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Abstracts for the MBAA Annual Conference

Oral Presentations

O-1

A new look at cleaning draft beer systems: The problems, the solution, and the long way to implementation

Presenter: Dirk Loeffler, Loeffler Chemical Corporation, Atlanta, GA

This presentation compares the various draft beer system cleaning approaches and scientifically analyzes their effectiveness. With the draft beer market in the US on a continuous decline, problems are discussed and analyzed and possible solutions are presented. What does it take to properly clean a draft beer system, and how does the industry have to approach this problem?

Dirk Loeffler is the technical director of Loeffler Chemical Corporation, a chemical company specializing in sanitation products and chemical automation for breweries with corporate offices in Atlanta, GA. In his position, Dirk continuously develops and implements new products and cleaning technologies. Dirk came to the United States from Germany in 1992 to lay the groundwork for the U.S. operations of Loeffler Germany, resulting in the incorporation of Loeffler Chemical Corporation in 1994. Born and raised in Cologne, Germany, Dirk graduated in 1989 with a degree in business administration. He then worked for Chemische Fabrik Kalk GmbH before joining the Loeffler family business, where he worked in technical sales and research and development. Dirk lives in Atlanta, GA, with his wife Alexis and their dog Elvis. Dirk has been an active member of the Master Brewers Association of the Americas since 1993, and he is also an active member of the American Society of Brewing Chemists and the Association of Brewers.

O-2

Saving water in the CIP process in the brewing process—A comparison of available technologies

Presenter: Mark Murphy, Butterworth, Inc., Houston, TX

Clean in place (CIP) is one of the largest consumption points and creator of effluent waste in a brewery. By defining CIP, impingement, factors that affect a good CIP, and device types used, this paper provides information focused ultimately on water conservation. A review of the traditional static "spray ball" shows that water usage is extremely high while it lacks cleaning effectiveness. Two-dimensional devices are reviewed for the same characteristics. Since many commercial breweries have CIP systems that were installed 20 or more years ago, three-dimensional devices are reviewed, including a case study. In the case study, a simple nozzle change resulted in a savings of 2,000 gallons per CIP on a fermenter. This savings also translated into over $1,800 per year.

Mark Murphy is a member of MBAA Districts Texas, Rocky Mountain, and St. Louis and has been a home brewer since 2001. A 1985 graduate of the University of Missouri-Rolla in Petroleum Engineering, Mark spent 25 years in the pump industry in a variety of management roles in service and sales. In 2008, Mark joined Butterworth, Inc. as national sales manager.

O-3

Troubleshooting microbiological quality issues in cellar operations

Presenter: Joseph Dirksen, Ecolab, St. Paul, MN

Microcontamination can occur in several areas of cellar operations. This paper reviews case studies pertaining to contamination in several areas of operation, including yeast storage tanks, fermentation tanks, and bright beer lines to fillers. This paper will review rapid test methods that were used to identify areas of contamination and recommendations for corrective action.

Joe Dirksen is executive technical coordinator for Ecolab, Food and Beverage Division. He is responsible for technical support to the beverage, bottled water, and brewery markets. Joe has been associated with Ecolab for 31 years in a variety of technical, marketing, and sales positions, including product development chemist, international R&D manager, beverage marketing manager, and beverage corporate accounts. Joe has a B.A. degree in chemistry from St. John's University, Collegeville, MN, and an MBA from the University of St. Thomas, St. Paul, MN. Joe is a member of the International Society of Beverage Technologists (ISBT) and serves on the ISBT Board of Directors. Joe is a member of the Master Brewers Association of the Americans (MBAA), and regular presenter at the MBAA Brewing and Packaging courses. Joe also is a member of the American Society of Brewing Chemists (ASBC). Joe is a Certified Food Safety Professional through the National Environmental Health Association.

O-4

Behavior of hydrogen sulfide during late-stage fermentation

Presenter: Yutaka Yamaguchi, Suntory Liquors Limited, Japan

Coauthor(s): Taichi Maruhashi, Takuya Hashimoto, Kaneo Oka, and Nobuyuki Fukui, Suntory Liquors Limited, Japan

Hydrogen sulfide gives beer an unpleasant off-flavor reminiscent of the smell of rotten eggs, so it is important to keep the concentration of hydrogen sulfide in finished beer well below the sensory threshold. Control of hydrogen sulfide at the end of fermentation is important not only for high quality beer, but also to keep the brewing period short. Hydrogen sulfide behavior during fermentation has been investigated. It is released from yeast cells during the cell maturation cycle and assimilated during the budding cycle. The decrease in beer's hydrogen sulfide content during late-stage fermentation is attributed both to the purging effect of carbon dioxide and assimilation by yeast. Several reports have been published on the effects of fermentation conditions and gene modifications on the production of hydrogen sulfide. In this study, another behavior of hydrogen sulfide was observed in the late stage of fermentation at the low malt ratio wort. Although hydrogen sulfide levels in late-stage fermentation are normally low under our brewing conditions, under certain conditions hydrogen sulfide content remains high. It was suggested that yeast metabolism and the free amino acid concentration in the wort were key determining factors. After that stage, the hydrogen

sulfide content increased again and then it declined at the end of fermentation. It seems that the hydrogen sulfide content is the result of the balance between its production, its assimilation, and the carbon dioxide purging effect. This investigation confirmed earlier work and provided a more detailed description of the behavior of hydrogen sulfide during the late stage of fermentation.

Yutaka Yamaguchi graduated with a master of the department of chemical science and engineering degree from Kobe University in 2005. After joining Suntory, he worked for two years in the position of second brewmaster at the Suntory Tonegawa Brewery in Gumma, Japan. Since 2007, he has been working at the Beer Development Department of Suntory Liquors Limited.

O-5

Metabolism of flavor compounds in *Brettanomyces bruxellensis* during secondary fermentations at varying pH

Presenter: Andrew Sandstrom, Colorado State University, Fort Collins, CO

Coauthor(s): Chad Yakobson, Crooked Stave Artisan Beer Project, Fort Collins, CO; Pat Murfin, New Belgium Brewing Company, Fort Collins, CO; Jack Avens, Corey Broekling, and Matthew Lewis, Colorado State University, Fort Collins, CO

There is variability in genome arrangement between strains of *Brettanomyces* ("Brett") yeast. These variations have been found to cause different characteristics in the yeast. Everything from cell morphology, colony growth, and metabolism vary between strains. By understanding the metabolism of different strains of Brett, certain flavor characteristics could be targeted in the production of beer. The effects of pH on seven-day secondary fermentations with two strains of *Brettanomyces bruxellensis* were studied. New Belgium Brewing Company (Fort Collins, CO) provided both strains; one was their production *Brettanomyces bruxellensis* (type 1), while the other originally came from White Labs Inc. (San Diego, CA) (type 2). Seven-day secondary fermentations were chosen in hopes of understanding the metabolism of flavor compounds by these two strains under New Belgium Brewing Company's process. "Fat Tire" (New Belgium Brewing Company) beer acidified with lactic acid (95%) was used for fermentations. During the acidification and transfer of the beer, some aeration occurred. Using gas chromatography with flame ionization detector (GC/FID), differences in metabolism between strains were seen. The variability due to pH differences can be attributed to the spontaneous creation of flavor compounds with the addition of acid. A pH-independent two-tailed *t* test with equal variance found yeast dependent compounds. Yeast type 1 had significantly less isoamylacetate, ethyl octanoate, and acetaldehyde compared to the control and type 2, while type 2 had a large increase in acetaldehyde, 3.6 times the amount of the control and 5.76 times the amount of type 1. A pH independent multivariate analysis was consistent with the findings of the two-tailed *t* test, it shows that the yeasts vary the most with respect to acetaldehyde. The reduction of esters was seen in type 1. This ester metabolism is most likely the activity of esterase enzymes that break down the esters into acid and alcohol components. Esterase activity increases the fatty acid content of the beer and affects the "goaty" flavor characteristic of Brett. In type 2, a large increase in acetaldehyde was due to a backup in the metabolism of ethanol or sugar. These differences could be used to create a specific flavor profile based on aging with different strains of *Brettanomyces*.

Andrew Sandstrom studied biomedical sciences at Colorado State University, Fort Collins, from 2006 to 2010. He started home brewing in 2006 when he moved to Fort Collins. In his senior year at CSU, Andrew took brewing science and technology, spending his last semester working with specialists in a variety of fields. Brewers Chad Yakobson (Crooked Stave Artisan Beers Project) and Pat Murfin (New Belgium Brewery) assisted on experimental design and carrying out the experiment. Cultures were grown, plated, and propagated for fermentations in CSU's Food Science Brewing Lab under Jack Avens. Samples were chemically tested in the Proteomics and Metabolomics facility at CSU under Corey Broekling and Matt Lewis. New Belgium Brewery provided yeasts and other lab supplies. Andrew has been a member of MBAA since 2010.

O-6

Pure culture fermentation characteristics of *Brettanomyces* yeast species and their use in the brewing industry

Presenter: Chad Yakobson, Crooked Stave Artisan Beer Project, Denver, CO

This study was conducted to evaluate the pure culture fermentation performance of eight strains of *Brettanomyces* yeasts with the objective to find characteristic compounds produced during fermentation. Colony formation and growth was initially observed on media agars recommended for use in the brewing industry, with strong growth observed on MYPG, WLN, and $CuSO_4$ agar medias. Cell growth during semi-aerobic batch culture showed 2-phase and 3-phase growth patterns, with maximum cell counts reached after 168 to 192 h of propagation. Pure culture fermentations were conducted with multiple pitching rates, and variation was observed in the different abilities of strains to achieve adequate attenuation after 35 days. Longer time was needed for most strains except *B. bruxellensis* (BSI-Drie), which achieved 82.16% apparent attenuation with a pitching rate of 6×10^6 cells/mL. When the strains were pitched at a rate of 12×10^6 cells/mL, a correlation was observed between final pH and final apparent attenuation, with a lower final pH resulting in greater attenuation. Fermentations were further conducted with wort preacidified with lactic acid at concentrations of 100, 500, 1,000, and 3,000 mg/L. Higher initial concentrations of lactic acid had a significant effect, increasing the level of attenuation observed in each strain, while generally decreasing the secondary metabolites produced. Compound analysis of the fermented beers showed ethyl acetate, ethyl caproate, and ethyl caprylate were the significant esters produced, with no isoamyl acetate detected throughout the study. Of the esters produced, ethyl caproate and ethyl caprylate were produced at levels previously unseen in fermented beer.

Chad Yakobson is the owner and brewer of Crooked Stave Artisan Brewery and a member of MBAA District Rocky Mountain. He obtained a B.S. degree in horticulture science before going on to study viticulture and oenology in New Zealand. He then switched his focus to the brewing industry, concentrating on various microorganisms present during barrel aging of sour beer. In 2010 Chad completed his master's thesis, "Primary Fermentation Characteristics of Brettanomyces Yeast Species and Their Use in the Brewing Industry," and was awarded an M.S. degree in brewing and distilling from Heriot-Watt University and the International Centre for Brewing and Distilling in Edinburgh, Scotland.

O-7

The different outcomes of bottle conditioning—How to choose the right yeast and parameters for the job

Presenter: Sylvie Van Zandycke, Lallemand Brewing, Milwaukee, WI

Coauthor(s): Tobias Fischborn, Lallemand R&D, Montreal, QC, Canada

A reliable and consistent bottle conditioning process is a prerequisite to ensure beer quality and brand recognition. Brewers have different expectations from their bottle conditioning process, and understanding how to achieve the desired results starts with choosing the right yeast for the job. In many cases, it has been demonstrated that cropped yeast; which has been reused many times is of variable quality and does not perform as well as fresh yeast. Dry yeast offers a convenient alternative; fresh and consistent every time, it also has the advantages of long-term and easy storage. More importantly, it alleviates the lengthy process of cell counting, as the number of viable cells per gram (typically 5×10^9 to 1×10^{10}) is often specified by the supplier. Bottle conditioning provides many benefits, including flavor enhancement and long-term shelf-life and is increasingly being used by craft brewers from all over the world. Reaching 100% carbonation with yeast alone is routinely performed in some breweries, while some others would rather partially carbonate and add less yeast. The outcome of the bottle conditioning process depends on several parameters such as the strain of yeast, the pitching rate, the type of beer to be refermented, the temperature, and also the priming sugar utilized to feed the yeast. More importantly, the combination of yeast and priming sugar is a determinant factor in a successful conditioning process. Indeed, not all yeast strains are able to utilize the full spectrum of sugars efficiently; this will in turn influence the organoleptic profile of the beer and refermentation performance. These parameters will be discussed based on an extensive study of low and high gravity Weiss beers refermented with different yeast strains in dry form. Tasting and analytical results will be provided, and recommendations for a successful bottle conditioning will be announced.

Sylvie Van Zandycke studied biochemical engineering and fermentation at the Institute Meurice (Brussels, Belgium); she completed her degree in September 1996. She then obtained her Ph.D. degree on Saccharomyces cerevisiae in July 2000 at Oxford Brookes University. From March 2000, Sylvie was employed as project manager for the brewing consultancy firm SMART Brewing Services. In 2004 she left the United Kingdom for Canada and accepted a post at Lallemand Inc. as project manager for their Genetic Identification Laboratory. She was involved with both yeast and bacteria QC and R&D, and her main focus in research was developing new methods for micro-organism identification and characterization, as well as detection of contaminants in alcohol production processes. Since February 2007, Sylvie has occupied the position of brewing fermentation manager and, more recently, technical sales manager for Lallemand Brewing to service and support the brewing industry worldwide with dry yeast and nutrition products.

O-8

About the influence of the false bottom on the lautering process in a lauter tun

Presenter: Simon Henke, Technical University Munich, Chair of Process Engineering of Disperse Systems, Germany

Coauthor(s): Jakob Aps, Johannes Tippmann, Jens Voigt, and Karl Sommer, Technical University Munich, Chair of Process Engineering of Disperse Systems, Germany

The lautering process is the most time-consuming step of the production of wort. Besides mash filters, the lauter tun is still the most common device for mash filtration in the brewhouse because no other separation technique has been established. For this reason, equipment suppliers have done a lot of development work on existing lauter tuns, which has led to an acceleration of this filtration step. Nevertheless, there are still many open questions regarding the performance of mash filtration in the lauter tun, especially causes of filtration problems during this unit operation have not been fully investigated. High flow rates through the filter cake often lead to increased compaction of the compressible filter cake. This work investigates how false bottoms with different free passage areas influence the lautering performance and the composition of the grain cake. For this reason a pilot-scale glass lauter tun was constructed, which offers the opportunity to make an image analysis of the grain cake during the whole process. A double-walled, heatable shell assures constant temperatures up to 194°F over the entire lautering time, so that a negative influence on the filtration result by decreasing mash temperature is excluded. The lauter tun is equipped with four different false bottoms, with defined free passage areas between 6 and 20%, which cover the range of available industrial-scale systems. Besides the optical analysis, the most important physical parameters of lauter wort are recorded in-line. The presented filtration equations allow the determination of filter cake permeability and the development of permeability during the filtration with these measurements. The experiments showed a correlation between the free passage area of the false bottom and the permeability of the grain cake.

Simon Henke graduated from Technical University Munich in 2009 with a degree in engineering for brewing sciences and beverage technology. In 2010 he started his work at the Chair of Process Engineering of Disperse Systems, TU Munich, as a research associate. His fields of activity are mass transport phenomena during the mashing process and filtration projects in the brewhouse. He is responsible for the pilot plant brewery at the Chair of Process Engineering of Disperse Systems and is jointly involved in dispensing technology projects.

