system in British breweries to the 'secretiveness' of the brewers and called for a more open publication of results rather than opinions. Stimulated by Hansen's challenge George Harris Morris immediately responded with a detailed paper¹⁶ read to the (London) Institute of Brewing in May 1900. At this time Morris was consulting chemist to the Country Brewers' Society and lecturer in technical bacteriology in the Jenner (now Lister) Institute. But between 1883 and 1894 he had been Horace Brown's assistant at Worthingtons in Burton-on-Trent. His paper recounted his experiences with pure yeast during that period. Morris had been sent by Brown to Copenhagen in 1885

to learn about pure yeast culture directly from Hansen. On his return to Burton he set about employing the new techniques with vigour using a Hansen-Kuhle yeast culture apparatus installed at Worthingtons. Both he and Horace Brown were convinced that the future lay in 'Hansen's beautiful system'. Morris describes in detail the extensive measures taken to guard against contamination during yeast propagation and in subsequent fermentations. Fermentations with the pure culture were carried out side by side with regular fermentations with the normal brewery yeast. The course of fermentation of both trials and controls were said to be 'identical'. Differences came when the beers were run into cask (or bottle) for conditioning. The pure yeast beers did not condition, or when they did so were always found to be contaminated with wild yeast. Morris met with failure with both 'stock ales' which received prolonged (six months plus) conditioning and 'running ales' which were 'brewed, racked and drunk all in the course of one month'. The beers tasted clean but remained thin and flat unless as Morris puts it 'cold malt-extract or ordinary sugar priming' were added. In nine years of experimentation in which he brewed over 2,000 barrels of beer using a variety of different isolates from the brewery culture, Morris could never obtain the same results with pure culture as he could with his 'ordinary' yeast.

Morris did not deny that pure culture worked well in bottom fermentation breweries and also in continental top fermentation breweries (he had been to Holland and Belgium to see for himself in 1890), but it did not work for any of Worthington's beers. He attributed this discrepancy to differences in attenuation between continental beers and those made in Burton. In his own words

In the case of the majority of English beers the amount of matter left unfermented is not considerable, and I doubt very much whether, in any but the quickest running ales, this readily fermentable matter is sufficient to provide the after-fermentation which we find is necessary.

It is evident from the subsequent discussion that the audience was convinced both by the meticulous nature of Morris's experiments and by his explanations of his results. They would all have known that a particular characteristic of beers produced in the Burton Union system was their high degree of attenuation. But if Morris was right, and all but the cheapest English beers could not be produced with a single pure culture (with-

out resorting to the apparently to him distasteful practice of priming) how about two pure cultures, one yeast for the primary fermentation and one for the secondary? This suggestion (really a reiteration of Van Laers process) was put to Morris by Matthew Cannon, a consulting brewer, but Morris discarded such a suggestion as possible but 'too cumbersome' in practice. Probably unknown to Morris at the time, for the results were not published, John Simpson Ford, chemist to William Younger's brewery in Edinburgh had met with similarly disappointing experiences with pure yeast. Ford had also spent time in Copenhagen with Hansen and had returned full of enthusiasm, but repeated extensive trials with single cell cultures (and with composite cultures) failed to give consistent results with Scottish ales and the technique was abandoned.¹⁷

The debate continues

The leading brewer's chemists in both England and Scotland may have been convinced that pure yeast was a dead letter in their countries, but the subject refused to lie down. In a paper¹⁸ given in Manchester in December 1900 to the North of England Institute of Brewing, entitled 'The Development of Scientific Ideas, as Applied to Fermentation Industries' two academic scientists, Drs William A. Bore and H.C. Harold Carpenter, in applauding Hansen's work and the transformation it had brought about in continental brewing practice noted how:

the inherent conservatism of the English character has prevented the majority of brewing firms from following the good example of their more enlightened and progressive competitors.

This prompted a brewer from Chester's Brewery in Manchester, Charles Frederick Hyde, to respond that his brewery had been using pure yeast successfully for seven years in which time they had introduced '147 new growths ... from the same stock' and had sent over 700,000 barrels of ale and porter to trade. Hyde went on to criticise Morris's recent paper and stated: 'Had Dr Morris taken the trouble to send him a postcard asking if he was using pure yeast, he should have at once replied in the affirmative'. Ouch!

