50 achievements in brewing science and technology in 350 years – Part 2

FROM THE 1930s TO TODAY | In the second part of this review of 350 years of technological achievements in brewing science we shall see that up to the 1970s still many brewing scientists came up with significant improvements. Since the 1970s developments have constantly changed direction and have increasingly been driven by the industry suppliers.

AS IN PART 1 (BRAUWELT International no. 6, 2013, p. 391-394), the major brewing achievements are listed chronologically rather than according to importance.

26. Professor Øjvind Winge (fig. 1), the first genetics university professor in Denmark and later professor at Carlsberg Laboratory, Copenhagen, discovered sexual reproduction by brewer's yeast in 1937, allowing controlled yeast breeding and the birth of genetically engineering. Winge also started a hops breeding program at Carlsberg Laboratory and ran a hops farm south of Copenhagen, which went on till the 1960s [12].

Fig. 1 Professor Øjvind Winge

27. Filtration of beer using Kieselguhr (fig. 2) from fossils originated from diatoms containing SiO_2 became common in the 1940s. Kieselguhr (KG) or diatomaceous earth (DE), the fossilized remains of microscopic single-celled aquatic algae, finds use as an efficient filter aid in several industries (e. g. breweries).

Fig. 2 Early Seitz Kieselguhr filter

28. The Danish chemical engineer Viggo Berglund, Director at Scandinavian School of Brewing, published a paper called "Vatten" (water) in the Swedish Brewer's magazine in April 1944. He documented and explained phosphate- and carbonate-interdependent buffers in brewing water in Danish. Berglund's work allowed a better understanding of the role of malt and water-hardness, and it marked the beginning of an era where systematic water treatment became common for brewhouse technology [7].

29. The classic long and cold beer maturation was replaced by a warm primary fermentation followed by a shorter, but very cold maturation. The biological understanding of the formation of diacetyl (butane-2,3-dione) during primary fermentation followed by the removal of diacetyl at the end of primary fermentation was gradually accepted in the 1950s, which has changed and shortened the process for lager beer ever since.

30. The stabilization of beer with different chemicals, first Nylon 66, later silica gel and PVP, became common in the 1960s. There is evidence that W. D. McFarlane & Co. used PVP to precipitate polyphenols already in 1954. Since 1961, McFarlane used PVPP (not PVP), and he delivered a presentation of his findings at the EBC Congress in Vienna 1961.The brewers Guinness and Carlsberg both worked with the company ISP, the producer of "Polyclar AT", in the early 1960s to develop the technology of "chemical stabilization" into practical use [14].

31. Stainless steel has replaced copper as brewhouse construction material since the 1960s. This change of construction material was driven by a need to lower material costs, but also because it was now possible to produce hygienic welding stainless steel.

32. Cylindroconical fermenters and fixed piping replaced horizontal fermenters and hose connections since the late 1960s. In 1930 the Swiss brewer Dr. Leopold Nathan described fermentation in cylindroconical fermenters (J. Inst. Brewing, 1930, 36, pp. 538-550) – he patented the tank itself in 1908 and again in 1927. His fermenters were 100 hl enamel lined tanks, later he used rolled aluminum plates – novel for that time. Brewers at that time were slow movers and suspicious of this type of tank and this process of fermentation, and we have to wait untill the 1960s

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before cylindroconical fermenters became common in breweries [13].

33. Fermentation under increased tank pressure – up to 1.8 ato at the top – was applied by Technical Director and Master Brewer *Henning Nielsen* at Faxe Brewery (today Royal Unibrew) in Denmark, while at the same time raising the primary temperature during fermentation from 10 to 16 °C. This process – inspired by German Dr. H. J. Wellhoener – was introduced in 1975 - 76 in tall CCTs and achieved a significant shortening of process time, but also increased the need for stabilization. The idea was to enhance efficiency by raising temperature while stalling the multiplication of CO_2. Independent of the new fermentation process the brewery introduced the sales of unpasteurized beer facilitated by an increased level of sanitation. The unpasteurized process was applied for 15 years to make a difference to competing brands (according to Henning Nielsen August 1st, 2013).

34. In 1958 the American Fred Calhoun founded the company Industrial Dynamics Filtec. This company is considered to be the first company manufacturing empty bottle inspection ma-

Fig. 3 Early ID Filtec EBI

chines (EBIs, fig. 3). Calhoun created and sold the world's first EBI in 1958. Efficient EBIs in beer bottling started generally to replace visual bottle inspection since the 1970s, when early EBIs, having only mouth and bottom bottle inspection, became available. Since the 1980s nearly all returnable glass packaging lines have used EBIs.