O-9

Applications of new analysis methods for the procedural characterization of mash

Presenter: Johannes Tippmann, Technische Universität München-Weihenstephan, Chair of Process Engineering of Disperse Systems, Freising, Germany

Coauthor(s): Jens Voigt and Karl Sommer, Technische Universität München-Weihenstephan, Chair of Process Engineering of Disperse Systems, Freising, Germany

Technological impacts on the mashing process are well investigated, and the influences of raw material quality, fineness of the ground malt, and temperature programs are explored. A number of analysis methods are provided from different institutes, but there are still new possibilities to analyze the mashing process. By analyzing the mash by particle size distribution, much information about the disagglomeration, gelatinization, quality of the malt, and of course the milling process can be observed. Meanwhile a large number of trials were done that show these differences. Another possibility is the measurement of the particle charge. Investigations show that a characterization of flour is possible, even the detection of different cereal types. With this background, an analysis method was developed, and a large number of trials were done to characterize the mash depending on their charge potential. However, both analysis methods are not only able to analyze the mash. With the information gained, additional important information about the influence on the lautering process and the expected filter performance can also be obtained. The presentation will

show the analysis methods, the results of the mash characterization, and the results of filtration tests.

Johannes Tippmann graduated from university in 2004 as a diploma engineer for brewing sciences and beverage technology. In 2005 he started work on his Ph.D. thesis with Karl Sommer on solid handling in the brewhouse. He gained wide experience in the procedural knowledge concerning beer production during his studies, performing student research projects and his diploma thesis on this topic. Since 2000 he has worked as a student research assistant in dispensing systems and has gained lots of experiences in this subject area. Since 2006, he has been responsible for research issues in dispense systems at the institute. He is also a member in the Dispensing Systems Technical Committees of the government Association for Food and Catering Industry (BGN) and of the DIN German Institute for Standardization. He is working for the MEBAK Dispense Work Group and has published a number of papers.

O-10

The effect of vibrations on barley malt and apple juice mashing

Presenter: Martin Zarnkow, Technische Universität München-Weihenstephan, Freising, Germany

Coauthor(s): Thomas Aldinger and Thomas Becker, Technische Universität München Weihenstephan, Freising, Germany

Mashing is a process in which insoluble substances are dissolved. Principal mashing for food processes has to satisfy ecologic and quality standards. Mashing is a process involving the raw material, technical equipment, and technological regime. Every parameter influences the substrate which is responsible for high final product quality. A vibration unit, an imbalance drive, well known from the setting of concrete and toothbrushes were used with frequencies between 70 and 150 Hz in brewhouse and apple juice mashing. During brewhouse mashing various benefits were obtained. The oxygen content was lowered with respect to lower staling agents in the final beer. Higher extract yield with higher enzyme activity was a remarkable advantage, too. The vibration unit used during mashing of apple juice was helpful to produce more apple juice in less time. If watering were performed during mashing higher extract, a better rate of yield could be obtained.

Martin Zarnkow apprenticed as a brewer and maltster from 1989 to 1991 at a small brewery in Frankonia. He finished a Diplom-Ingenieur (FH) degree with an option in brewing technology in 1996 at TU München Weihenstephan. He worked as a brewmaster for one year in a medium-sized brewery in Germany. Since 1997 he has been the head of the research group for beverage technologies and head of the central laboratory at the Lehrstuhl für Brau-und Getränketechnologie (Institute for Beer and Beverage Technology) at TU München in Weihenstephan. External Ph.D. research performed at the University College of Cork, Ireland, on the subject "Proso Millet (Panicum miliaceum L.) a Sustainable Raw Material for the Malting and Brewing Process" was finished in 2010.

O-11

Whole grain conditioning—Alternative method to increase brewhouse performance

Presenter: Jens Voigt, Technische Universität München-Weihenstephan, Process Technology, Research and Development, Ludwigsburg, Germany

Grist composition, mashing process, and lautering performance (LP) are closely connected. Interrelations have hardly been described in all their variants. Common tables are not valid if grain is conditioned or steeped. A new method of whole grain conditioning (WGC) has been developed to increase LP by keeping or improving technological values and using common roller mills. WGC means an increase of water content to 10 to 15%. Due to short contact time and high mixing rate the water accumulates mainly in the husks and germs. Those are less destroyed during milling, which leads to proper LP and beer quality. Various trials have been executed in pilot scale. Compared to dry grist the LP rises by 5 to 20% with WGC, depending on raw material mixtures (malt with/without adjuncts). Hence, different process optimizations are possible (brews/day, yield, beer quality). Scale-up trials have been already started. Compared to steep conditioning, simple technical adaptations lead to success. Currently, further trials are in progress.

Jens Voigt received a Diploma Engineer (M.S.) degree in brewing and beverage technology from TU München-Weihenstephan, Germany, in 1985. He held several positions in the brewing equipment supply industry from 1985 to 2003. He received his doctorate in brewing technology with Prof. Narziss in 1993. Since early 2004 he has been an assistant professor with Karl Sommer at the Chair for Process Technology of Disperse Systems at the WZW (Wissenschaftszentrum Weihenstephan [Center of Life Science, Weihenstephan]), working on brewing process technology issues. He is member of MBAA and IBD, as well as the editorial boards of the Technical Quarterly of the Master Brewers Association of the Americas and the Journal of the Institute of Brewing. Jens is currently chair of the IBD International Section. He is also a member of the MBAA Global Emerging Issues Committee and the EBC Brewing Science Group. His work group was awarded the EON award for environment in 2008.

O-12

Effects of long dry steeping and high-temperature germination on selected quality parameters of malt

Presenter: Fuminori Katono, Kanbaku Company Limited, Tochigi, Japan

Coauthor(s): Tetsuya Arita, Suntory Liquors Limited, Tokyo, Japan; Hitoshi Matsubara, Suntory Business Expert Limited, Tokyo, Japan; Nobuyuki Fukui, Suntory Liquors Limited, Tokyo, Japan

The inter-relationship between the conditions of the malting process and the resultant malt quality were investigated. A correlation was found between the wet and dry periods and the water content of the steeped barley. It was concluded that a longer dry period in the steeping process is important to stimulate cytolysis. No difference was found in the resultant malt extract levels and acrospire length. When the degree of steeping was kept to about 43%, the germination process at a higher temperature was found to stimulate cytolysis. However, proteolysis was greatly reduced by increasing the temperature. As a result of high temperature germination, we obtained a malt with a 10% increase in Calcofluor modification and a 20% decrease in Kolbach index. Malt with a lower cytolysis level tends to form gel, which causes an increase in viscosity and can lead to filtration difficulties. Since the combination of modified steeping and germination produced malt that would contribute to a good quality malt, we expect that this technique will be useful in the commercial-size malting process.

Fuminori Katono graduated from Niigata University with an M.A. degree in agriculture. In 2003 he joined Suntory, where he worked in the Tonegawa Brewery as second brewmaster. In 2005 he moved to the Beer Production Department, taking charge of the quality control of raw materials. He is currently production director at the Malting Plant of Kanbaku Co., Ltd., an affiliated company of Suntory.

O-13

Malting process optimization of barley (*Hordeum vulgare* L.) to reduce the content of initiators and maximize the content of inhibitors of sunstruck flavor

Presenter: Alicia Muñoz Insa, TUMünchen, Lehrstuhl für Brau- und Getränketechnologie, Freising, Germany

Coauthor(s): Martina Gastl, TUMünchen, Lehrstuhl für Brau- und Getränketechnologie, Freising, Germany; Thomas Becker, Technische Universität München Weihenstephan, Freising, Germany

Sunstruck flavor is an off-flavor formed by exposure to light during storage of beer. Isohumulone, present in hops, is the main substrate of this reaction, but other substances present in malt also play an important role. Substances such as riboflavin, cysteine, and methionine are known as off-flavor initiators and tryptophan and polyphenols as off-flavor inhibitors. In this work, the malting process of barley was optimized to ensure good processability and also to maximize the content of inhibitors and minimize the content of initiators of sunstruck flavor. Minimizing or maximizing the content of initiators or inhibitors, respectively, present in malt makes it possible to reduce the off-flavor in the final beer or beverage. The influence of three malting parameters (degree of steeping, germination time, and germination temperature) on the quality of barley malt was investigated. A series of malt quality parameters was evaluated to examine and guarantee good processability: extract, apparent attenuation limit, Kolbach index, free amino nitrogen, β-glucan, and viscosity. Also, the content of inhibitors and initiators of sunstruck flavor in malt was analyzed.

Alicia Muñoz Insa was born in 1983 in Spain. She graduated with a Dipl. Ing. degree at the Universidad Politécnica de Madrid in 2009 and carried out her diploma thesis research at TU München. Since 2009 she has been a Ph.D. student at the Lehrstuhl für Brau- und Getränketechnologie, TUM, working in the field of beverages of alternative cereals.

O-14

Wheat beer—Possibilities to influence the character

Presenter: Gerrit Bluemelhuber, Doemens Academy GmbH, Graefelfing, Germany

Coauthor(s): Bertram Sacher, Doemens Academy GmbH, Graefelfing, Germany

Wheat beers are very common top-fermenting beers. The two major possibilities for influencing aroma are the 4-vinylguaiacol (clove) aroma and the isoamylacetate (banana) aroma. It is well documented that the choice of yeast strain influences the formation of these flavors. Although the yeast strain definitely has a big influence on the aroma profile, there are a few more important aspects during the brewing process that influence the aroma profile. Raw materials , method of mashing, conditions of fermentation (especially temperature), and equipment used all influence the final aroma profile. In this presentation different aspects and their influence will be shown.

Gerrit Bluemelhuber was born in Mainz, Germany. After working in the Sonnenbrauerei, Mainz, Germany, he started his studies in Weihenstephan, where he received a Dipl.-Ing. degree in brewing and beverage technology in 1996. After that he worked at the Technical University of Munich, where he received his Ph.D. degree in 2002. From 2004 to 2009 he worked in his own engineering firm as a consultant for energy and environmental techniques. Since April 2009 Gerrit has been the managing director for consultancy at Doemens in Graefelfing, Germany. He is responsible for the complete consultancy portfolio of Doemens and for the scientific projects that are executed by Doemens.

O-15

Antioxidant activity and polyphenol content of special types of beer

Presenter: Sasa Despotovic, Faculty of Agriculture, University of Belgrade, Belgrade, Serbia

Coauthor(s): Ida Leskosek-Cukalovic, Mile Veljovic, Miomir Niksic, and Viktor Nedovic, Faculty of Agriculture, University of Belgrade, Belgrade, Serbia

Antioxidants have important nutritional importance for the human body. They are considered as promoters of cardiovascular health, preventing cancer, and they could even slow down the aging process in humans. Beer as a popular beverage, when consumed in moderation, could be a good source of antioxidants, mainly phenolic acids originating from hop and barley. It is well known that beer is rich in phenolic compounds that have better quality, foam stability, sensory characteristics, and a longer shelf life. This study examined total polyphenol content and antioxidant activity of novel beer types produced with herbs (*Melissa officinalis*, *Thymus vulgaris*, *Humulus lupulus*), a mushroom (*Ganoderma lucidum*) and red grapes. Total polyphenol content was determinate using the standard EBC method and the Folin-Ciocalteu method, as a standard galic acid was used. Similarly, antioxidant activity was measured by the ferric reducing antioxidant power (FRAP), using the free radical 2,2-diphenyl-1-picrylhydrazyl (DPPH•) method and the 2,2′-azinobis (3-ethylbenzothialozinesulfonicacid) radical ABTS assay. Total polyphenol and phenolic acid contents to a great extent vary among different beer types (beer with a grape shows the highest polyphenol content). Similarly, the antioxidant activity of beer with a grape showed higher values then beer with *Melissa officinalis*. The contribution of single herbs and mushroom extract, as well as red grape must, to the antioxidant activity of beer were also studied.

Sasa Despotovic is a Ph.D. student at the Department of Brewing, Institute for Food Technology, Faculty of Agriculture, University of Belgrade, Serbia. He graduated from the Department of Brewing. Since 2008, Sasa has been an assistant teacher for the course Beer and Malt Technology. He is a member of the Serbian Society for Food and Nutrition. He is currently working on a project investigating the possibilities for making novel beer products based on their potential pharmacodynamic action. Sasa is interested in microbiology, food safety, and development of methods for antioxidant activity of beer-based products.

O-16

Beer is good for you: Reality or oxymoron?

Presenter: Charles Bamforth, Department of Food Science and Technology, University of California, Davis, CA

We might say that the topic of beer and health is a minefield. The author is willing to traverse this territory armed with the latest information.

Charlie Bamforth is the Anheuser-Busch Endowed Professor of Malting & Brewing Sciences at UC Davis. He has been part of the brewing industry for more than 33 years. He is the former deputy director-general of Brewing Research International and research manager and quality assurance manager of Bass Brewers. He is a special professor in the School of Biosciences at the University of

Nottingham, England, and was previously visiting professor of brewing at Heriot-Watt University in Scotland. Charlie is a Fellow of the Institute of Brewing & Distilling, the Society of Biology, and the International Academy of Food Science and Technology. Charlie is editor-in-chief of the Journal of the American Society of Brewing Chemists, is on the editorial boards of several other journals (including the Technical Quarterly of the Master Brewers Association of the Americas), and has published innumerable papers, articles, and books on beer and brewing and has also written prolifically on soccer. His latest contributions have been The Brewmaster's Art (A seven-CD recording in The Modern Scholar series) and Beer Is Proof God Loves Us: Reaching for the Soul of Beer and Brewing (FT Press). In October 2010 he was on the honor roll as one of the 20 professors who are changing the classroom in the United States (Playboy magazine).

O-17

Reduction potential of fermentable and unfermentable sugars in beverages and the brewing process

Presenter: Thomas Kunz, Berlin Institute of Technology, Department of Biotechnology, Chair of Brewing Science, Berlin, Germany

Coauthor(s): Eon-Jeong Lee, Torsten Seewald, Victoria Schiwek, and Frank-Jürgen Methner, Berlin Institute of Technology, Department of Biotechnology, Chair of Brewing Science, Berlin, Germany

The properties of reducing sugars are interesting for the shelf life of beverages, human nutrition, and the brewing process, especially during wort boiling, where the sugar reactions are accelerated. During the last decades, various research groups have applied different methods to ascertain the reducing potential of sugars. In comparison to the traditional Fehling method, the method according to Chapon and Louis to determine the reducing potential of beer and wort is not applicable for determining the reducing power of sugars. This method describes the reducing power of beverages against a complex of Fe^{3+} with 2′,2′-dipyridyl. Our research work proved that the proposed analytical parameters for the Chapon method, concentration, temperature (20/25°C), and time (300 s), are unqualified. However, varying different parameters, like temperature (80°C) and concentration, showed that the basic reaction mechanism of the Fe^{3+} reduction is able to differentiate reducing potentials between different sugars in low pH areas. The functional principle can be used to achieve information about the behavior of sugars at different temperatures and during storage of beverages. To emulate the accelerated aging trials, an optimized Chapon method using a temperature of 60°C (1h) was developed. Sugars in low pH beverages behave differently than the generally known behavior described by Fehling when using NaOH in the Fehling II solution. The applications of the optimized method demonstrate that in a low pH area (4.2), the strongest reducing potential results from isomaltulose (Palatinose™), followed by fructose, Vitalose®, and maltotriose. Additional investigations using the reaction mechanism according to Fehling (Cu^{2+}) in this pH area showed similar results. At low pH, the formation of the open-chain aldehyde structure of glucose is inhibited. In contrast, fructose possesses a higher ability to generate the open-chain-structure at low pH, resulting in much stronger reducing properties. The results also show that sucrose has a higher reducing potential against Fe^{3+} than glucose. The increasing reducing potential of the "non-reducing sugar" sucrose at low pH can be explained by the acid hydrolyzed formation of invert sugar and the strong reducing potential of the formed fructose. Other investigations at higher temperatures (80/90°C) and higher pH (5.1) give evidence about the behavior of fermentable sugars during wort boiling. Besides the described mode of action of glucose, fructose, and sucrose, the stronger reducing potential of maltotriose against maltose is remarkable. Finally, the optimized Chapon method can be used to support the investigation of the complex reaction mechanism of different sugars in beverages (juice, wine, beer) and the brewing process.