Meanwhile, Jørgensen remained active in promulgating the doctrine of pure yeast. In October 1901 an English

brewer, Ralph Grey, fresh from a trip to Jørgensen's laboratory in Copenhagen read a paper in Manchester in praise of the technique. In May 1903 Jørgensen himself, in a paper coupled with, and presented by, Walter Alfred Riley jnr. of Morgan's Brewery Company in Norwich, again claimed success in British breweries, blaming the failures of others on poor yeast selection techniques.¹⁹ By now George Harris Morris was unable to fight his corner having died of pneumonia at the age of 43 on New Years Eve 1901 at a time when his career was at a low ebb. But other prominent English brewing scientists and brewers took up the cudgels pointing out that things were not so straightforward as Jorgensen tried to tell them; that failures to give condition and flavour in stock ales in particular were too widespread to be discounted so easily. Julian Levett Baker, newly appointed chemist to Watney, Combe, Reid, also spoke from experience of the problems of maintaining a pure culture in the typical English brewery of the time. Alfred Chaston Chapman, a rising consulting chemist, spoke particularly forcefully of the 'unfavourable results which were obtained' in several English breweries he had attended in the course of his work. Chapman went on to question the apparent success of Jørgensen and Riley, raising a valid practical point which has resonance today, when he asked how the authors were so sure that they were still using a single strain of yeast after repeated repitchings rather than a mixture of several 'closely allied' culture yeasts:

He certainly would be extremely sorry to be asked to detect the presence of 10 to 20% of a variety of one yeast in another ... He could not help thinking that the results brought forward to-night did not carry them much further.

Indeed the two sides in the by now stale argument were as far apart as ever, but even as they debated that May evening in 1903 in Brewers' Hall, London, fresh discoveries were being made in Copenhagen which would lend decisive support to the doubting English brewers and show that in some cases two yeasts really were better than one.

Enter the British yeast

In April 1904 the Director of the laboratory of the New Carlsberg Brewery, Niels Hjelte Claussen, delivered a paper to the London Section of the Institute of Brewing entitled: 'On a Method for the Application of Hansen's

Pure Yeast System in the Manufacturing of Well-Conditioned English Stock Beers'.²⁰ In this paper Claussen disclosed that he had isolated the organism, 'that was responsible both for the condition in these beers and for their flavour'. Claussen further noted that in his experiments this organism 'produces a slow [secondary] fermentation in wort or in beer fermented with ordinary brewer's yeast' in the course of which

a considerable amount of acid is formed, accompanied by ethereal substances, the taste and flavour of which cannot fail to attract the attention of any connoisseur by their striking resemblance to the flavour of stored English beers.

He noted that the idea of a specific secondary yeast was not new, but the reason why to date it had not been found was because of the assumption that it would be a species of *Saccharomyces*. He had found that this was not the case. It was a different yeast altogether; a small, ovoid organism with a pointed end, 'a non-sporulating budding fungus, belonging to the group *Torula*', which he had for the first time isolated from a sample of English stock ale, and which because of its connection with the British brewing industry he had named *Brettanomyces*. He concluded that 'judgements passed against the applicability of Hansen's pure yeast system to English beer brewing by eminent English brewing chemists were essentially sound' and that 'the real truth is that Jørgensen is completely mistaken'. English brewers who had failed with pure yeast had done so because of the scrupulous measures they had taken to exclude adventitious contamination with *Brettanomyces*. Some of those who had succeeded had done so because of less than adequate precautions in this matter, or because they only produced 'running ales' which received condition due to continued primary fermentation with *Saccharomyces*. He noted that Jørgensen's successes had all been achieved with this latter type of beer. True secondary fermentation required for stock ales only occurred after months of storage in cask.

Claussen's paper can now be seen as decisive in essentially ending what had become something of a sterile argument. In essence he had said nothing new, but what he had done was produce evidence rather than conjecture. He had shown by experiment that two entirely different yeasts were required to produce the unique English stock ale. On the other hand, so long as sufficient fermentable matter remained in the beer when it

was run to cask, only one species of yeast was required to make the lighter quickly processed running beers which had been successfully produced both in England and abroad. Morris's failure even with the latter had been, as Morris suspected, due to the unusually good attenuation of Burton brewed beer. Why Claussen had seen this so clearly where others had not, is perhaps because he approached the subject without pre-conceived prejudices. Some English brewers had shown considerable confusion between continued primary fermentation and true secondary fermentation; whereas Jørgensen can perhaps be seen as blinded by dogma.