35. The whirlpool separator for removing hops and trub after the wort boiling was introduced to replace the hop-backs at Molson's brewery in Canada in 1960 and was ubiquitous in breweries by the 1980s [13].

36. The Danish citizen and chemical engineer Morten Meilgaard spent most of his career in senior technical roles with

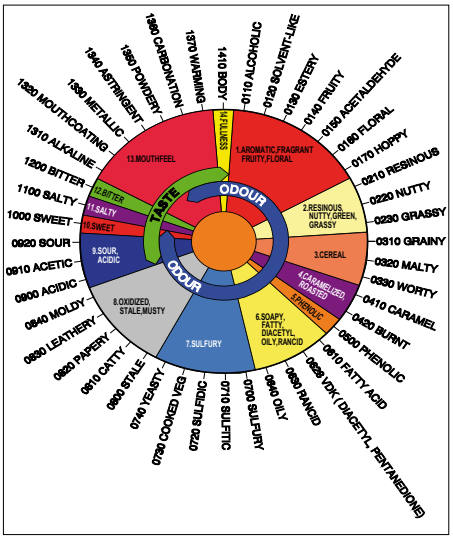

Fig. 4 Flavor wheel

Stroh in the U.S. He also was head of an ASBC work group which published "The flavor wheel origin" in 1975 (fig.4). The work introduced a new flavor terminology based on 122 flavor expressions divided into 14 classes, creating a beer flavor language, which was adopted by most nations and all large brewing groups worldwide soon after publishing [15].

37. High Gravity Brewing (HGB) using deaerated, softened and carbonated water became practice for international lager brewers in the 1970s. Unfortunately, no exact date or "first brewery" can be identified – perhaps because the first users of this technique were not really committed to this idea, before HGB became common practice for most lager brewers in the 1980s [13].

38. Crop yield from spring barley and two-row barley growing have steadily increased from four t/ha in the 1970s to seven t/ha after the year 2000 in parts of the world where barley enjoys ideal growing conditions, i.e. in Northern Europe.

39. VTT, Hartwall and Sinebrychoff, all Finnish, invented an immobilized process for short and continuous maturation time for beer processing in Finland in the 1980s. Finnish citizen and chemical engineer *Esko Pajunen*, later EBC President and Research Director of Carlsberg Laboratory, patented the process in the U.S. in 1990 (fig.5). The process was invented to allow a larger volume of beer processing with a limited number of fermenters during peak season. Although proven to work, the process did not gain international popularity, and even in Finland it is not used very much, perhaps because the brewers are concerned with rapid spreading of potential infections [17].

40. The scientific discipline of breeding yeast strains with particular properties has been about for a long time, first as natural breeding, later using GMO-techniques. It was understood since the 1980s, that many fermentation properties can be targeted by smart breeding. Examples are flocculation, faster diacetyl reduction, special flavors, temperature robustness etc.

41. A mashfilter with high speed lautering by use of a rubber membrane working under air pressure and a hammer mill producing more than 12 brews in 24 hours and a yield of 100 percent extract was offered by the Belgian company Meura in 1987 (fig. 6).

42. Beer was filled in PET bottles for the first time in 1993. They had poor barrier characteristics, and shelf life was weeks rather than months. After the year 2000 multilayer PET and PET with inner carbon layer showed better barrier characteristics, and oxygen penetration could be reduced.

43. In the 1980s a microarray approach for screening of yeast strains was introduced, generally known as an "Omnilog". A phenotype-microarray system allows for simultaneous monitoring of the phenotypic reaction of cells like yeast strains to environmental challenges spotted on micro titer plates.

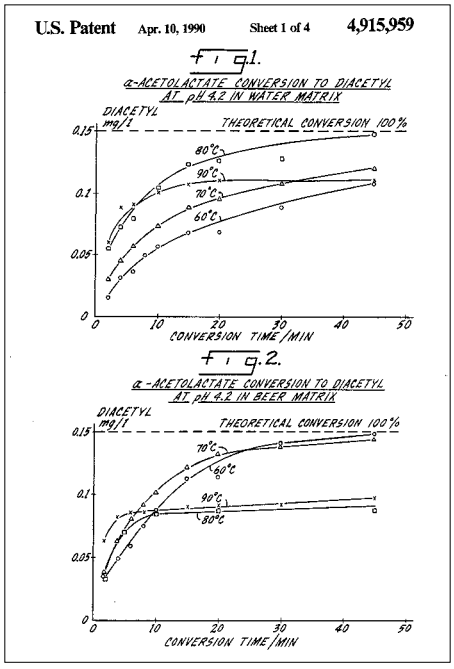
U.S. Patent Apr. 10, 1990 Sheet 1 of 4 4,915,959

Fig. 1.