After qualifying as a certified technician in preservation engineering (1991–1993), Thomas Kunz completed his basic studies in chemistry at the University of Applied Sciences, Isny (1994–1995) and his basic studies in food chemistry at Wuppertal University (1995–1998), before starting to study food technology at the University of Applied Sciences, Trier (1998–2002). After graduating, he worked as a chartered engineer in the area of EPR spectroscopy at the Institute of Bio Physics at Saarland University (2002–2004). Since January 2005, he has been employed as a Ph.D. student at the Research Institute of Brewing Sciences, Berlin Institute of Technology (Technische Universität Berlin). His main research focus lies in analyzing radical reaction mechanisms in beer and other beverages using EPR spectroscopy.

O-18

Serial repitching: Does yeast generation number matter?

Presenter: Katherine Smart, University of Nottingham, Loughborough, U.K.

Serial repitching is a common practice in brewing. Great care is taken to ensure that a yeast crop is recovered and stored effectively before reuse in subsequent fermentations, with the expectation that performance will be consistent irrespective of the number of fermentations a crop has completed (generation number). Early generation yeast tends to be slow to perform, while later generation yeast tends to exhibit genetic changes, poor viability, and inconsistent flocculation and flavor profiles. Efficient fermentation requires conditions appropriate for ensuring high productivity, while maintaining yeast viability, genetic stability, and fermentation performance. However, optimal conditions for the former can be sub-optimal for the latter. This paper will focus on the stresses customarily associated with fermentation, providing insight into the reasons why yeast generation is important. This paper will demonstrate that previous assumptions concerning the relative impact of certain stresses may not be correct. In particular, we will focus on whether certain stresses could even be beneficial to fermentation.

Katherine Smart completed a B.S. (honors) degree in biological sciences at Nottingham University in 1987 and was awarded the Rainbow Research Scholarship to complete a Ph.D. in brewing yeast and fermentation at Bass Brewers, Burton-on-Trent. She then moved to Cambridge University to take up an appointment as a research fellow in the Department of Plant Sciences, where she worked on bioactive surfaces, biofouling, and bacterial contamination of beverages in collaboration with the beverage packaging company Elopak. In 1992, Katherine became a lecturer in microbiology and fermentation at Oxford Brookes University. By 2000, she had been appointed Scottish Courage Reader in Brewing Science and became the youngest Fellow of the Institute and Guild of Brewing. In 2005 Katherine moved to the University of Nottingham, where she became the SABMiller Professor in Brewing Science. She was nominated as a Fellow of the Royal Society for the Arts, Manufacturing and Commerce in 2009 and a Fellow of the Society of Biology in 2010. She leads brewing science at the University of Nottingham, which offers a state-of-the-art e-learning M.S. degree in brewing science, and has established brewing science research programs in barley genomics, malting, yeast genomics, fermentation, and flavor. She currently holds some £8 million in research funding for brewing and bioetha-

nol fermentations. Katherine has received several awards for her research, including the Institute of Brewing and Distilling Cambridge Prize (1999), the prestigious Royal Society Industrial Fellowship (2001–2003), an Enterprise Fellowship (2002), and the Save British Science Award at the Houses of Parliament in the United Kingdom (2003). Her core research interests are yeast cell biology, fermentation (beer fermentations, bioethanol fermentations), and stress responses in yeast.

O-19

Improvement of the oxidative and colloidal stability of beer by use of alternative filter aids

Presenter: Frank-Jürgen Methner, Berlin Institute of Technology, Institute of Biotechnology, Chair of Brewing Sciences, Berlin, Germany

Coauthor(s): Thomas Kunz, Berlin Institute of Technology, Institute of Biotechnology, Chair of Brewing Sciences, Berlin, Germany

Filtration trials with kieselguhr, CMF, and other filter aids have shown a different influence on the haze formation and oxidative stability of beer. Our recent studies have shown that in stabilized beer the chill haze formation is correlated with oxidative processes and reaction products originating from the Fenton-Haber-Weiss reaction (Fe^{3+}, Cu^{+}, $OH^{\bullet}$) system after the consumption of the endogenous antioxidant potential (EAP). These reaction products start interacting and generate metal ion complexes with oxidized, haze-active polyphenol-protein complexes. These complexes are significant for their visible chill haze formation. The formation is dependant on temperature, because of the low bonding forces. Based on the stronger bonding forces of specific metal ions in beer at lower pH values a higher haze formation can be observed. This phenomenon can be explained by more bonding sites that stabilize the generated chill haze. However, the EAP consumption proceeds slower, because there is a lower concentration of iron ions available for the acceleration of oxidative processes and the radical generation caused by the Fenton-Haber-Weiss reaction system. This results in a higher oxidative stability, but later and stronger chill haze formation. Contradictory to that, experiments at higher pH areas resulted in an earlier but lower haze formation due to the weaker bonding power in the metal complexes with haze active polyphenol-protein complexes and in a significantly faster consumption of the EAP. The results show that a lower availability of iron ions generally leads to a higher oxidative stability. Based on the described reaction mechanism the metal ion insertion during filtration has an important influence on the oxidative beer stability and haze formation. A high metal ion insertion with kieselguhr filtration leads to an acceleration of oxidative processes by the Fenton-Haber-Weiss system and results in a faster consumption of the antioxidative potential. Depending on the metallic ion content a stronger chill haze formation by oxidation and the formation of metal complexes with oxidized haze active polyphenol-proteins can be observed in beer stabilized with PVPP. In comparison to the kieselguhr filtration combined with PVPP stabilization, a new filter aid (polystyrene combined with PVPP) without metal ion insertion was used for beer filtration. The results clearly demonstrate higher oxidative beer stability and lower radical generation mainly caused by lower metallic ion content. Additionally, significant higher colloidal beer stability could be observed. It has been shown that this research work can provide useful knowledge about the increase in oxidative beer stability using a new filter aid and avoiding the undesired haze fermentation in beer and other beverages.

Frank-Jürgen Methner studied brewing science at Berlin Institute of Technology (TU Berlin) from 1975 to 1981. After his studies, he worked as an operations supervisor at the Schlösser Brauerei. From 1982 to 1986 he as a scientific assistant with teaching duties at the Research Institute for Brewing and Malting Technology of the VLB. His Ph.D. thesis was on "Aroma Formation of Berliner Weissbier with special focus on Acids and Esters." For 18 years, starting in 1987, Frank-Jürgen held a leading position as a director at the Bitburger Brauerei, Bitburg, Germany, with responsibilities in fields such as technology and quality assurance. Beginning with the winter semester of 2004/2005, he took over the Chair of Brewing Science at the Berlin Institute of Technology.

O-20

Tracing current developments in beer filtration and stabilization

Presenter: Roland Folz, VLB-Berlin, Germany

A long-term study to investigate the performance and technological behavior of different filtration and stabilization innovations in the brewing world was carried out by VLB-Berlin. The trials were performed in pilot scale, as well as in industrial applications. Results will be presented on the use of cross-flow membrane filtration, Crosspure filtration and stabilization, CSS stabilization, tannin stabilization, and the creation of a stabilization kinetic. As stabilizing in the cross-flow membrane process is still an unsolved challenge, VLB is running a research project to create new opportunities using the principle of ligand excess. Some of the results refer to this project, as, for example, the new model of stabilization kinetics for different beer matrix. The Crosspure combined stabilization and filtration process has been evaluated in a German brewery meeting the demands of a technical approval test. The analytical and technical results will be presented. The CSS system has become popular as a continuous running stabilization device. A field study with a German brewery shows a pH shift that was traced by ion chromatography to solve the phenomena. Furthermore, as the use of isinglass will soon have to be stated on the label, purified tannic acids have been tested as a possible alternative. The author will create a holistic view on innovations that are currently discussed, as well as possibilities that have recently become commercially available to the brewing industry in order to help brand owners decide on new possibilities based on independent technological results.

Roland Folz apprenticed as a brewer and maltster at the Beck's Brewery in Bremen, Germany. After working for an additional year at the Beck's brewery, he started his studies in Berlin and received a diploma engineer degree in brewing technology from the Technical University, Berlin. After graduation, he was employed as head of the Technical Department/Production at the Preussen Pils brewery in Pritzwalk, Germany, for two years. In October 2006, he started working at VLB-Berlin as a global consultant for brewing and beverage technology, he did his Ph.D. research on flavor stability and PET topics. Since autumn 2008, Roland has been head of the Brewing & Beverage Technology and Applications Department at the VLB-Berlin. This department includes the education and teaching section of VLB, as well as the research activities regarding technological topics, global consulting, analytics, and services.

O-21

Biogas from spent grains—State-of-the-art technology

Presenter: Jens Voigt, Technische Universität München, Center of Life Sciences, Weihenstephan, Germany

Brewer's spent grains form a major portion of the waste from the brewing process and can be used for re-gaining of energy in the form of biogas. Since this waste is not in competition

with other crops that are specially produced for energy production, the ecological balance of a brewery plant can be improved. If the biocenosis for fermentation is carefully selected and the spent grains are milled to a suitable particle size, the efficiency of biogas generation can be improved. The energy balance of a brewery can be influenced positively. The fermentation is done in several process steps with hydrolysis and methane formation. In a further step, the fermentation will be set up in a continuous solid-state fermenter, which leads to reduced plant sizes and increased biogas yield.

Jens Voigt received a Diploma Engineer (M.S.) degree in brewing and beverage technology from TU München-Weihenstephan, Germany, in 1985. He held several positions in the brewing equipment supply industry from 1985 to 2003. He received his doctorate in brewing technology with Prof. Narziss in 1993. Since early 2004 he has been an assistant professor with Karl Sommer at the Chair for Process Technology of Disperse Systems at the WZW (Wissenschaftszentrum Weihenstephan [Center of Life Science, Weihenstephan]), working on brewing process technology issues. He is member of MBAA and IBD, as well as the editorial boards of the Technical Quarterly of the Master Brewers Association of the Americas and the Journal of the Institute of Brewing. Jens is currently chair of the IBD International Section. He is also a member of the MBAA Global Emerging Issues Committee and the EBC Brewing Science Group. His work group was awarded the EON award for environment in 2008.

O-22

Energy conservation in craft breweries across three orders of magnitude

Presenter: Jaime Jurado, The Gambrinus Company

Large brewing organizations have set new expectations on water and energy optimization in the brewery, galvanizing and engaging staff in plants in disparate locations to benchmark and reach target goals in terms of reductions. Every brewery appreciates as a desired objective the need and the challenge to increase its output while reducing overall energy consumed. Justification of investments resulting in reduced energy or GHG footprint in the brewery can be difficult for the artisanal brewery, which does not have scale in its favor. Examples will be presented across all areas of the brewery, with data on projected payback and potential savings that can be realized. Some solutions are scalable across three orders of magnitude, and some are applicable to only one scale. Notable brewers have committed to approaches beyond the constraints defined by ROI due to company philosophies in anticipation that their customers will endorse such commitments, and data addressing this framework will be shared. Every brewery must find its balance in how it can reduce its energy footprint, and there is a place for emerging technologies and approaches, as well as in proven and established investments. The engineer's perspective presented must be reconciled with brewing and quality philosophies.

Jaime Jurado has served as director of brewing operations for more than 14 years at The Gambrinus Company Breweries. His focus includes engineered approaches to growth, such as modeling and resolving optimal tank sizes at one brewery, upgrading and improving energy yield in another, reducing the GHG footprint by design in another. Jaime is a senior member of the AIChE, a past chair of the San Antonio ACS Section, program chair of CERMACS ACS conferences, and past president of MBAA. He completed his studies as a Brauerei Praktikant in Nürnberg, Würzburg, and Augsburg, Germany, at Patrizier-Bräu AG and has his undergraduate degree in chemical engineering and his M.S. degree in electrical engineering. He also did three years of postgraduate study and research in medical engineering, while retaining part-time employment in the brewing industry.

O-23

Initiatives to restrict carbon dioxide emissions by Asahi Breweries

Presenter: Yoshinori Ito, Asahi Breweries, Ltd., Ibaraki Brewery, Japan

Asahi Breweries is pursuing environmental initiatives centering on diverse energy conservation measures in order to conserve the global environment and restrict carbon dioxide (CO_2) emissions. At last year's MBAA Annual Conference, Asahi Breweries gave a presentation on its energy conservation management system, as one of many energy conservation measures that Asahi Breweries employs, including the use of a proprietary pre-isomerizer and evaporator (PIE) system that shortens the wort boiling time by adding pre-boiled hops. All Asahi Breweries plants carry out wastewater treatment using anaerobic wastewater treatment equipment based on methane fermentation, which is integrated into the plant wastewater treatment facilities. The process releases methane gas as the main ingredient for biogas, which is recycled as a fuel for steam and afterburner boilers used for gas turbine cogeneration. Gas turbine exhaust gas from cogeneration has a high flow rate and low oxygen density, and Asahi Breweries found that it was not possible to combust low combustion-heat biogas on its own in afterburner boilers. It was found to be necessary to simultaneously combust liquefied natural gas (LNG) in a separate burner in order to use the biogas effectively. Asahi Breweries has successfully reduced steam consumption throughout its breweries by deploying diverse energy conservation measures, including PIE. However, the decrease in steam consumption caused a decline in the rate of biogas use, as the biogas could not be utilized for cogeneration afterburner boilers without simultaneously combusting LNG to achieve effective combustion. Therefore, Asahi Breweries developed a new biogas burner for gas turbine exhaust gas to improve the rate of biogas use. The biogas burner enables low combustion-heat biogas to be combusted on its own, even if the exhaust gas has a high flow rate and low oxygen density. These biogas burners are improving the rate of biogas use and are having a significant impact on reducing CO_2 emissions at breweries.

Yoshinori Ito joined Asahi Breweries in 1989. After joining the company, Yoshinori was put in charge of a new product development and bringing new products to market. Yoshinori joined the Nagoya Brewery, Brewing section in 1996 and became the manager of Development Laboratories for Alcoholic Beverages, Department of Beer Product Development in 1999. Yoshinori joined marketing headquarters in 2000. The marketing of Honnama became the first happousyu in Asahi Breweries, Ltd. in October 2000. Yoshinori joined the Product Strategy Department in 2003. In 2006 Yoshinori became the deputy general manager (Ibaraki Brewery) of the Production Technology Center and general manager in 2009.

O-24

Managing peak energy with smart grid controls

Presenter: James Spencer, New Belgium Brewing Co.

Peak energy is an important issue facing this country, rising demand is pushing the capacity of the generation and distribution infrastructure beyond its capacity. As a result, there are increasing capital costs that will be passed on to the consumer through higher rates, and more equipment must be installed to provide power during these peak times. In light of the challenging issues, the Department of Energy awarded a group from Fort Collins, CO, a grant to explore innovative ideas that

could reduce the peak load on the grid and extend the capacity by as much as 30%. The solution that this group developed involved using smart grid controls to manage technology for site power generation and load reduction methods. The smart grid controls are configured to provide communication and information between the grid and these assets so they can be deployed at times of peak energy demand. This solution would leverage existing and new distributed generation and load-shedding methods and reduce or eliminate new investments in the utility's electrical power infrastructure. This presentation will provide the details of how this technology has been implemented at New Belgium Brewery and other sites in Fort Collins.

Jim Spencer has been with New Belgium since 2005. He leads the brewery's engineering design team, which is responsible for many brewing technology innovations, as well as some remarkable energy efficiency and water-saving ideas at the brewery. Jim has 25 years of experience in engineering and project management in the brewing and beverage industries. He has a B.S. degree in chemical engineering from Colorado School of Mines and an MBA from the University of Colorado.