Too late for stock ales

The truth of Claussen's solution was quickly accepted by the English brewers - the *Brewing Trade Review*, the official organ of the Brewers' Society, noting²¹ with some glee in its report on Claussen's paper that 'English brewers have not been so stupidly conservative after all'. In the extensive discussion which followed his paper brewers who had obtained success with pure yeast confirmed that this was only obtained with running beers and not stock ales. Even Hansen himself looked favourably on Claussen's work to judge from the comments he made when giving a lecture at the opening the new bacteriological laboratories at Heriot-Watt College in 1905.²² In reality, however, Claussen's work had little practical effect, for the stock ales which required his *Brettanomyces* had now all but disappeared from the scene. William Waters Butler, the scientifically orientated chairman of Mitchells & Butlers, noted in the discussion of Claussen's paper that only Burton beer was really stock beer and that even in the Burton breweries it had all but been replaced by lighter beers. Certainly, no instance is known of Claussen's patented process involving production of stock beers by fermentation with *Saccharomyces* followed by repitching with *Brettanomyces*, ever being taken up in England. There was, however, at least one attempt further afield. Clausen himself left Denmark to work in the United States for a few years in 1905 and Holger Ludwig Schiønning, who was an assistant of Hansen's in the Carlsberg Laboratory, took up his work and made his own isolates of *Brettanomyces* from English stock ale and Irish stout. A paper giving the results of his essentially taxonomic study of the organism was read to the Institute of Brewing at the Criterion Restaurant in

Piccadilly in October 1908.²³ In it he recorded that the Kalinkin Brewery in St. Petersburg had used two yeasts to produce English style stock beers. Indeed Hans Seyferrt of the Russian brewery had already claimed priority over Claussen in a paper²⁴ published shortly after the latter's work was made public, in which he announced that he had isolated a 'Torula' from English beer in 1889 which produced the typical taste of stock ale. Another who may have had a priority claim but never aired it was James Wilson Tullo, a Guinness chemist who in a confidential company report of 1899 described the isolation and characteristics of two types of 'secondary yeast' from stout which seem to fit the description of what was to become *Brettanomyces*, but this was not made public until over 60 years later.²⁵ Schiønning himself isolated two different species of *Brettanomyces* which he described in some detail, noting how

they carry the fermentation further, being able to multiply and further ferment the sugar residue of the beer, and accordingly as the amount of alcohol and carbonic acid gas thus increases, acids are formed at the same time, which combine with the alcohol to form esters, imparting to the beer the characteristic English taste and aroma.

During the discussion of the paper Hansen was quoted as having said that he was

forced to the conclusion that under the present conditions of English brewing for the production of stock ales of the present character, a single-cell yeast alone was not sufficient.

Hansen died in 1909 and Schiønning left in the same year to join the Danish beer taxation service. Work on *Brettanomyces* at Carlsberg ceased.

Pure yeast and running ales

But if stock ales could not be produced by pure culture, all the evidence now indicated that running ales, made to be drunk within a month after minimal conditioning, could. At least one English brewing scientist acted upon the message and realised the possibilities opened up by Claussen's clarification of the question. Raymond Louis Siau of W. Butler & Co's Springfield Brewery published a paper²⁶ in 1906 entitled 'Brewing Infection and Pure Yeast'. Work on pure culture had been going on spasmodically at Butlers since the late 1880s²⁷ and Siau's

paper indicates that he had fully assimilated the lessons learnt in the past 20 or so years in which the pure yeast question had been debated. He proceeded to apply these lessons to the brewing of mild ale, the staple of Butler's Wolverhampton brewery. And, apparently without the benefit of a culture plant, succeeded in producing an acceptable beer consistently using a single strain of yeast.