α-ACETOLACTATE CONVERSION TO DIACETYL AT pH 4.2 IN WATER MATRIX

DIACETYL mg/l

THEORETICAL CONVERSION 100%

80°C 90°C 70°C 60°C

CONVERSION TIME/MIN

Fig. 2.

α-ACETOLACTATE CONVERSION TO DIACETYL AT pH 4.2 IN BEER MATRIX

DIACETYL mg/l

THEORETICAL CONVERSION 100%

70°C 80°C 90°C 80°C

CONVERSION TIME/MIN

Fig. 5 US Patent 4915959-1

Fig. 6 Meura 2001 mashfiler

The phenotypic reactions are recorded as either end-point measurements or respiration kinetics similar to growth curves and the technique nowadays allows for fast processing of vast amounts of cells and analysis of large amounts of data for yeast breeders.

44. Increasingly, since the 1990s, breweries make use of performance management systems to meter and act on underperformances. KPIs like waterfactor [hl/hl], percent OEE, percent extract losses, heating and cooling consumptions [kWh/hl] and commissioning test conditions [i.e. DIN 8782] became common brewery management concepts, starting with the international brewing groups and later becoming common practice for all. No international industry standard has been achieved, however, as brewers increasingly act within their own company structure.

45. Low lox barley varieties offering longer beer flavor stability are identified and patented with Patent no. WO02/053721 filed jointly by Carlsberg Research Centre, Heineken Technical Services and Brasserie Kronenbourg in 2002. Nowadays large quantities of low lox barley varieties are grown and malted, providing longer shelf life for lager beers.

46. By inspiration from other industries brewers started looking at the whole manufacturing supply chain from procurement to distribution in the noughties (fig. 7). Early inspiration came from companies outside the brewing industry like Norwegian Orla and FMGC, companies like Anglo-Dutch Unilever, American Kraft Food and Swiss Nestlé, who have developed and used supply chain management (SCM) concepts to increase material flow, speed-up service precision and lower logistics costs. In many cases SCM is combined with continuous improvement (CI) concepts particularly from car manufacturers, where especially Toyota has been a common inspiration source for their Toyota Production System, commonly known as "Lean" since the Americans *Jones & Womack* in 1996 wrote the CI best seller "Lean thinking". By the mid-2000s most international brewing groups focused on CI. Today, some of them use Lean, some TPM, others Six Sigma, but all use CI to reduce losses, increase material flow and quality precision. Anyway, brewers were followers of SCM and CI, not innovators.

47. Experiments with membrane filtration – avoiding filter aids like kieselguhr – have been ongoing in small scales since the 1980s. The first large scale plant supplied by Westfalia/Pall was commissioned by the Head Brewer *Anders Kokholm* at Carlsberg Fredericia Brewery in March 2005.

48. Application of a proline-specific endoprotease (by the trade name of "Brewer's Clarex") by DSM allows chemical stabilization, filtration and removal of chill haze. This became possible approx. in 2007, and "Brewer's Clare" has been large-scale marketed since the drinctec exhibition in Munich in 2009. In addition, the proline-specific endoprotease allows warm filtration at 4 - 7 °C, this way saving beer filter cooling energy.

49. Since 2010, the collection of CO_2 from fermenters straight after wort tank filling has been another issue. This technique is still being tested at pilot breweries, but is expected soon to become industry standard.

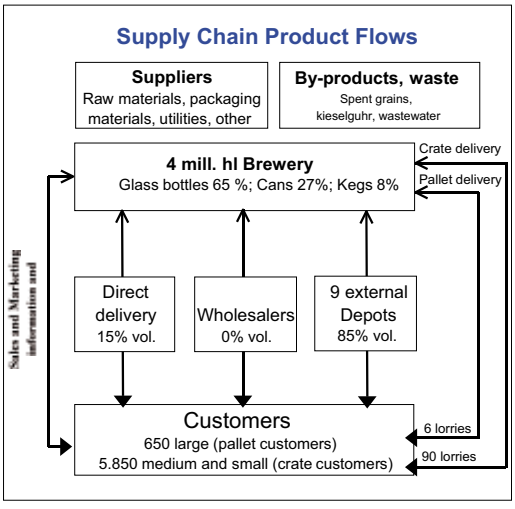

Fig. 7 Supply Chain flows

50. A fully continuous large scale brewery has been proposed and documented with scope from milling to warehouse by Scandinavian School of Brewing (see BRAUWELT International no. 2, 2011, p. 88 sqq. and no. 3, 2011, p. 135 sqq.). ■

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