O-25

A survey on positive results from microbiology analyses—Do we have the fast detection methods we need?

Presenter: Gudrun Vogeser, PIKA Weihenstephan GmbH, Pfaffenhofen/Ilm, Germany

During beer production, the growth of several microorganisms can cause spoilage. Well known are some representatives of the genera *Lactobacillus* and *Pediococcus*, in addition to anaerobic *Megasphaera* and *Pectinatus* species. Different bacteria species inherit different capabilities for spoilage. Besides generating turbidity by growing to high numbers, they may cause off-flavors such as diacetyl, acetic, lactic or propionic acid, hydrogen sulfide, etc. The brewer not only needs to detect these spoilers at a very early stage, but also has to know about their spoilage potential as soon as possible. By application of the PCR method it is possible to receive knowledge about the appearance of a spoiling microorganism at a very early stage and to identify the species. The microbiological flora in different breweries have been monitored with PCR applications, and the data from 2010 and 2011 (as far as available) will be shown. The influence of malt contamination with spoiler organisms on the microbiology in the following brewing process is examined. By comparison of different PCR applications that are commercially available for in-house analytics, an attempt is made to describe from the brewer's point of view the requirements for the most valuable fast detection system—ease of use, worth of result, and costs.

Gudrun Vogeser is a specialist in microbiology and molecular biology techniques used for the detection of beer- and beverage-spoiling microorganisms. She is founding member and, since 2009, chair of the European Brewery Convention (EBC) Microbiology Committee. She received a diploma in microbiology and finished her Ph.D. thesis in 1992 at the Chair of Brewing Technology at Weihenstephan, Germany. As a post-doc she started working on molecular biology methods to be used for the fast detection of beer-spoiling bacteria, focusing on polymerase chain reaction. After working as a scientist at the Chair of Brewing Technology in Weihenstephan, she founded, in January 2000, the company PIKA Weihenstephan, Pfaffenhofen. The company specializes in serving the brewing industry in microbiological analytics, both with diagnostics and products.

O-26

Constructing beer quality

Presenter: Alastair Pringle, Pringle-Scott LLC

Beer quality can be defined in many ways, including fitness for consumption, conformance to specification, and sensory quality. New breweries are confronted with the daunting task of having to design a quality program to meet these criteria. Several approaches can be used to develop a new quality program, such as 1) adoption of one from an established brewery; 2) development of one based on current capabilities; or 3) development of one from basic principles. This paper describes how to develop a quality program using the latter approach. A quality program should address quality from three aspects: 1) health and safety; 2) nutritional characteristics; and 3) sensory profiles of the beer brands. Sensory is not defined by regulations and formal programs, unlike the first two aspects of quality. The first step in developing a program that addresses sensory quality is to identify the beer parameters that are important to the brewer and customer. The next step is to identify how these parameters can be measured and establish their acceptable limits. Following these efforts, the control points for the quality parameters should be identified and a strategy developed for controlling them through automatic or manual means. Finally, control point limits should be established together with an action plan to address situations when they are operating outside of these limits. Management of sensory quality is then primarily controlled at the process level, unlike a traditional quality program. In this approach, in-line measurement and operating parameters are used as predictors of beer quality parameters, thus providing real-time control, while the measurement of beer quality parameters is used to audit the process.

Alastair Pringle's first job was working in an English pub. His interest in brewing motivated him to acquire undergraduate and graduate degrees in microbiology. Alastair joined Anheuser-Busch Inc. in 1984 following five years of post-doctoral experience in the Unite States and two years as a visiting professor at UCLA. At Anheuser-Busch he held a number of technical management positions, including director of brewing research, in both corporate R&D, and brewing technical services. He has worked on all aspects of brewing, including malting, mashing, fermentation, finishing, and new product development. He is currently principal at Pringle-Scott LLC, a science based consulting company that serves the fermentation and food industries. Alastair is also an associate instructor at Maryville University in St. Louis, MO, where he teaches microbiology.

O-27

Reducing fermentation variation

Presenter: Peter Bouckaert, New Belgium Brewing Co., Fort Collins, CO

Fermentation time and temperature profile consistency are important to produce consistent beer. This study focuses on fermentation time consistency. The aim of the work was to reduce the standard deviation of fermentation time by a factor 3. Most work was done on ale fermentations and then later applied to the lager fermentations within this brewery. Screening of the relative importance of different variables affecting fermentation time was initially done through modeling of existing fermentation data. Models gave a better fit (r^2) when yeast vitality data from the previous fermentation and yeast storage were used instead of current fermentation data such as yeast count and methylene blue viability. Yeast vitality was quantified through the heat-up rate of the fermentation, length

of the fermentation, and cool-down rate of the previous fermentation and yeast storage time. The key variable for predicting fermentation time was the rate of temperature increase in the fermenter. The most important parameter to control heat-up rate was found to be the temperature in the fermenter during filling. Other variables and interactions between variables were previous fermentation time and heat-up rate, cool-down rate of previous fermentation, yeast storage time, pitching rate, and (more for lagers) temperature of the environment. Two full factorial (two levels) designed experiment on knock-out temperature and pitching rate showed that pitching rate could be used to reduce the standard deviation of fermentation time within the range tested. Variables affecting vitality were addressed in a couple of different ways. Cool-down rate of fermentations was resolved by reserving fermenters with high variability in cooling for aging only. Yeast storage time was addressed by guidelines, a limited amount of yeast storage tanks, and monitored. Fermentation time and heat-up rate became less variable in this process. Outliers for the latter parameters were used as yeast harvest selection criteria.

Peter Bouckaert studied biochemical engineering, with specialization in brewing and fermentation technology, in Ghent, Belgium. He was brewmaster for nine years at the Rodenbach brewery, worked in the Kronenbourg and De Gouden Boom breweries, and was involved with some distilleries, all in Belgium. He started his own brewpub, De Zwingel, in 1994. In 1996 Peter changed course and became brewmaster in New Belgium Brewing Co. in Fort Collins, CO.

O-28

What yeast has taught me about brewing over the years

Presenter: Tom Eplett, MillerCoors

As brewers, there is the expectation that if we deliver a consistent wort to our yeast the yeast in turn will deliver a consistent product. Personal experience tells otherwise. When something unexpected does happen, we go to the literature to find a cause and effect. Fortunately, there are a considerable number of publications that explain rate of cell growth, biomass increase, sulfur compound development, formation of flavor compounds, etc. The goal of the author is to tie together what has been published over the years back to actual operational experiences with regard to fermenter vessel aspect ratio and tank design, tank stratification, and CO_2 generation. In addition, what is the impact of what is seen during fermentation with variations in wort gravity, wort aeration/oxygenation and trub carryover, wort cooling rate/temperature, and corresponding yeast pitching practices? This multitude of variables that a brewer is challenged with is then compounded by brewery design and layout. This raises the question of how to translate these "on the floor" experiences to the publications that can be easily assimilated by brewery and lab personnel. The outcome of this publication (presentation) will address the issues encountered in fermentation, the literature that explains what is experienced on the brewery floor, and what can be done to respond to or resolve these complex and trying issues.

Tom Eplett has been a member of MBAA since 1984. He served as president and on the Board Governors for MBAA District Western New York; he also served on the Board Governors for District Milwaukee and is the current by-laws chair. He started his brewing career in 1976 at the Miller Brewery in Fulton, NY, and has held numerous positions in quality and brewing at Fulton, Milwaukee, and MillerCoors Corporate. Tom is currently the senior staff brewer at the Eden, NC, brewery. He is a graduate of Bloomsburg University with B.S. degree in biological sciences, Syracuse University with an MBA, and has a diploma in brewing technology from the Siebel Institute, where he was the class valedictorian.

O-29

Influence of harvest date on the chemical composition of Willamette and Cascade hops

Presenter: Daniel Sharp, Oregon State University, Corvallis, OR

Coauthor(s): Shaun Townsend, Yanping Qian, and Thomas Shellhammer, Oregon State University, Corvallis, OR

Hop aroma development while the plant matures in the field is a rapid and dynamic process that requires a comprehensive, in-depth chemical and sensory analysis to maximize agronomic characteristics of interest to brewers. The complex aroma chemistry associated with hops in beers has been a confounding variable for the practical brewing scientist, and a deeper understanding of hop aroma development during cultivation is needed to elucidate important factors in hop aroma. The effect of harvest date, location, and variety on key chemical components of two commonly used aroma hop varieties in the craft brewing industry was investigated for the 2010 growing season. Willamette and Cascade hops were harvested at 3 time points within a 3 week window (early, normal, and late), from 3 different farms in the Willamette Valley and then analyzed for moisture, acids content, total oil content, and essential oil composition. Analytics were performed using standard American Society of Brewing Chemists methods of analysis. The response of analytes was dependent in many cases on the variety being examined, its location within the Willamette Valley, as well as time of harvest. Hop acids did not change appreciably over the time span of this study, while hop oil content increased hyperbolically to a plateau. Increases in oil quantity were strongly correlated ($r > 0.80$) with increases in α-pinene, β-pinene, myrcene, limonene, methyl heptanoate, linalool, and eudesmol concentrations. Relative percentages of many compounds did not correlate with later harvest dates, while location appeared to have an effect on oil concentrations for each variety at each time point.

Daniel Sharp is a master's student in the food and fermentation science program at Oregon State University. His research is currently focused on hop studies being conducted in Thomas Shellhammer's lab. Daniel's primary area of study is the aroma compounds in hops and beer. Prior to joining the food science program at OSU, Daniel earned a B.A. degree in both Spanish and adventure leadership at the University of Oregon. After graduation he lived and worked in South America, first as a mountain guide in Venezuela and later as a brewer at the Center of the World Brewery, Ecuador's only microbrewery at the time.

O-30

Innovative hop management to improve oxidative beer stability

Presenter: Philip Wietstock, Berlin Institute of Technology, Department of Biotechnology, Chair of Brewing Sciences, Berlin, Germany

Coauthor(s): Thomas Kunz, Jakob Frenzel, Wiebke Hense, and Frank-Jürgen Methner, Berlin Institute of Technology, Department of Biotechnology, Chair of Brewing Sciences, Berlin, Germany

The influence of specific hop bitter acids, like α-, β-, iso-α-acids, as well as the hop dosage regime on the oxidative stabil-

ity of wort and beer were evaluated using EPR spectroscopy, GC-MS, HPLC, and sensory analyses. The addition of hops resulted in significantly higher oxidative stabilities of wort and beer compared to brews where no hops was added. Furthermore, hop α- and β-acids showed similar radical quenching abilities, while iso-α-acids displayed a negligible effect. Consequently, the isomerization of α-acids to iso-α-acids significantly reduced the antioxidant capacity of wort. Compared to a single hop dosage at the beginning of wort boiling, it was possible to increase the concentration of strongly antioxidative α-acids in wort by applying fractional hop dosage regimes while achieving comparable hop bitter yields. The radical generation could be decreased by 15–28%, yielding significantly higher oxidative wort stabilities. Based on these results, further investigations were carried out, whereby fractional hop dosage regimes were also applied during the whirlpool rest. To compensate for lower hop bitter yields, it was necessary to partially preisomerize the used hop extract before adding it. The results clearly demonstrate that the fractional addition of preisomerized hop extracts in the whirlpool leads to a higher content of antioxidative α-acids in the pitching wort. Hence, a lower radical generation can be detected, and the oxidative stability of wort increases significantly, while comparable bitter units can be achieved. One explanation for this phenomenon may lie in diminished precipitations of hop ingredients during wort boiling and hot trub formation. In conclusion, the ideal stage for adding α-acids to the wort in order to increase the oxidative stability of wort is during the whirlpool rest. Considering all results, the fractional later hop dosages, especially during the whirlpool rest, increased the antioxidant properties of wort and beer. Additionally, in a lot of cases, the higher amount of α-acids in the pitching wort resulted in slightly higher SO_2 contents after fermentation. The enhanced SO_2 formation may be caused by higher α-acid contents which, in turn, lead to a lower consumption of SO_2 by oxidative processes during fermentation.

After qualifying for the final secondary-school examinations (2000), in 2002 Philip Wietstock started his biotechnology studies for qualification as a graduate engineer at the Technische Universität Berlin, which he successfully completed in 2009. During his studies, he worked as a student research assistant at the VLB/Technische Universität Berlin. Currently, Philip is working on his dissertation, for which he is investigating the influence of hops on oxidative stability of beer.

O-31

Percent co-humulone in hops: Effect on bitterness, utilization rate, foam enhancement and rate of beer staling

Presenter: Val Peacock, Hop Solutions Inc., Edwardsville, IL

In 1972, Lloyd Rigby first presented the idea that what made an aroma hop superior was the lower percentage of co-humulone, which leads to a more pleasant bitterness. There have been a number of works over the years on the subject, more agreeing than disagreeing, but the issue seems to be more of a personal choice. However, are there other issues the brewer should consider in deciding if low co-humulone hops are desirable? For instance, the utilization rate for cohumulone is significantly better than for n-humulone and ad-humulone, resulting in real cost savings. On the other hand, iso-cohumulone is only half as effective at promoting foam in beer as the other iso-humulones. In addition, iso-cohumulone degrades in beer much more quickly than the other iso-humulones. Loss of these iso-α-acids is directly related to the amount of stale flavor in beer. As a result, packaged beer will remain fresh longer with the use of low co-humulone hops. Cost factors would favor high co-humulone hops, while non–bitter-related quality factors all point to low co-humulone as being superior. The issue of the quality difference of bitterness must be determined by the individual brewer.

Val Peacock received a B.S. degree in chemistry from Iowa State University in 1973 and a Ph.D. degree in organic chemistry from the University of Wisconsin in 1978. He was a research associate at Oregon St. University, working on hop flavor in beer from 1978 to 1981 and 1987 to 1988. From 1981 to 1986, he was a research scientist for the Seven-Up Co. From 1988 to 1989, he was a research chemist for Redd Citrus, a firm manufacturing natural citrus flavors from waste streams from juice processing. From 1989 to 2008, he was the manager of hop technology for Anheuser-Busch. In 2009, he founded his own consulting firm, Hop Solutions Inc. (H.S.I.).

O-32

A comparison of flash and tunnel pasteurization technologies used for brewery packaging applications

Presenter: J. David Duff, FleetwoodGoldcoWyard, Romeoville, IL

Pasteurizing beer products can be achieved using either flash or tunnel pasteurizers. This paper covers the general deign, description, features, and capabilities of each technology and is followed by an evaluation and comparison of both technologies on a number of levels. The outcome of this review offers the brewer a better understanding of each technology, as well as provide a mechanism for selecting which technology is best suited for their particular operation.

David Duff has been a member of MBAA since 1982 and has held positions in his local District, as well as contributing on the Technical Committee as an organizer and session moderator. David began his career with Labatt Brewing Company, and after completing the Labatt Management Training Program, he held various packaging management positions in five different facilities throughout Canada. In 1997 David left Labatt to join forces with the Stroh Brewing Company and worked at their headquarters in Detroit, MI, as director of packaging operations until the brewery ceased operations. For a short time after leaving Stroh, David worked with Pepsi Bottling Group as plant manager in their Detroit facility before returning to the beer industry in 2005, where he has held the position of North American sales executive with FleetwoodGoldcoWyard, which is part of the Barry-Wehmiller Group of Companies.

O-33

Draught line quality standards review and implementation program

Presenter: Jeffrey Schaefer, New Glarus Brewing Company, New Glarus, WI

We have developed a protocol for draft-line cleaning, as well as a program to educate tavern owners and line-cleaning companies in Wisconsin. Draught line cleaning is arguably the most inconsistent and least understood aspect of draught beer. Each state is unique in how these systems are maintained. Wisconsin is a free-enterprise state, meaning bars and restaurants are responsible for cleaning their own draft lines or hiring a third party to clean them. We have encountered many challenges in implementation and training accounts on the 2009 Brewers Association Draught Quality Standards. Once retailers, line cleaners, and distributors see what is happening within their draft systems, they make the needed changes to meet or exceed our draught quality standards.