All seemed set for the English brewers to join the rest of the world, where following the triumph of bottom fermentation the technique was now standard practice, and embrace pure culture. But it was not to be. Siau's paper was the last to be published on pure yeast from a U.K. source for nearly 30 years. There are no recorded attempts to employ the technique in the British industry in the intervening period and it is likely that it became extinct in the country by the First World War. This is despite the fact that primed running beers, which were perfectly amendable to production using pure yeast, were the norm by 1914. When the subject was revived in a modest way by Whitbread's chief chemist Bernard Meredith Brown in the mid 1930s²⁸ with the aim of obtaining a stable culture which would give a high degree of attenuation for use in bottled beer production, he was granted 'permission to experiment with yeast grown from laboratory cultures ... on one condition, that single cell cultures were not to be used'. Instead he compromised by using a culture derived by combining a loopful of each of 10-15 colonies taken from an agar plate and described as being 'of typical primary yeast appearance'. How many strains of yeast were contained in this culture was not determined. Brown's technique could perhaps best be described as producing purified rather than pure yeast. Indeed he was inherently suspicious of single cell culture, remarking that

no two living organisms are identical. This, I have no doubt, is as true of two yeast cells as of two Englishmen. And who would be so bold as to select one Englishman as typical of his race.

Hansen must have been turning in his grave at such a biological inanity. A few years later, at the end of the 1930s, another London brewery, Charringtons, introduced true pure culture using a highly flocculent yeast in the production of a heavily primed draught mild ale.²⁹ But, it was not until the early 1960s that the U.K. brewers turned to pure yeast in any numbers as a means

of systemising production and increasing product consistency. Even then the move was far from being a general one. To this day some local and regional English brewers use an undefined mixed culture with generally good results.

The reasons for rejection

Why were English brewers so slow to take up pure culture? One answer is that it was an example of English conservative brewing attitudes.³⁰ The true position is however rather more complex. We have seen how the special character of the true English ales, the stock ales, could in fact not be produced by single pure culture. The confusion caused by this fact and the affect it had upon the otherwise positive attitudes of George Harris Morris & Horace Brown was significant. When pure yeast was first introduced in the 1880s Burton was still the centre of brewing science. That two of its most famous practitioners had failed must have influenced the many country brewers who had not the expertise to tackle the matter themselves. Even when Claussen demonstrated decisively the reason for these failures it had little impact. As we have noted, by then stock ales sold in such small quantities as to not be worth the bother. Siau's 1906 paper and the earlier experiences of a handful of other brewers had demonstrated that it was perfectly possible to produce primed running ales using a single strain of yeast, but where was the gain? What was the payback for the investment required and the chance taken? The early years of the 20th century saw a decline in the beer trade in Britain, followed by a World War and economic depression; hardly conditions to inspire innovation in a conservative industry. Based on wide experience of both ale and lager brewing, Harold Lloyd Hind³¹ in his famous textbook *Brewing Science and Practice* first published in 1940, considered that

Pure yeast does not appear to be so essential in top fermentation breweries as it has proved to be to maintain regularity of fermentation in lager breweries ... In many top fermentation breweries, the same yeast is maintained in use for many years without any of those signs of degeneration or infection that set in much more rapidly with bottom yeast.

This doctrine of if isn't broken don't fix it undoubtedly carried the day amongst British brewers. Another factor was the difficulty in selecting an appropriate single

strain to use. By common consent, because of the higher fermentation temperatures employed, the flavour of ales is generally more reliant upon yeast activity than is the flavour of lagers. Further, the evidence of genetic fingerprinting of modern ale and lager yeasts shows a much greater heterogeneity in the former. This is not surprising when one considers that lager yeasts are generally taken to have originated in a narrow region of Bohemia/Bavaria, whereas ale yeasts have a much more widespread origin and hence gene pool. Selecting a single strain of ale yeast with the required flocculation and attenuation characteristics to yield a beer which also matched the flavour produced from the many diverse yeasts existing in a typical top fermentation brewery culture was thus no easy matter, as brewing technologists discovered in the 1960s. At least one national ale brewer still uses a 'pure mixed culture' derived in the mid 1960s from the then brewery stock culture which combines two separately propagated single strains combined at pitching to ensure the acquired attenuation and characteristic flavour of their product is attained. And, just as Hansen and Jørgensen said would be the case, the proportions of these cultures drift with time requiring frequent replacement of the culture and occasional problems with the beer.

***Brettanomyces* today**

So what became of *Brettanomyces*? The great reforming and combative brewery microbiologist John Lester Shimwell (who wrote under the pen name *Brettanomyces* for the *Brewers' Journal*) reviewed its status in 1940 thus

at one time an organism indispensable to British breweries for stock-ale production, it has now taken on the role of 'undesirable ferment' in running beers by causing frets and 'wild yeast' trouble and wreaks its vengeance on the brewing community that once spurned its assistance ... the frets pass off in a few weeks, leaving an aromatic vinous flavour, but this, of course, does not suit modern conditions.³²

And, as far as the great majority British brewers are concerned, so *Brettanomyces* remains. It has become an increasingly rarely found spoilage organism in beer, causing occasional off-flavours and over conditioning in casks.³³ As Brian Gilliland³⁴ of Guinness noted in 1961, by which time quickly produced and consumed beers

had gained virtual hegemony in the British Isles, 'they grow very slowly ... they would not have time to produce significant change in flavour.' *Brettanomyces* has also turned up as an occasional contaminant in soft drinks, weissbier, pilsner, and more frequently in wine.³⁵ In the latter, attempts have recently been made³⁶ by some wine writers to have the flavours produced by *Brettanomyces* - usually described as 'wet dog/horse blanket' in this context - to be viewed in a more positive light as something that adds to the complexity of some red wines.

But it is in the production of lambic and gueuze, the special Belgian beers obtained by spontaneous fermentation, that *Brettanomyces* continues to wield its major influence. The organism was detected³⁷ in lambic in the 1920s and extensive studies of Professor Verachert^{38, 39, 40 & 41} and his colleagues at the Catholic University of Leuven from the 1970s onwards have shown the crucial part played by *Brettanomyces* in the complex microflora of these beers. After some eight months, well after the main fermentation is complete, *Brettanomyces* species start to grow in lambic⁴² causing a further slow fermentation and 'the appearance of special flavours'. The additional fermentation is possible because *Brettanomyces* species excrete the enzyme α -glucosidase⁴³ which is not found in brewing strains of *Saccharomyces*.⁴⁴ The enzyme nibbles away at the chain ends of residual dextrans releasing free glucose. This activity explained the long observed limited, but significant, extra fermentation of 1-2 °Sacch, by *Brettanomyces* so important for condition in stock beers. Accompanying this secondary fermentation in lambic, Verachert detected⁴⁵ the production of high levels of acetic and lactic acid and massive amounts of ethyl acetate and ethyl lactate (10-20x flavour threshold) accounting for the estery/ethereal quality of beers associated with *Brettanomyces* fermentations. To what extent lambic resembles old English stock ale and porter is a moot point. There is nobody alive today who has ever tasted authentic sample of the latter beers from their heyday. From contemporary descriptions lambics and old stock beers have a vinous, estery, solvent like character in common, but, with a pH of around the 3.3 mark, lambic must surely be much more acidic and harsh. Indeed, even in an age when richness of flavour was more common, it is hard to imagine that a beer with all the extreme features of lambic would ever have met with the wide acceptance enjoyed by porter and stock

ale in the 18th and 19th centuries. It is significant that the high hop rate in these English beers would have kept bacterial activity in check, while lambic is produced with much lower levels of aged and therefore less effective hops⁴⁶ and bacterial as well as yeast growth is an important feature of their production. The precise species of *Brettanomyces* isolated from lambic and stock ale also differ and have been reported to produce differing levels of flavour intensity.⁴⁷

The strains of *Brettanomyces* that facilitate lambic production arise from the prevailing wild flora present in the brewery. A more controlled entrance is practiced in the Abbaye Notre-Dame d'Orval Brewery for its famous Trappist beer, Orval.⁴⁸ This beer is produced by a primary fermentation with a pure strain of *Saccharomyces* followed by transfer to conditioning tanks and re-pitching with a mixed culture which includes a species of *Brettanomyces*. The secondary fermentation continues over a period of three weeks at 15°C with further maturation in bottle. Neils Hjelte Claussen would undoubtedly have approved of this method of production. Indeed there is a case for Orval being the closest extant relative of the deceased English stock ales - it is even dry hopped. An even more ambitious use of pure culture *Brettanomyces* has recently been introduced by the U.S. craft brewer Arthur Tomme,⁴⁹ who's 'Cuvee de Tomme' is an 11% v/v alcohol beer which is fermented over a period of nine months with a strain of *Saccharomyces cerevisiae* and three *Brettanomyces* species. We may perhaps see further developments along similar lines in the future as free-thinking brewers search for diversity of flavour in their products. Thus, *Brettanomyces*, the 'British Yeast', may now be spurned in the country which gave it its name, but species of the genus live on in pockets elsewhere where two (or more) yeasts are regarded as better than one in producing beers of unusual character.