Jeff Schaefer is a long-time beer industry enthusiast beginning with his experience as a keg route delivery representative and retail sales manager; he is currently working as brewery sales director at New Glarus Brewing Company. Jeff is the resident draft specialist and has been the driving force behind New Glarus Brewing Company's retail draft beer team. Jeff has been trained by Siebel Institute of Technology, Micro-Matic, and Perlick in draught beer quality and draught beer dispense. Jeff heads up the training of New Glarus Brewing Company's distributor draught specialists throughout the state! His enthusiastic passion for draft beer is contagious. Jeff became a member of the WI Brewer's Guild Technical Committee in 2010.

O-34

Optimization of manufacturing conditions in canning lines by using a 3D simulation technique

Presenter: Hiroaki Tamura, Asahi Breweries, Ltd., Ibaraki, Japan

Coauthor(s): Kimiaki Yamashita, Asahi Breweries, Ltd., Ibaraki, Japan; Kouhei Yuge and Takashi Kitazumi, Seikei University, Tokyo, Japan

Can containers account for the largest percentage of beer beverages according to container type in the Japanese market. The ability to manufacture can products in an efficient and stable manner is one of the most important challenges for breweries. At the same time, in recent years there has been a sharp push to reduce the volume of can containers and make them lighter, so there is a very strong demand to achieve stable handling of these containers, which are physically weak. In order to address these issues, Asahi Breweries conducted detailed analysis of the behavior of can products in actual manufacturing situations and developed a three-dimensional (3D) simulation model in order to achieve stable handling of cans. The model was developed by precisely entering data that was considered to be effective, ranging from equipment dimensions and detailed properties of materials to the frictional resistance of lubricants, in addition to manufacturing conditions. Through repeated trial and error, we developed an effective model that very closely matched the movement of actual cans. Using the simulation model, the actual process can be improved, and the optimum manufacturing conditions can be determined, even if different comparison equipment is used. Our vision of the future is to widely and effectively utilize the simulation model, such as for deploying new materials, starting up new canning lines, and optimizing existing canning lines.

Hiroaki Tamura received a M.S. degree in biosciences from the University of Tsukuba in 2006 and began working for Asahi Breweries, Ltd. From 2006 to 2009, he worked in the packaging section. He is currently an industrial engineer at the Production Technology Center.

Poster Presentations

Moderators: Ian Stanners, Molson (retired); Susan Welch, Malteurop North America

P-35

EquiTherm energy recovery system additional energy-saving potential in a state-of-the-art brewhouse

Presenter: Alexander Lenz, Krones AG, Werk Steinecker, Freising, Germany

In terms of energy management, wort production constitutes the section of the process that requires the most primary energy in the form of heat. This is where design-enhanced energy management deploys a new energy recovery system. Besides the familiar energy recovery system between the lautered-wort heater and the wort boiler, an additional energy recovery system in the brewhouse will cut thermal energy consumption still further. For this purpose, during wort cooling high-temperature energy is removed from the wort. This heat is used to heat the mash in an almost entirely recuperative process. In conjunction with the ShakesBeer mash kettle, primary energy savings of more than 25% can be achieved in the brewing process. A 200,000-hL brewery, for example, can save over 250,000 kWh of thermal energy a year. In addition, significant quantities of water and refrigeration energy are saved. The investment will pay for itself after 3 or 4 years. To install the EquiTherm system in the brewhouse, only a few changes are necessary. First of all the ShakesBeer EcoPlus has to be installed because only with the optimized pillow plates is the heat flow large enough to reach the heating rates. Also, whether the energy storage tank is big enough has to be checked, and furthermore, the wort cooler has to be extended or replaced by a more efficient one. The new wort cooler has up to 3 zones. In the first zone the high-temperature energy is removed from the wort. The second zone is for warm water production, and the last zone works with glycol or ice water to cool down the wort to fermentation temperature. The first EquiTherm system is running in Löbau, Germany. The installation of the system was done during the peak season within 6 days. Since the installation and optimization has been done, the brewery is saving more than 30% of primary energy.

As the team manager for the Technology Center Brewhouse, Alexander Lenz is responsible for the technology of the brewing of the Krones Processing Division and for the commissioning and acceptance tests of all of its plants. In 2005, after he had finished his studies on brewing technologies at Doemens, he started his career at Krones in the Technology Department at the Steinecker plant in Freising, Germany, as a commissioning engineer. In 2010 he became team manager of the Technology-Brewhouse Department in the Processing Division of Krones AG.

P-36

Software in brewing: When it's time to build your own software (and when it's not)

Presenter: Mike White, White Labs Inc., San Diego, CA

Software that provides tracking of lots serves as an important tool for breweries in the modern era. Lot-tracking software can maximize a brewer's use of ingredients, ensure a higher level of quality control, and provide a consistency of product. Brewers throughout a plant can be sure they are using the appropriate ingredients, and they in turn will continually update the database via technology solutions, such as handheld devices, or they will manually enter the information into a computer. Lot tracking can also serve as an important tool for ingredient companies, particularly those that take large amounts of product and either separate or combine them through the production process. But, the technology is far from easy to implement. Given the varying sizes of breweries, the wide variety of ingredients, and the daunting challenges of training staff members to use advanced technologies, implementing a technology solution to track ingredients within the plant is no easy task. In almost every case, the solution means creating customized software solutions. The presenter, Mike White, is communications director for White Labs Inc., which over the past five years has implemented a lot-tracking system called Yeastman. The system tracks production in the com-

pany's San Diego, CA, yeast plant, keeping tabs on such data as when lots are split or expanded. The internal system is tied into an online site that answers the #1 question the company receives from its customers: "When can I get my yeast?" The challenges were immense, and the final product varies considerably from the beta models. Yet, with perseverance and commitment, and significant investment, full implementation of the system in 2010 coincided with one of the strongest years of expansion in White Labs' history. White will provide a wealth of experience on what to think about before and during implementation of a customized computer program for your brewery or related business. This is intended as a big picture, non-technical presentation. In other words we are not comparing the various software solutions; we are getting you to think about what questions you need answered before and during implementation of your technology solution. The presentation will 1) highlight the top 10 questions to be answered as part of the process; 2) display a chart showing our own customized technology solution (Yeastman); and 3) provide a list of 10 things you need to implement after you create your technology solution, such as intense and ongoing staff training.

Mike White serves as communications director for White Labs. White joined White Labs in 2005 after working as a newspaper reporter for many years. For more than a decade he has published Craft Beer Quarterly (CBQ), which is sponsored by White Labs and other companies. In addition to publishing CBQ and other materials for the company, Mike maintains the White Labs' website, administers the online tracking and ordering system (Yeastman), works with the customer service staff, and attends trade shows and festivals.

P-37

Wood aging of specialty products

Presenter: Jens Voigt, Technische Universität München-Weihenstephan, Process Technology, Research and Development, Ludwigsburg, Germany

Wood aging is still an up-to-date technology for making special products. Undoubtedly the cask conditioning adds special flavor compounds to the beers. A series of trials was done both in lab- and pilot-trial plants in order to show such effects during shorter and longer storage periods. The modification of flavor compounds in longer and shorter storage, where compared, and tasting was done. The trials included more traditional brands like bock made from wheat malt, porter, maibock, alt, and ale mostly done with special malts. Pale, darker, and smoked malts were used. Also, the influence of special casks (bourbon whiskey casks) and special yeasts was studied. Outside of the Reinheitsgebot, cask-conditioned beers like Kriek, fruit-flavored variants, and sugar-additions were done. The paper describes the wide range of possibilities created by the use of specialty malts for beers produced by wooden cask aging.

Jens Voigt received a Diploma Engineer (M.S.) degree in brewing and beverage technology from TU München-Weihenstephan, Germany, in 1985. He held several positions in the brewing equipment supply industry from 1985 to 2003. He received his doctorate in brewing technology with Prof. Narziss in 1993. Since early 2004 he has been an assistant professor with Karl Sommer at the Chair for Process Technology of Disperse Systems at the WZW (Wissenschaftszentrum Weihenstephan [Center of Life Science, Weihenstephan]), working on brewing process technology issues. He is member of MBAA and IBD, as well as the editorial boards of the Technical Quarterly of the Master Brewers Association of the Americas and the Journal of the Institute of Brewing. Jens is currently chair of the IBD International Section. He is also a member of the MBAA Global Emerging Issues Committee and the EBC Brewing Science Group. His work group was awarded the EON award for environment in 2008.

P-38

Wort stripping: An innovative system for the controlled reduction of unwanted aromatics featuring optimized trickle-film formation and stripping gas utilization

Presenter: Roland Feilner, Krones Ag, Germany

There is a huge variety of wort-stripping systems on the market at present, utilizing highly disparate technologies in order to reduce the amount of unwanted volatile substances, which are formed post-boil primarily during the whirlpool rest period. The focus lies mainly on dimethyl sulfide (DMS). Many of these systems achieve the desired reduction by generating large surface areas in the form of thin-film stripping. These processes are integrated in the copper, a separate tank, or directly in the whirlpool. Other vendors utilize pressure reduction or thermal end-treatment. A new concept featuring a reduced carbon-footprint, easy retrofit options, and without the use of vacuum or thermal energy is described . The innovative design enables the entire internal surface area of the external stripping tank to be covered with an even, turbulent trickle film. Besides generating an efficient, uniform, and turbulent layer, a stripping-gas control function is provided for maintaining the driving gradient between the gas and liquid phases and for influencing the quantity of the substances to be expelled. In industrial-scale trials, DMS reduction rates of up to approximately 70% could be achieved. The very flexible system can be integrated very easily in each existing boiling system, between whirlpool and wort cooling station. There are several rudiments to use the benefits of the new system. One is the reduction of the primary energy at wort boiling up to 50%, because it's possible to reduce DMS additionally to the minimized boiling process. Second is the reaction regarding bad malt quality, resulting in higher DMS content after wort boiling by keeping the boiling system on a constant low energy level followed by wort stripping. Third is the reduction of the boiling time accessory to the minimized energy boiling process. The stripping gas control function enables reaction to specific malt quality terms and wort parameters at a very low energy level combined with high beer quality and unchanged beer character.

Roland Feilner (born in 1981) finished his apprenticeship as brewer and maltster, after which he studied food science technology in Weihenstephan, graduating in 2006 as an engineer. His career entry at Krones AG, Germany, started with membrane filtration of beer. At the same time, he worked as a process and development engineer for thermal product treatment, especially for juice and beer pasteurization. In addition, the vacuum degassing of beverages and juices was one of his main development areas. Currently he is responsible for new developments in wort treatment and process technology in the Krones R&D Division.

P-39

A CIP procedure using the addition of hydrogen peroxide that is particularly effective under low solution flow conditions

Presenter: George Agius, Diversey Inc., Canada

Coauthor(s): Jonathan Crawshaw, Sleeman Brewing Company, Guelph, Canada; Bart Schuurman-Hess, Diversey Inc., Canada

During clean-in-place (CIP) of brewery equipment, there are several instances where the flow of the cleaning solution is

limited. In these situations, there is little mechanical action imparted by the circulating cleaning solution to help remove soils. In some extreme cases, the flow could be so limited that some areas of the surface may not be wetted by the cleaning solution. Increasing the flow by increasing the size of CIP pumps is often not practical, and the remaining combination of chemical action, time, and temperature may not be sufficient to completely remove all soils from the surface. In critical areas, the remaining soils may become a source of microbiological infection. The addition of hydrogen peroxide to the circulating CIP solution has been effectively employed over a number of equipment surfaces to achieve consistent cleaning, including the lauter tun, brew kettle, whirlpool, wort loop, centrifuge, and plate heat exchangers. The improved cleaning of the surfaces has been verified by visual inspection, and the cleaning performance has remained consistent over a period of several months. The decomposition of the hydrogen peroxide in alkaline media into water and oxygen is thought to create microbubbling through nucleation, which generates surface mechanical action to help dislodge the soils and also increase the surface contact area of the cleaning solution.

George Agius received his master's degree in chemistry and was a lecturer in organic and physical chemistry at the Royal University of Malta between 1971 and 1981. In 1982 he joined JohnsonDiversey, where he has held several research positions, leading to the position of technical director (1990) responsible for new product development, engineering systems, and customer technical support. During this time, George directed the development of synthetic lubricants, new sanitizers, bottle scuff maskants, low environmental-impact and acidic CIP cleaners, bottle-washing programs, new pasteurizer treatments, and associated engineering systems. George is currently working on the application of chlorine dioxide and the development of dry conveyor lubricants and other sustainability initiatives for use in the food and beverage industries. George has contributed a number of papers on various topics to brewing, educational and archaeoastronomy journals. He has recently moved from the position of brewing business development in North America to the position of global expert for the food industry, with responsibilities for developing the company's expertise in the Americas and across the globe. George is married to Joyce and has two daughters, Suzanne and Louise. He enjoys canoeing, photography, astronomy, and reading on the history of science.

P-40

"Always optical" modern oxygen management in breweries

Presenter: Arjen Van Zeijst, Norit Haffmans, Venlo, The Netherlands

A growing number of breweries and brewing groups are standardizing oxygen (O_2) measurement using optical technology. Compared to traditional O_2 measurement, optical O_2 measurement reduces operating costs, as it requires less maintenance and calibration, provides better measuring stability, and has a rapid response time. The versatility of optical O_2 measurement allows it to be used throughout the brewery in areas such as the brewhouse, filling, carbon dioxide (CO_2) recovery, and wastewater treatment. Examples of areas where optical O_2 measurement is applied include wort aeration and, after aeration, monitoring of dissolved O_2 content to assure optimal conditions for fermentation. Optimal control of the aeration is possible. In the fermentation process, the CO_2 gas produced can be recovered, purified, and liquefied. Using optical O_2 technology to monitor the O_2 content of the CO_2 gas results in a more efficient and economical operation of a CO_2 recovery system. Following the fermentation process, it is important to monitor and prevent O_2 pick up during filtration and before filling. Faster than traditional measurement, optical O_2 measurement, reduces product loss and increases efficiency with shorter switch over times. Even if the O_2 quantity in the beer or beverage is within specifications, packaging will affect the total O_2 enclosed in a package. The total package oxygen (TPO) has a major influence on a product's shelf life and flavor stability and can only be measured in the package. New insight into TPO based on the differentiated O_2 measurement (head space O_2 and dissolved oxygen [DO]) compared to the traditional method of calculating DO × Z will be shared. The innovative optical O_2 measurement technology achieves a fast and accurate picture of the entire brewing or beverage production process. This results in quicker response times, an immediate reduction of product losses, and reduced operating expenses.

Arjen Van Zeijst completed electrical engineering studies at HTS Venlo in 1996 and started working for a PVD coating machine manufacturer as a process control engineer. In 2002 Arjen became a project engineer responsible for the process control department. In 2006 Arjen became an international sales manager and in 2008 started working for Norit Haffmans as area sales manager for the Americas.

P-41

BRITESORB TR: Colloidal stabilization of beer using combined removal of tannoids and haze protein

Presenter: Kenneth Berg, PQ Corporation, Conshohocken, PA

Beer can be stabilized against forming a chill haze by either removing tannoids or by removing haze-forming protein. Some beers require the removal of some of both components before adequate stabilization is achieved. This has traditionally been achieved using a double treatment: a silica gel and polyvinylpolypyrrolidone (PVPP), either added to the beer together or separately. A relatively new product, BRITESORB TR, can perform both functions with a single addition with potential savings in complexity, product storage, time, and cost.