A version of this article was previously published in two parts in The Brewer and Distiller International, 2007, 3 (2), pp.26-8 and 3 (4), pp.38-40.

References

1. Hansen, E.C. (1896) *Practical Studies in Fermentation, being contributions to the life story of micro-organisms.*

London: E. & F.N. Spon. pp.1-2.

2. Trolle, B. (1976) in *The Carlsberg Laboratory 1876/1976.* Copenhagen: Carlsberg Foundation ed Holter, H. & Moller, K.M., p.349.

3. Hansen, E.C. (1896) op. cit. pp.232-252.

4. *ibid.*

5. Hansen, E.C. (1889) 'Some points in connexion with practical brewing'. *Transactions of the Laboratory Club*, 2, pp.93-108.

6. Evans, R.E. (1892 & 1893) 'Yeast'. *Transactions of the North of England Institute of Technical Brewing*, 1, pp.37-54 and *Transactions of the Yorkshire Institute of Brewing*, 1, pp.13-28.

7. Hagen-Schow, A. (1890) 'Pure yeast and fermentation'. *Transactions of the Laboratory Club*, 1, pp.122-130.

8. Miller, A.K. and Hyde, C.F. (1894) 'The significance of pure yeast (Hansen) to high fermentation.' *Transactions of the North of England Institute of Technical Brewing*, 3, pp.39-50.

9. Raeburn, N. (1894) 'The present state of the pure yeast question in England with a practical demonstration of the method of pure yeast culture and yeast analysis.' *Transactions of the Yorkshire Institute of Brewing*, 1, pp.121-134.

10. Van Laer, H. (1894) 'Studies on secondary fermentation and "frets"'. *Transactions of the Institute of Brewing*, 7, pp.55-85.

11. Raeburn, N. (1894) op. cit.

12. Jorgensen, A. (1894) 'Hansen's system of pure yeast culture in English top-fermentation.' *Transactions of the Institute of Brewing*, 7, pp.227-247.

13. Jorgensen, A. (1899) 'Biological studies on English yeast types, with particular regard to their practical use.' *Journal of the Federated Institutes of Brewing*, 5, pp.259-271.

14. Murphy, A.J. (1899) 'Some aspects of the pure yeast question.' *Journal of the Federated Institutes of Brewing*, 5, pp.432-455.

15. Hansen, E.C. (1900) 'Some remarks on the discussion in connection with Jørgensen's "Biological studies on English yeast types, with particular regard to their practical use."' *Journal of the Federated Institutes of Brewing*, 6, pp.22-27.

16. Morris, G.H. (1900) 'Some experiences with the use of pure cultured yeast.' *Journal of the Federated Institutes of Brewing*, 6, pp.333-349.

17. Hopkins, R.H. (1944) 'Obituary. John Simpson Ford (1866-1944)'. *Journal of the Institute of Brewing*, 50, pp.161-163.

18. Bore, W.A. and Carpenter, H.C.H. (1900) *Journal of the Federated Institutes of Brewing*, 6, pp.454-476.

19. Jorgensen, A. and Riley W.A. (1903) 'Practical work on English single-cell yeasts Part I.' *Journal of the Federated*

Institutes of Brewing, 9, pp.294-313.

20. Claussen, N.H. (1904) 'On a Method for the Application of Hansen's Pure Yeast System in the Manufacturing of Well-conditioned English Stock Beers.' *Journal of the Institute of Brewing*, 10, pp.308-331.

21. Anon. (1904) *Brewing Trade Review*, 1, p.447.

22. Hansen, E.C. (1905) 'Considerations on technical mycology.' *Journal of the Institute of Brewing*, 11, pp.587-599.

23. Schionning, H. (1909) 'On torula in English beer manufacture'. *Journal of the Institute of Brewing*, 15, pp.2-28.

24. Seyffert, H. (1904) *Woch.Brau*. 21, p.519 via. 'Notes on the preparation of English types of beer.' *Journal of the Institute of Brewing*, 10, pp.604-605.

25. Gilliland, R.B. (1961) 'Brettanomyces. I. Occurrence, Characteristics, and effects on Beer Flavour.' *Journal of the Institute of Brewing*, 67, pp.257-261.

26. Siau, R.L. (1906) 'Brewing infection and pure yeast.' *Journal of the Institute of Brewing*, 12, pp.118-134.

27. Barnard, A. (1889) *The Noted Breweries of Great Britain and Ireland*. Causton: London, 1889, Vol. 2, pp.150-151.

28. Brown, B.M. (1934) 'The production of pure yeast'. *Journal of the Institute of Brewing*, 40, pp.9-16.

29. Burns J.A. (1964) 'Yeast Propagation'. Unpublished report on a symposium held at the University of Birmingham 16 July 1964, pp.1-13.

30. Teich, M. (1983) 'Fermentation theory and practice: the beginnings of yeast cultivation in English brewing'. *History of Technology*, 8, pp.117-133.

31. Hind, L.H. (1940) *Brewing Science and Practice: Volume II Brewing Processes*. London: Chapman & Hall, p.801.

32. Shimwell, J.L. (1940) 'A review of M.T.J. Custers' new work on "Brettanomyces"'. *Brewers' Journal*. 76, pp.416-417.

33. Andrews, J. & Gilliland, R.B. (1952) 'Super-attenuation of beer: A study of three organisms capable of causing abnormal attenuations'. *Journal of the Institute of Brewing*. 58, pp.189-198.

34. Gilliland, R.B. (1961) 'Brettanomyces. I. Occurrence, Characteristics, and effects on Beer Flavour'. *Journal of the*

Institute of Brewing. 67, pp.257-261.

35. *ibid*.

36. Capron, S. & Harropp. (2005) 'Understanding Brettanomyces'. *Wine International*. 21 June, via <http://www.wineint.com/story.asp?storycode=1860>.

37. Hansen, E.C. (1905) *op. cit*.

38. Shantha, H.M.C., De Cort, S. & Verachtert, H. (1993) 'Localisation and characterisation of a-glucosidase activity in *Brettanomyces lambicus*'. *Applied and Environmental Microbiology*. 59, pp.2352-2358.

39. Spaepen, M. & Verachtert, H. (1982) 'Esterase activity in the genus *Brettanomyces*'. *Journal of the Institute of Brewing*. 88, pp.11-17.

40. Van Oevelan, Spaepen, M., Timmermans, P. & Verachtert, H. (1977) 'Microbiological Aspects of Spontaneous Wort Fermentation in the Production of Lambic and Gueuze'. *Journal of the Institute of Brewing*. 83, pp.356-360.

41. Van Oevelen, De L'Escaille & Verachtert, H. (1976) 'Synthesis of aroma compounds during the spontaneous fermentation of lambic and gueuze'. *Journal of the Institute of Brewing*. 82, pp.322-326.

42. Van Oevelan, Spaepen, M., Timmermans, P. & Verachtert, H. (1977) *op. cit*.

43. Shantha, H.M.C., De Cort, S. & Verachtert, H. (1993) *op. cit*.

44. Pretonus, I.S., Lambrechts, M.G. & Marmur, J. (1991) 'Glucoamylase multigene family in *Saccharomyces cerevisiae* var. *Diastaticus*: an overview'. *Critical Reviews in Biochemistry & Molecular Biology*. 26, pp.53-76.

45. Van Oevelen, De L'Escaille & Verachtert, H. (1976) *op. cit*.

46. *ibid*.

47. White, C. & Tomme, A. (2005) 'Brettanomyces yeast in beer'. *Craft Brewers' Quarterly*. April, via <http://www.white-labs.com/bacteria.html> and <http://www.yeastbank.com/features/tomme.html>

48. Gilliland, R.B. (1961) *op. cit*.

49. White, C. & Tomme, A. (2005) *op. cit*.