Ken Berg received a B.A. degree in biology (biochemistry concentration) from Cornell University in 1976, and a Ph.D. degree in biochemistry from Brandeis University in 1981. After a post-doctoral appointment at North Carolina State University, Ken designed protein purifications for Lee Scientific in St. Louis, MO. For the last 25 years, Ken has been employed by PQ Corporation and has been active in development of new silica-based adsorbents for the food industry, supporting PQ's silica gel plants, and contributing to the beer industry both as vendor technical support and as a member of MBAA and ASBC. Ken lives near Philadelphia and teaches music in New York and studio art in Texas.

P-42

The analysis of green-beer off-flavors using liquid-liquid extraction and GC-MS

Presenter: Acacia Baldner, Standing Stone Brewing Company, Ashland, OR

Coauthor(s): Larry Chase, Standing Stone Brewing Company, Ashland, OR; Steven Petrovic, Southern Oregon University, Ashland, OR

There are many techniques for maturing beer in cylindroconical fermenters prior to transferring the beer to serving vessels or bottling it. At Standing Stone Brewing Company a common method of maturing ale-style beers is to allow the beer to age in the fermenters at a lower temperature than the

active fermentation temperature for a period of a few days. The method analyzed here is conducted by lowering the fermenter temperature to 50°F from the active fermentation temperature of 68°F and holding that temperature for 5 days after an identical specific gravity is measured 2 days in a row. This allows yeast the opportunity to metabolize unwanted flavor byproducts produced during the initial fermentation period. The objective of this research is to measure the concentration changes in these green-beer off-flavors over the 5-day 50°F maturation period. Analyses of these concentration changes would allow brewers to identify whether there is a significant flavor change throughout the entire maturation period or if a shorter maturation period would also adequately improve beer flavor quality. A shorter maturation period would allow the brewer a faster turnover rate of moving beer out of fermenters into serving vessels or bottles, freeing up space for additional beers to be fermented. The beer analyzed for this research was a brown, session-style ale taken from Standing Stone Brewing Company. Liquid-liquid extraction into a 2:1 pentane/dichloromethane solution was used to isolate the green-beer volatiles from samples collected throughout the maturation period. These extracts were then concentrated using a stream of nitrogen, and the resulting concentrates were analyzed via gas chromatography–mass spectrometry (GC-MS). The predominant off-flavor compounds detected by GC-MS were identified as isopentanol (also known as isoamyl alcohol, with a banana/solvent flavor), ethyl acetate (also known as acetic ester with a fingernail polish/fruit flavor), and phenylethanol (roses, estery, spicy flavor). Triangle taste tests were performed as a sensory evaluation technique to distinguish between mature and immature beer. From the taste tests it was determined that an average of 75% of the samples were identified correctly.

Acacia Baldner studied chemistry and biology at Southern Oregon University and in 2011 earned a bachelor's degree in biochemistry. During her time at SOU she was an avid homebrewer, which sparked her passion for brewing and was the impetus in her decision to become a professional brewer. This passion has led Acacia to begin entering her beers in local homebrewing contests, and in September 2010, she was awarded 2nd place for her blackberry lambic at the Jackson County Harvest Fair. To achieve her dream of becoming a professional brewer, Acacia will attend the Master Brewer Program at UC Davis in January 2012.

P-43

The use of micro-oxygenation of beer to simulate oak barrel maturation

Presenter: John Stewart, New Holland Brewing Company, Holland, MI

Coauthor(s): Molly Browning, New Holland Brewing Company, Holland, MI

It is becoming increasingly popular for wineries to use micro-oxygenation machines on wine held in tanks to mimic the results of oak barrel maturation. Oxygen is slowly injected at a very low dose ranging from 0.5 mL/L/month to 2 mL/L/month through a ceramic membrane. It is claimed that this process oxidizes tannins and creates a softer, more rounded wine similar to what is found after oak barrel aging. As more and more breweries are aging beer in oak barrels, it was sought to determine if micro-oxygenation could be used to achieve similar results with beer. A high-gravity ale was aged in both 5- and 55-gal previously used flavor-neutral American oak barrels and a stainless-steel tank equipped with a micro-oxygenation unit. Spectrophotometer and gas chromatography analysis of polyphenolic and ester compounds of the micro-oxidized, oak aged, and control beer were performed to compare oxidation of these compounds.

John Stewart has been a member of MBAA since 2007. In fall 2010 he attended the MBAA Brewing and Malting Science course. In 2006 he began his career in brewing with New Holland Brewing Company after graduating from Grand Valley State University with a degree in biology. John is currently the QA/QC manager at New Holland Brewing Co.

P-44

Antifoams from hops

Presenter: Yves-Yannick Ford, Barth Innovations Ltd., Paddock Wood, Kent, United Kingdom

Coauthor(s): Keith Westwood, Barth Innovations Ltd., Paddock Wood, Kent, United Kingdom; Andreas Gahr, Hopfenveredlung St. Johann GmbH & Co. KG, Train-St. Johann, Germany; Agnieszka Rajca Ferreira, formerly at Botanix Ltd., Paddock Wood, Kent, United Kingdom; Katarzyna Wolinska, Barth Innovations Ltd., Paddock Wood, Kent, United Kingdom; Mita Lad, University of Nottingham, Nottingham, United Kingdom

Control of foaming is important during brewing operations, especially at the fermentation stage. We have developed hop-based solutions for this problem. These are emulsions of hop extracts in water that show effective antifoam action together with potentially beneficial effects on the final beer. Pilot brewery trials were conducted, using the hop extract emulsions as antifoam agents during fermentation, to assess both the antifoam performance and the effects on the final beer. A dose rate of 10–50 g/hL of the emulsions successfully suppressed foaming to the same extent as commercial silicone antifoam used at the recommended 5 mL/hL. Use of the hop extract emulsions increased utilization of the hop bitter acids so that the final beers had elevated levels of bitterness compared to the control (no antifoam). In addition, the hop extract emulsions also had a positive effect on the final beer foam stability. The positive effects on hop acid utilization and on beer foam stability are thought to be at least partly due to decreases in losses of iso-α-acids. Iso-α-acids will partition into the foam phase, and thus, partial loss of these components is likely due to foam deposition on vessel walls, etc. The positive results from the brewing trials have encouraged us to further develop the formulation to enhance effectiveness. A simple, rapid, and reproducible method has been devised to test antifoam performance in the laboratory, and results are presented to show that this method is a reliable predictor of antifoam performance in a pilot brewery trial. Since the products are based on hop extract and natural emulsifiers, the stability, both in terms of performance and microbiological contamination, is important. Data from storage trials conducted under ambient conditions, and under accelerated aging at 30–40°C, show that the emulsions remain microbiologically clean and effective as antifoams for at least 12 months.

Yannick Ford studied biochemistry at the University of Oxford (1987–1991), and continued his studies at Oxford for a doctorate in plant biochemistry (1991–1995). He then worked for nine years at Horticulture Research International on a variety of research projects, with a particular interest in plant secondary metabolites and their potential beneficial effects. He joined Botanix Ltd., a member of the Barth Haas Group, in 2004, and has worked in both research and regulatory affairs roles. In 2010 Yannick transferred to Barth Innovations Ltd. as research chemist and regulatory affairs manager and continues to work on development of new products for brewing applications.

P-45

Comparison of utilization of different hop products using a newly developed hop yield enhancer

Presenter: Christina Schönberger, Barth Haas Group

Coauthor(s): Marcus Hertel, Hertel GmbH

This work presents the possibility to increase the utilization of hop pellets in brewing with a newly developed hop yield enhancer. The effective increase can be attributed to the optimization of various process parameters as the increase of exchange surface with the hop product and higher temperatures for an effective isomerization resulting in a higher isomerization gradient. Thus, clearly more of the added bitter acids can stay solute until the final beer (nearly no losses due to the pH drop during fermentation). Ongoing comparative trials now confirm the suitability of the hop yield enhancer for different hop products as hop pellets and hop extracts. In addition, boiling times can be reduced significantly due to the higher isomerization gradient and, thus, the higher polarity (faster extraction of bitter acids out of the hop product into wort) while using the new apparatus. As in this case the isomerization of bitter acids is not a limiting factor for the reduction of wort boiling times anymore, this goes along with an improved wort quality in regard to thermal load. The hitherto gained results with this new technique will be presented.

Christina Schönberger studied brewing and beverage technology at the Technische Universität München-Weihenstephan, Germany (1995–1999), graduating as an engineer in 1999. She pursued her doctoral thesis work at the Chair of Brewing Technology I on "Sensory and Analytical Characterisation of Non-volatile Taste Compounds in Bottom Fermented Beers," graduating summa cum laude in December 2003. After working for the Berman Brewers Association for a year as a consultant for technical and governmental issues, she joined the Barth Haas Group in 2005 as manager of technical Sales. Within this role she is also responsible for the guidance of research projects and authors hop-related professional articles.

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Improvement of the taste of low alcohol beers (<1.2% ABV) especially by applying aroma hops

Presenter: Andreas Gahr, Hopfenveredlung St. Johann GmbH & Co. KG, St. Johann, Germany

Coauthor(s): Adrian Foster, HVG Hopfenverwertungsgenossenschaft e.G., Wolnzach, Germany

Alcohol legislation in the U.S. and the EU is getting more strict. Especially in the EU, the legal alcohol limits are increasingly questioned, and an EU-wide blood alcohol limit of 0.0/mL is under discussion. This may cause severe problems for breweries. Rarely are alcohol-free beers (in the EU < 0.0–0.5% ABV, depending on country) a tasty alternative. Low-alcohol beers (<1.2% ABV), a beer category that is not very popular yet, may have the possibility to fill the gap. In several brewing trials at the Research Brewery St. Johann, a recipe has been developed for a high-quality low-alcohol beer using stopped fermentation and specific hopping regimes. The beers were produced with different levels of iso-α-acids (10–15 mg/L) and late additions of aroma pellets from 1 to 3 g/L. It could be shown that especially the use of aroma hops is able to widely compensate for the sensory defects of low-alcohol beers. Comprehensive beer analyses demonstrated in which degree positive non–iso-α-acid bitter components, aroma components, and polyphenols were transferred from aroma hops to beer. Sensory results, verified by a panel of more than 40 people, showed that the sensory properties of the low-alcohol beers at different bitter levels were improved remarkably. The beers showed also a good flavor stability.

Andreas Gahr was trained on the job as a brewer and maltster at the Augustiner Brewery, Munich, Germany. He received a brewmaster degree from the Technical University Munich-Weihenstephan in 1994 and worked for another four years at the university for the Chair of Brewing Technology I. Since 1998 Andreas has been the head of the Research Brewery St. Johann, which belongs to the hop processing company of Hopfenveredlung St. Johann GmbH & Co. KG and deals with all kinds of hop-related brewing trials and product development, as well as technological and raw material trials for suppliers and the brewing industry. In 2010 he received, together with his coauthors, the MBAA Inge Russell Best Paper Award.

P-47

Analysis of historic varieties of malting barley

Presenter: Keith Thomas, University of Sunderland, Sunderland, United Kingdom

Coauthor(s): Amal Muhammed, University of Sunderland, Sunderland, United Kingdom; Christopher Ridout, Norwich Research Park, United Kingdom; Mitchell Andrews, Lincoln University, Christchurch, New Zealand; Noel Carter, University of Sunderland, Sunderland, United Kingdom

Historic varieties of barley are rarely grown today and even more rarely used for brewing. Many were selected for the quality of their malt and suitability for brewing, but this changed when mechanical harvesting found that tall varieties were difficult to process. Breeding for shortness and productivity produced greater yields but may arguably have lost other features. This study reports work conducted on samples of historic barley varieties from the archive stocks at the John Innes Centre in the U.K., with information on their characteristics and a focus on disease resistance. Comparison between historic varieties and examples of modern varieties has provided information on growth characteristics that may relate to cultivation practices. We have found novel disease resistances that will be of value for breeding, and investigations into mechanisms of these have been pursued. This work has relevance to the selection of barley varieties to meet future needs and optimize quality for brewing applications.

Keith Thomas received his degree in biological sciences from the University of York, U.K., and his post-graduate teaching certificate from the University of Manchester. His doctoral study was on the conversion of cellulose by products to alcohol, after which he pursued his interests in the brewing applications of fermentation. In 1986 Keith established Brewlab Ltd., an independent company providing training and consultancy to the brewing industry, and in 1995 he established sister company Darwin Brewery, as a commercial brewery providing training support. Keith is currently senior lecturer in microbiology at the University of Sunderland and actively participates in brewing applications through research and consultancy.

P-48

CDC Meredith, CDC Reserve, and CDC Kindersley—Newest Crop Development Centre, University of Saskatchewan two-row malting barley varieties

Presenter: Brian Rossnagel, University of Saskatchewan, Saskatoon, SK, Canada

Coauthor(s): Aaron Beattie, Tom Zatorski, and Graham Scoles, University of Saskatchewan, Saskatoon, SK, Canada

After the development and release of the world-leading two-row malting barley variety Harrington in 1981, the University of Saskatchewan malting barley breeding program followed a two-pronged approach for subsequent variety development. One breeding stream targeted malting and brewing end users interested in a similar high enzyme "Harrington-type" variety, resulting in the release of CDC Kendall in 1996, while the second approach was aimed at end-users desiring a somewhat lower malting enzyme package, resulting in the release of CDC Copeland in 1999. Both varieties represented significant agronomic improvements and have been widely grown across western Canada. From an end-user perspective, both have found success in domestic and international markets. To complement these two breeding streams, the CDC breeding program has recently placed increased emphasis on selection for lower grain protein to assist farmers in achieving malting grade and to increase malt extract levels for end-users, as well as selection for lower malt β-glucan and more uniform/balanced modification to make our product more attractive to malting/brewing end-users. These efforts have resulted in the development and release of the moderate-enzyme, low-protein variety CDC Meredith in 2008 and the higher enzyme, low-malt β-glucan CDC Kindersley in 2010. In collaboration with Sapporo Breweries, the program also released the relatively high-enzyme, low-protein, sprouting-tolerant variety CDC Reserve in 2008. In addition to malting/brewing quality improvement, these varieties again represent a significant advantage in agronomic performance for western Canadian barley growers. Commercialization of these varieties is underway, with CDC Meredith most advanced in the marketplace

Brian Rossnagel has been a plant sciences professor and the barley and oat breeder for the Crop Development Centre at the University of Saskatchewan since 1977. Raised on a small mixed farm in central Manitoba, he earned a B.S. degree in agriculture (1973) and then a Ph.D. degree in plant breeding and agronomy (1978) at the University of Manitoba. Over his career, he has released more than 80 barley and oat varieties with a wide range of specific uses, from low-lignin, high-fat feed oats to two-row malting barley. Some additional keystones of his breeding and research career are the development of hulless barley for feed, food, and malting and consistent collaboration with other researchers, including cereal chemists, animal nutritionists, agronomists, plant biotechnologists, and plant pathologists. Having been conferred numerous honors and awards over the last few decades, his three most recent commendations (all in 2010) are the American Oat Workers Conference Distinguished Service to Oat Improvement Award, recognition as a University of Saskatchewan Distinguished Chair, and induction into the Saskatchewan Agriculture Hall of Fame.

P-49

Declining barley acreage

Presenter: Karen Hertsgaard, Institute of Barley and Malt Sciences, NDSU, Fargo, ND

Barley acreage in the U.S. has been declining steadily since the 1980s and shows no sign of rebounding. In fact, recent reports indicate a possible 35% decrease in production from the 2010 crop, which was a record low production year. However, excellent growing conditions produced record yields and quality in both 2009 and 2010, which has served to fill the short-term needs of maltsters and brewers. Competition from other crops, changes in U.S. farm policy, and disease have all contributed to the decline. The real problem is finding ways to address the decline and ensure a long-term supply of quality barley for U.S. companies. This presentation will address the causes of declining production, why this is a serious problem for the malting and brewing industries, and how barley stakeholders can address the problem. Multiple groups are working on methods to assist growers to produce more quality barley for malting and brewing. These include the development of new varieties and genetic research, investigations on cropping systems, development of new crop insurance products, and educational activities offered by the Institute of Barley and Malt Sciences and commodity organizations. These projects will be presented and discussed in order to help identify which are potentially most helpful and to determine if other information is needed.

Karen Hertsgaard is the information specialist for the Institute of Barley and Malt Sciences, which is a national center providing education, outreach, and research for U.S. barley producers and the domestic and international consumers of U.S. malting barley, headquartered at North Dakota State University. Karen holds an M.S. degree from North Dakota State University in agronomy/small grain physiology and lives on an active farm south of Fargo, where wheat, sugar beets, corn, and soybeans are the main crops produced.

P-50

History of barley production in the USA

Presenter: Paul Schwarz, NDSU Plant Sciences, Fargo, ND

Coauthor(s): Richard Horsley, NDSU Plant Sciences, Fargo, ND; Scott Heisel, American Malting Barley Association, Milwaukee, WI

Barley was introduced to North America by European colonists beginning in the early 17th century. However the development of both barley cultivation and brewing in North America was quite different from what occurred in Europe, and some misconceptions persist even until today. A unique difference is that six-row barley remained the primary form in the U.S. until the latter half of the 20th century. Barley was first grown in New England in 1602, and early cultivation was largely driven by the desire of the colonists to produce beer. It is generally assumed that the first introductions were English two-row landraces, and as these were very poorly adapted to the climatic conditions of New England, production was quite limited. Cultivation only began to increase with westward movement into New York in the 18th century. After some experimentation, farmers found landraces of Scottish six-row barley to be most suitable. New York remained a major producer of barley until the late 19th century. In the western U.S., barley production in California developed with the Spanish Missions in the later 18th century. Production expanded with the gold rush of the mid-19th century, and California was a major producer of barley until the 1970s. Some malting barley was actually exported to the U.K. The coastal barley types of California descend from six-row types that were originally brought to Spain from North Africa. In terms of the foundation of modern production regions, there were about 100 years of barley migration from the eastern U.S. to the Midwest and West. Factors were European immigration and the growth of brewing in Midwestern cities such as Cincinnati, Chicago, and Milwaukee, as well as disease and pest problems in eastern production areas. The McKinley Tariff of 1890 also essentially eliminated barley imports from Canada into the eastern U.S. Ohio, Iowa, and Wisconsin were all at one time major producers of barley. Barley breeding began with the rediscovery of Mendel's laws of inheritance around 1900. Early efforts were directed toward the improvement of Manchurian/Oderbrucker six-row types that were well-suited to the historic production

regions and also to the light lager style of beer that was brewed with adjuncts. North Dakota became a major production center in early 20th century. Significant efforts toward the development of adapted two-row types did not occur until the latter half of the 20th century. Montana and Idaho became major U.S. producers only after 1950. This poster presents a timeline of barley production in the U.S. and also a description of some of the more historic barley cultivars.

Paul Schwarz is a professor of plant sciences at North Dakota State University, where he directs the Malting Barley Quality Laboratory and serves as the director of the Institute of Barley and Malt Sciences (IBMS). Over the past 30 years, Paul has published numerous articles on barley and malt. His current areas of interest are grain mycotoxins and food safety, as well as the history of malt barley quality testing. He holds a B.S. degree in agronomy from the University of Wisconsin-Madison and M.S. and Ph.D. degrees in cereal chemistry from North Dakota State University. Paul has previously worked at the Kurth Malting Corp., Milwaukee; Brauerei Egger AG, Worb, Switzerland; and the Coors Brewing Co., Golden, CO.

P-51

Identification of barley varieties by lab-on-a-chip capillary electrophoresis

Presenter: Martina Gastl, Technische Universität München, Lehrstuhl für Brau- und Getränketechnologie, Freising, Germany

Coauthor(s): Elisabeth Steiner and Thomas Becker, Technische Universität München, Lehrstuhl für Brau- und Getränketechnologie, Freising, Germany

There is an increasing demand in the grain-handling chain to control purity and sorting accuracy of different classes and varieties of grains. It is needed to ensure that varieties with specific qualities are delivered at high purity and quality. To control the grain-handling chain that stretches from farmers to transporters, to storage silos, to end-users (maltsters and brewers) in the market, low-cost, rapid tests are needed. Lab-on-a-chip capillary electrophoresis provides a rapid identification method. This method has been used for identification of different barley varieties and related malt. Distinction can be made between members of a set of 50 commonly grown European barley and malt varieties. Genuine barley samples were malted in a micromalting plant. The technique can also been applied to the separation of proteins from other grains.

Martina Gastl apprenticed as a brewer and maltster from 1994 to 1996 in Klosterbrauerei Andechs, Germany. She studied brewing and beverage technology at the Technische Universität München-Weihenstephan, Germany. She graduated as an engineer in 2002. From 2002 until 2006 she completed her Ph.D. degree on the "Technological Influence on Lipid Degradation in Terms of Improvement of Beer Flavour Stability." She is currently assistant professor and head of the raw material research group at the Lehrstuhl für Brau- und Getränketechnologie in Weihenstephan. Since 2008 she has been working on her post-doctoral lecture qualification; her research interest involves "Characterization and Interaction of Flavour Active Taste Compounds in Cereal Based Beverages Influencing Beverage Harmony."

P-52

Screening of barley and malt in terms of *Fusarium* contamination, malt quality, and mycotoxins

Presenter: Martina Gastl, Technische Universität München, Lehrstuhl für Brau- und Getränketechnologie, Freising, Germany

Coauthor(s): Michael Hess, Technische Universität München, Lehrstuhl für Phytophatologie, Freising, Germany; Thomas Becker, Technische Universität München, Lehrstuhl für Brau- und Getränketechnologie, Freising, Germany; Michael Rychlik, Technische Universität München, Zentralinstitut für Ernährungs- und Lebensmittelwissenschaft, Abteilung Bioanalytik Weihenstephan, Freising, Germany

Contamination with *Fusarium* species represents a rising threat to yield quantity and quality, especially for brewing barley. High contamination bears the risk of mycotoxins and a decrease in quality. In addition it is often reported that the visual determination of red kernels can lead to the prediction of gushing. Investigations have shown that in barley the *Fusarium* species *F. poae*, *F. tricinctum*, *F. sporotrichioides*, and *F. avenaceum* have been detected. A limit value for mycotoxins (especially DON) and a rate for red kernels (6 red kernels in 200 g) is often stipulated in contracts. It is assumed that the red kernels are caused by *Fusarium* contamination. There is currently no data available on the relationship between the kinds of contamination, visual evaluation, quality specifications, and mycotoxins. Different field samples of barley and their corresponding malts were analyzed. A quality control was performed. Moreover, the grains and malts were assessed mycologically for fungal contamination and screened for *Fusarium* toxins by LC-MS/MS.

Martina Gastl apprenticed as a brewer and maltster from 1994 to 1996 in Klosterbrauerei Andechs, Germany. She studied brewing and beverage technology at the Technische Universität München-Weihenstephan, Germany. She graduated as an engineer in 2002. From 2002 until 2006 she completed her Ph.D. degree on the "Technological Influence on Lipid Degradation in Terms of Improvement of Beer Flavour Stability." She is currently assistant professor and head of the raw material research group at the Lehrstuhl für Brau- und Getränketechnologie in Weihenstephan. Since 2008 she has been working on her post-doctoral lecture qualification; her research interest involves "Characterization and Interaction of Flavour Active Taste Compounds in Cereal Based Beverages Influencing Beverage Harmony."

P-53

The road to hulless malting barley varieties at the Crop Development Centre, University of Saskatchewan—From CDC McGwire to CDC ExPlus and HB08304

Presenter: Brian Rossnagel, University of Saskatchewan, Saskatoon, SK, Canada

Coauthor(s): Aaron Beattie and Tom Zatorski, University of Saskatchewan, Saskatoon, SK, Canada; M. J. Edney, Canadian Grain Commission, Winnipeg, MB, Canada; Graham Scoles, University of Saskatchewan, Saskatoon, SK, Canada

For the past 35 years hulless barley development and breeding have been a significant segment of the Crop Development Centre, University of Saskatchewan, barley research and breeding program. Since the release of the first hulless feed variety, Scout, in 1982, program emphasis has shifted to hulless barley for food and malting/brewing. The high-performing, agronomically superior variety CDC McGwire released in 1999 set the stage for and provided the baseline for further hulless malting barley variety development. CDC ExPlus, with improved malting quality, was released in 2009. It has been followed by HB08304 (to be released in 2011), which demonstrates agronomic improvement versus the standard CDC McGwire and further malting/brewing quality advantage versus CDC ExPlus, having lower grain protein, lower malt β-glucan, and increased malt enzyme activity.

Brian Rossnagel has been a plant sciences professor and the barley and oat breeder for the Crop Development Centre at the University of Saskatchewan since 1977. Raised on a small mixed farm in central Manitoba, he earned a B.S. degree in agriculture (1973) and then a Ph.D. degree in plant breeding and agronomy (1978) at the University of Manitoba. Over his career, he has released more than 80 barley and oat varieties with a wide range of specific uses, from low-lignin, high-fat feed oats to two-row malting barley. Some additional keystones of his breeding and research career are the development of hulless barley for feed, food, and malting and consistent collaboration with other researchers, including cereal chemists, animal nutritionists, agronomists, plant biotechnologists, and plant pathologists. Having been conferred numerous honors and awards over the last few decades, his three most recent commendations (all in 2010) are the American Oat Workers Conference Distinguished Service to Oat Improvement Award, recognition as a University of Saskatchewan Distinguished Chair, and induction into the Saskatchewan Agriculture Hall of Fame.

P-54

Safe and environmentally friendly method for onsite cleaning and repassivation of 304 stainless-steel pasteurizer components

Presenter: Jack Bland, MBAA District Mid-Atlantic

Coauthor(s): Rick Brundage, MBAA District New England; Tom Soukup, MBAA District Mid-Atlantic; Scott Pavlich, Kevin Emery, and Dave Duff

With few exceptions, virtually all of the tunnel-type pasteurizers in modern breweries are 304 stainless-steel (SS) construction. While this metallurgy offers excellent corrosion resistance in brewery packaging area environments, it is critical that stains or deposits not be allowed to remain on internal or external pasteurizer surfaces. Any debris or deposition on the 304 SS surface will rapidly reduce its corrosion resistance. Hot, humid conditions on the packaging floor, coupled with volatile hypohalous amines from the pasteurizer water treatment program, will amplify the rate of corrosion underneath any deposits on the stainless-steel surface. Previous standards for deposit removal and re-passivation of 304 SS involved the use of hydrofluoric and nitric acid. This procedure is no longer acceptable as an onsite method due to strict environmental regulations. ChemTreat, in conjunction with an equipment manufacturer, has developed an effective, safe, and environmentally friendly alternate process for onsite cleaning and passivation of brewery pasteurizers with 304 SS metallurgy. This paper will detail the process and show before and after photographs of a variety of internal/external pasteurizer surfaces. Conclusions will summarize best practices for maintaining the passivation of 304 SS metallurgy following cleaning.

Jack Bland, ChemTreat director of technical support, Brewing Services Division, has more than 35 years of experience in the water treatment of brewery pasteurizer and utilities boiler/cooling water systems. He has authored numerous MBAA papers on a variety of topics related to best practices for water treatment in these systems and has been an active lecturer at the annual MBAA packaging course for many years. Jack has been an active MBAA member since 1982.

P-55

Withdrawn

P-56

Using unfermentable sugars during fermentation to improve the palate-fullness, flavor, and oxidative stability of beer

Presenter: Thomas Kunz, Berlin Institute of Technology, Department of Biotechnology, Chair of Brewing Sciences, Berlin, Germany

Coauthor(s): Eon-Jeong Lee, Christof Reinhardt, and Frank-Jürgen Methner, Berlin Institute of Technology, Department of Biotechnology, Chair of Brewing Sciences, Berlin, Germany

Several breweries use unfermentable sugars to increase the beer palate-fullness. Besides the direct addition of sugars to the final beer, it is a standard custom to add these sugars at the end of the wort boiling process prior to fermentation; especially for low-solubility sugars. The aim of this study was to investigate the influence of the addition before fermentation of commonly used unfermentable sugars (polydextrose, Palatinose™ (isomaltulose) and Vitalose® (contains mainly trehalose) in direct comparison to fermentable sugars (glucose and sucrose) on the fermentation process, palate-fullness, beer flavor, and SO_2 formation. The amount of sugar (fermentable and unfermentable) added to basic wort (10.5% original gravity) was calculated to achieve a realistic increase in final extract of 1, 2, 3, and 5%. A control fermentation with no sugar addition (10.5%) and 12% extract was also performed. The fermentations were carried out simultaneously and under the same conditions. Yeast growth, SO_2 formation, extract, and pH development of every trial was monitored. After fermentation and filtration, the beers were analyzed (viscosity, extract, pH, color, SO_2 content, etc.). Additionally, a trained sensory panel tested every trial, with special focus on palate-fullness, sweetness, and flavor in direct comparison to the control beer where 0% sugar was added (pilsner type). In comparison to the control fermentation, higher SO_2 formation was generally observed in the brews in which sugars were added. Sugar additions (fermentable and unfermentable) up to 1–2% yielded a significant increase in SO_2 content. Compared to unfermentable sugars, higher glucose and sucrose additions (>2%) resulted in higher SO_2 contents of the finished beers. It seems that the general increase in SO_2 is based on the osmotic pressure change in the wort. Besides this, the addition of fermentable sugars leads to a higher SO_2 formation because of a stronger increase in the yeast cell number at the beginning of fermentation. At higher sugar concentrations (2–5%), there is a preponderance of SO_2 formation at the beginning of fermentation during the exponential growth phase of the yeast. This correlation is confirmed by the different influences of unfermentable sugars on SO_2 formation. With respect to the trials with unfermentable sugars, it could be observed that the addition of polydextrose leads to diminished SO_2 formation compared to Palatinose™ (isomaltulose) and Vitalose® mainly due to the smaller influence of polydextrose on the osmotic pressure of the wort. In summary, the results show that the addition of unfermentable sugars to 2% leads to a better palate-fullness and higher concentration of antioxidant substances like SO_2 without a detectable influence on beer flavor or sweetness.

After qualifying as a certified technician in preservation engineering (1991–1993), Thomas Kunz completed his basic studies in chemistry at the University of Applied Sciences, Isny (1994–1995) and his basic studies in food chemistry at Wuppertal University (1995–1998), before starting to study food technology at the University of Applied Sciences, Trier (1998–2002). After graduating, he worked as

a chartered engineer in the area of EPR spectroscopy at the Institute of Bio Physics at Saarland University (2002–2004). Since January 2005, he has been employed as a Ph.D. student at the Research Institute of Brewing Sciences, Berlin Institute of Technology (Technische Universität Berlin). His main research focus lies in analyzing radical reaction mechanisms in beer and other beverages using EPR spectroscopy.

P-57

Conserving energy while evaporating CO_2—A review of the different technologies

Presenter: Heiko Grimm, Norit Haffmans, Rockford, IL

Factors including increased environmental awareness and the desire to limit costs are driving breweries to be as inventive as ever in reducing energy consumption throughout the entire operation. A broad size range of breweries can conserve energy by taking a closer look at the CO_2 evaporation process. Energy conservation is achieved by tying the evaporation process with the local refrigeration system. By combining a hot return loop from the cooling plant with the liquid CO_2 stream that is supposed to be evaporated, the brewery can keep the "deep cold energy" in the process. Additionally, a possible strain on the cooling plant during the high season can be reduced. Three solutions to tie the streams together have been identified and proven useful. Two of these directly use the hot glycol return loop to evaporate the liquid CO_2 and indirectly use an intermediate cooling medium to transfer the energy into the house ammonia system. For the third option, when a brewery has a CO_2 recovery plant a combination of the CO_2 stream to be liquefied as well as the CO_2 stream to be evaporated to the consumers has shown the greatest energy and OPEX savings with a LiquiVap system. The LiquiVap simultaneously liquefies gas entering the system from the fermenters and vaporizes liquid CO_2 coming from the storage tanks. The return on investment for breweries with capacities larger than 500,000 bbl is a reasonable two years. In addition, a LiquiVap system enables the brewery to invest in a plant that has a smaller, more energy efficient and less costly cooling and vaporization system due to the fact that the LiquiVap system takes over some of the work load.

Heiko Grimm graduated in 2007 from Technische Universität München-Weihenstephan, Germany, with a master's degree in brewing and beverage technology. After the conclusion of his master's thesis on new beer stabilization methods, he began working for Haffmans BV in June 2007 as product manager CO_2 units responsible for the units and inline business of Norit Haffmans worldwide. In 2010, he transferred to product manager CO_2 systems, working closely with North American representatives. In January 2011, he transferred to the United States to work directly with customers in the North American market. He is currently responsible for the USA, Canada, Mexico, and Caribbean region for all CO_2 and brewing systems sales of the Norit group.

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CIP water management using fluorescence-based technology

Presenter: David Workman, Nalco Company, Naperville, IL

Coauthor(s): Thomas Lindley and Brian Ornay, Nalco Company, Naperville, IL

Water conservation has become part of the industrial landscape. Corporate sustainability goals necessitate that every process be examined, and CIP processes are not exempt. Cleaning and sanitizing of process equipment can account for up to 20% of a plant's total water use. A key step in the CIP process is the rinse cycle, with its removal of process cleaning and sanitizing chemicals prior to the next stage in the CIP or the re-introduction of product. Accurate determination of the CIP rinse cycle endpoint is problematic with current methods that employ indirect sensors and/or timers to indicate when a rinse stage is complete. These methods often lead to (a) over-rinsing to ensure process cleaning, and sanitizing chemicals are removed, resulting in excess water usage; or (b) an under-rinsed cycle that can compromise product integrity. An inert fluorescent tracer can be introduced into the CIP process to provide accurate determination of rinse stage endpoint. Tracking the tracer concentration decay during the rinse cycle provides a real-time methodology to accurately quantify the removal of the CIP solution being used. The rinse endpoint is then targeted to an acceptable residual CIP solution concentration, which protects product integrity while optimizing water usage by prevention of over-rinsing. Controlling the rinse endpoint based on the direct measurement of a CIP solution component (inert fluorescent tracer) eliminates plant and operational variations (such as tank location, tank volume, flow rate variations, and seasonal water quality changes) from the endpoint determination. Distinct rinse cycle set points are established for both cleaning and sanitizing cycles. Rinse cycle endpoints can be data-logged, and individual CIP Circuits can be tracked and trended to monitor for system characteristic changes that may currently go unnoticed. This new application is built upon Nalco's 3D TRASAR technology for boilers and cooling towers and 20 plus years of fluorescence experience. The inert tracer is caustic, oxidant resistant, and stable in most CIP process conditions. The detection limit of the tracer is well below FDA guidelines for process additives. Results from a successful implementation at a regional craft brewer will be discussed where >25% decrease in rinse times was noted.

Dave Workman is a staff scientist at Nalco Company in Naperville, IL. During a 20-year career with Nalco, Dave has worked on a variety of water- and process-centric projects, including multiple TRASAR applications. Before coming to Nalco, he received a Ph.D. degree in chemistry from The Ohio State University and completed a post-doctoral study at the Massachusetts Institute of Technology.

P-59

Optimizing energy management of industrial process steam via on-demand steam systems

Presenter: Jason Smith, Miura North America, Inc.

Both recent economic and environmental conditions in the U.S. have converged to bring about unprecedented attention to energy efficiency and sustainability in the country's industrial sector. Historically, energy costs in the U.S. have been low in comparison to global averages in some measure due to an extended tolerance for externalized costs related to environmental degradation. Consequently, awareness, innovation, and implementation of technologies focused on energy efficiency and reduced environmental impact have not kept pace with other industrialized nations. A recent survey conducted by Energy & Environmental Analysis, Inc. for Oak Ridge National Laboratory indicates that the current U.S. inventory of commercial/industrial boilers stands at around 163,000 units and 2.7 million MMBtu/hr total fuel input capacity. These boilers consume nearly 8,100 TBtu per year, representing about 40% of all energy consumed in the commercial/industrial sectors. Moreover, this same survey indicates that nearly 50% of all commercial/industrial boilers in the U.S. are 40+ years old, while as many as 80% are 30+ years old.

Boilers account for nearly half of all industrial energy consumption and represent one of the most energy-intensive systems involved in the brewing industry. Innovation in conventional boiler technology has stagnated for many decades, and the vast majority of those in operation today are based on 19th-century technology. Given the preponderance of aged, obsolete boiler technology currently in service in this industry, it is critical to raise awareness and examine the role of emerging new technologies to address the energy and environmental challenges inherent with process of steam/heat generation. In the same way that tank-less/instantaneous water heating systems are ushering in a new era in energy efficiency in the residential sector, compact modular on-demand steam-generation systems are poised to support the same kind of transformation in the industrial sector. Moreover, given the large amount of energy consumed and the sharp minute-to-minute variations in process steam demands in the brewing industry, on-demand steam generation has the opportunity to play a significantly larger role in increasing energy efficiency. This presentation will illustrate how emerging on-demand process steam boiler technologies will play a part in addressing the energy and environmental challenges facing the North American brewing industry.

Jason Smith has a background in architecture and engineering, with more than15 years of experience with the design and construction of high-performance "green" buildings and more than 5 years of experience as a LEED accredited professional, integrating sustainable design solutions into facilities that address energy efficiency and contribute to reducing their environmental impact. Jason is celebrating two years with Miura North America, directing energy and environmental initiatives, with a focus on energy efficiency advocacy, education, and market transformation in the area of thermal energy systems. Jason currently chairs the Energy Efficiency Deployment Sub-committee of the Department of Energy's ITP Steam Systems Best Practices Steering Committee and is an active member of the following organizations devoted to energy efficiency and sustainability: ESC, ACEEE, ASE, IDEA, APPA, ASHE, AEE, and USGBC.

P-60

Reducing carbon dioxide (CO_2) usage through the use of acid and detergent cleaning of bright tanks

Presenter: Dana Johnson, BIRKO Corporation

Greenhouse gas emissions (i.e., carbon dioxide [CO_2]) from the brewery can be decreased by cleaning bright tanks with acid and detergent rather than with caustic. When cleaning bright tanks with acid and detergent only, the bright tank can remain under pressure, and the cleaning can be done (in most cases) with ambient-temperature water. In addition to being a sustainable practice, this method also has the added benefit of greatly reducing the amount of dissolved oxygen (DO) in the subsequent packaged beer, because the tanks do not need to be purged of carbon dioxide, cleaned, cooled and re-carbonated, as they do when cleaning-in-place (CIP) with caustic. In addition, acid recycles well, thereby reducing chemical usage at the same time. By incorporating a detergent blend along with the acid, protein dispersion and beerstone (calcium oxalate) displacement is enhanced as well.

Dana Johnson is the current MBAA District Rocky Mountain Membership chair. After attending college at Mesa College in Grand Junction, CO, he has been with BIRKO Corporation since 1979 and has been calling on the craft brewing industry since 1995. Dana has authored numerous brewing magazine articles on cleaning, sanitizing, and process aids for brewers and is a frequent contributor to the Brewers Association Forum. When not calling on or delivering products to brewers in the Denver area, Dana enjoys making wine and beer at home with his wife Tammy and stepdaughter Leah.

P-61

Unique storm water management at a brewery using a rain garden/biorentention

Presenter: Jeffrey Van Voorhis, Symbiont Science, Engineering, and Construction

MillerCoors in Milwaukee, WI, partnered with the Milwaukee Metropolitan Sewage District and Symbiont Science, Engineering and Construction to demonstrate the effectiveness of a rain garden/bioretention swale for storm-water treatment at the parking lot across the street from the brewery's visitor center. The system is designed to capture, slow, and treat overland runoff from an industrial parking lot and storage yard on MillerCoors' property. Rainwater contaminated with dirt, oil, and other pollutants that accumulate on pavement enters the rain garden during storm events. The water pools above a specially engineered sand-soil composite mixture. The engineered soil is designed to promote rapid infiltration to filter out pollutants and store rainwater. Most of the rainwater that soaks in recharges the groundwater table, is used by vegetation, or evaporates. Any remaining treated water is slowly discharged to the city of Milwaukee sewer system. Vegetation consists exclusively of native grasses and perennial flowers planted in bands to simulate natural prairies. Although designed to capture rainwater, the plantings need to withstand extended periods of drought. This project demonstrates the combined aesthetics and performance potential of storm-water systems at industrial facilities. This project was awarded the Engineering Achievement Award by the Wisconsin Section of the American Society of Civil Engineers.

Jeffrey C. Van Voorhis has a B.S. degree in civil engineering, with an environmental emphasis, from Purdue University. He has more than 15 years of professional experience in water and wastewater treatment for the food and beverage chemical industries. He is currently a manager at Symbiont Science, Engineering, and Construction located in Milwaukee, WI. He has served as the project manager for a variety of projects, and he is familiar with all phases of water and wastewater treatment projects, beginning with characterization and permitting through design, construction, and startup. Symbiont has successfully completed projects for the beverage industry across the nation. Jeffrey incorporates sustainability into his projects. His MBA from Marquette University incorporates a valuable economic perspective to his projects to best serve his clients. He has been an active member of MBAA for several years.

P-62

Beer volatile analysis: Validation of headspace solid-phase microextraction (HS/SPME) coupled to gas chromatography–mass spectrometry

Presenter: Gustavo Charry, MillerCoor, Milwaukee, WI

Coauthor(s): Maritza DeJesus-Echevarria and Fernando Perez, University of Puerto Rico-Mayaguez Campus, Mayaguez, Puerto Rico

Volatile compounds such as higher alcohols, esters, and aldehydes are formed by the yeast, as by-products of their metabolism, during the beer fermentation process. The most widely used technique for the identification of volatile compounds is gas chromatography–mass spectrometry (GC/MS) and headspace sampling. Recently, headspace solid-phase microextraction (HS/SPME) technology has been used because it is a relatively simple, fast, sensitive, and solvent-free technique that enables extraction and concentration steps to be performed simultaneously. GC/MS/FID and HS/SPME parameters, in-

cluding fiber type, absorption, equilibration time, desorption time, salting-out effect, and others were optimized. Results evidenced the importance of proper control over extraction conditions to ensure precise quantification of compounds. Concentrations found in local beer for the compounds of interest, acetaldehyde, ethyl acetate, 1-propanol, 2-methyl 1-propanol; 2-methyl 1-butanol, 3-methyl 1-butanol, isoamyl acetate, 2-phenyl ethyl alcohol, and 2-phenyl ethyl acetate, were with the 0.32–43.7 ppm range. The results also showed that the reproducibility of the technique depends on the compounds, where alcohols have higher values (RSD mean value 5.01%) than esters (RSD mean value 2.3%) and aldehydes (RSD 4.4%). The simplicity of the validated development methodology could be used as a regular quality control procedure for beer.

Gustavo Charry started his focus in the food industry in Bogotá, Colombia, where he studied chemical engineering at the University of Los Andes. His passion for the brewing industry started in Mayaguez, Puerto Rico, where he obtained his M.S. degree in food science and technology in 2009, and led to a common project between the university and the local brewery. He worked as a researcher in Cervecera de Puerto Rico for two years, focusing on beer flavor development during fermentation. Gustavo jointed MillerCoors Milwaukee brewery in 2010, working as a quality engineer focused on flavor stability.

P-63

Withdrawn

P-64

Monitoring the rate of oxygen uptake for the control of yeast performance, fermentation, and quality of beer

Presenter: Koji Nakazawa, Asahi Breweries, Ltd., Moriya, Japan

Coauthor(s): Yuichi Nakamura, Asahi Breweries, Ltd., Osaka, Japan

Yeast activity has been investigated on the basis of the proportion of viable cells and the physiological status and function of viable cells, and many variables have been devised to evaluate yeast viability and vitality. Among these methods is the oxygen consumption method, which makes it possible to keep track of specific yeast vitality to some degree by measuring the oxygen consumption rate at a set temperature over a fixed period of time. However, it has been considered difficult to keep exact track of slight differences in yeast vitality in the brewing environment. We investigated whether it was possible to use the oxygen consumption rate in our breweries to predict yeast vitality and the progress of fermentation, with the goal of achieving stable management of the fermentation. As a result, oxygen consumption rate was different depending on the physical conditions of yeast and handling conditions, and the rate decreased when the yeast was stored for a few days. The rate was controllable by changing temperature conditions in the wort cooling process. In the 500-kL industrial-scale study, it was confirmed that by increasing wort temperature, the yeast stored for a long time achieved an oxygen consumption rate equivalent to the yeast collected on the test day, and the fermentation performed well. These findings suggest that the rate of oxygen uptake can be used to evaluate yeast vitality and manage fermentation. It is important to control oxygen uptake conditions according to the behavior of yeast.

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Optimized fermentation and maturation with ECO-FERM™

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For the fermentation and maturation of beer, the brewmaster has access to only a small number of tools to control and optimize the processes—recipe parameters: temperature, pressure and time; process parameter: gravity of the wort, yeast strain; continuous fermentation and maturation processes; mixing of the tank. The complex mixture of fermenting wort and yeast cells normally reacts very quickly to changes in the temperature and pressure profile or to additional application of "stress." GEA Brewery Systems has developed the system ECO-FERM™ to improve performance during fermentation and cooling down to cold maturation temperatures. This provides a process using jet mixing in a cylindroconical tank (CCT). A jet without any movable parts is installed in the cone of a CCT using the Venturi principle, so only one-third of the total flow inside the CCT is pumped around with a circulation pump. Approximately 10% of the carbon dioxide produced during fermentation is dissolved in the beer; the other 90% bubbles up to the liquid surface, forming a bubble column in the CCT. This bubble column leads to an upward movement of the liquid in the center of the CCT and consequently to a downward movement at the cooled shell of the tank. The jet in the cone provides powerful support of this natural upward motion. Improvement of this upward flow will keep a larger number of active yeast cells in suspension, and in addition, yeast cells on their way down to the cone are sucked from the jet and resuspended in the fermenting liquid. More yeast cells in motion will speed up the chemical reactions. The hydraulic jet also improves temperature homogeneity in the tank and significantly enhances the heat transfer coefficient at the tank shell. The paper presents first results from an industrial application in a 2,660-hL CCT with worts of 14°P. For all trails a wort batch of 5,320 hL was used to avoid differences resulting from brewhouse operations. The batch was divided into a tank equipped with ECO-FERM™ and a reference tank using the standard process of the brewery. The results cover process duration and temperature homogeneity, as well as analytical results of the beers, including DLG tastings.

Rudolf Michel received both his engineering and his Ph.D. degrees from the Technical University of Munich at Weihenstephan. He was a member of the scientific staff at the Institute of Chemical Engineering at Weihenstephan, working on the mechanisms of hot-break separation in a whirlpool tank and on hygienic design of armatures and pipe work systems in the food industry. Rudolf's industrial experience includes an apprenticeship as brewer and maltster at Mahr's Bräu in Bamberg, Germany. He joined GEA Brewery Systems in June 2000 as director of brewing and technology and has been involved in major brewing projects and research works around the world for GEA Brewery Systems. Currently, he is leading the research and development team dealing with improvements in brewing technology and environmental aspects of the brewing industry. He is a member of DBMB and has published more than 64 papers.