

SCIENCE, EXPERIENCE, & TRADITION

Balanced for Perfection

71st Annual Meeting of the American Society of Brewing Chemists
June 16–20, 2007 • The Fairmont Empress • Victoria, British Columbia, Canada



ASBC

2007

Annual Meeting
June 16-20
Victoria, British Columbia



Annual Meeting
June 16-20

Victoria, British Columbia

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Photos courtesy of Tourism Victoria:

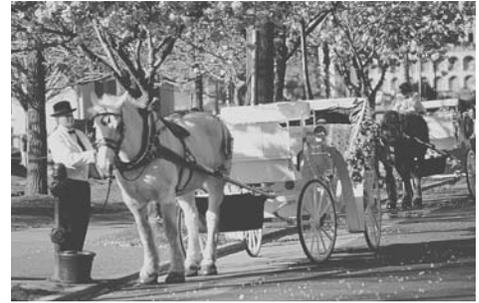
Front Cover—Downtown & Inner Harbour;

*Page 1—Fisherman’s Wharf, Victoria’s Hanging
Baskets, Blossoms with Horse Carriage.*

Photo courtesy of The Butchart Gardens Ltd.:

Page 14—Butchart’s Japanese Gardens

Welcome to beautiful Victoria, British Columbia, Canada!



Greetings from the ASBC Program Committee. It is our pleasure to welcome you to the 2007 ASBC Annual Meeting in the beautiful city of Victoria, British Columbia.

There are great things planned for this meeting! From opening keynote speaker Arthur Klatsky discussing alcohol and cardiovascular conditions to closing speaker Greg Evans presenting the brewing history of Vancouver Island, there is something for everyone. This year's incredible program highlights 10 technical sessions featuring 35 oral presentations. In addition, there are 33 posters, 5 workshops, 1 short course, and a gourmet food and beer pairing special event. Opportunities exist around every corner to network, learn, build business relationships, and hear first-hand information on the latest brewing science and related research. Plus, there will be ample time to connect with colleagues and suppliers while enjoying the exhibits and hospitality.

Take in all the information you can throughout the meeting and take time to view the exhibits, socialize in the hospitality room, catch up on the latest news in the industry, and relax in beautiful Victoria.

The 2007 ASBC Program Committee

General Information

Registration Desk

Registration will be located in the Victoria Conference Centre on Level 1.

The conference centre is connected to The Fairmont Empress hotel.

Saturday, June 16	2:00 – 5:00 p.m.
Sunday, June 17	7:00 a.m. – 5:00 p.m.
Monday, June 18	7:00 a.m. – 3:00 p.m.
Tuesday, June 19	7:00 a.m. – 3:00 p.m.
Wednesday, June 20	7:00 a.m. – 12:00 p.m.

Silent Auction

Victoria Conference Centre – Level 1

Saturday, June 16	Drop-Off	2:00 – 5:00 p.m.
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Victoria Conference Centre – Pre-function 1

Sunday, June 17	Bidding Open	7:00 a.m. – 5:00 p.m.
Monday, June 18	Bidding Open	7:00 a.m. – 1:50 p.m.



The ASBC Foundation is hosting a Silent Auction to benefit the Brian Williams Scholarship Fund. The Foundation's goal is to maintain the \$20,000 fund, which will allow the Foundation to present at least one \$1,000 Brian Williams scholarship every year.

Stop by the Silent Auction at the Victoria Conference Centre Pre-function 1 on Sunday, June 17, 7:00 a.m.-5:00 p.m., and on Monday, June 18, 7:00 a.m.-1:50 p.m., to place your bids on the many items available.

Exhibits

Victoria Conference Centre – Carson Hall

Exhibit Set Up

Saturday, June 16	3:00 – 5:00 p.m.
Sunday, June 17	9:00 – 11:00 a.m.

Exhibits Open

Sunday, June 17	3:30 – 6:30 p.m.
Monday, June 18	10:00 a.m. – 12:00 p.m.
Tuesday, June 19	10:30 a.m. – 1:00 p.m.

Exhibit Take Down

Tuesday, June 19	1:00 – 4:00 p.m.
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Posters

Victoria Conference Centre – Carson Hall

Poster Set Up

Saturday, June 16	3:00 – 5:00 p.m.
Sunday, June 17	9:00 – 11:00 a.m.

Posters Open

Sunday, June 17	3:30 – 6:30 p.m.
Monday, June 18	10:00 a.m. – 12:00 p.m.
Tuesday, June 19	10:30 a.m. – 1:00 p.m.

Poster Session – Authors Present

Sunday, June 17	4:30 – 5:30 p.m.
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Poster Session – Authors Present – Even Numbers

Monday, June 18	10:00 a.m. – 10:30 p.m.
Tuesday, June 19	12:00 – 12:30 p.m.

Poster Session – Authors Present – Odd Numbers

Monday, June 18	11:30 a.m. – 12:00 p.m.
Tuesday, June 19	10:30 – 11:00 a.m.

Poster Take Down

Tuesday, June 19	1:00 – 4:00 p.m.
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Meeting Attire

Business casual dress is encouraged for all meeting events.

Photo Release

By virtue of your attendance at the ASBC Annual Meeting, you agree to ASBC's use of your likeness in promotional materials.

Medical Emergencies

Medical emergencies should be communicated to an ASBC staff member at the registration desk and/or the hotel staff by dialing 57. This is the hotel's internal emergency number and places the call on priority. Front office managers and security personnel are fully trained in industrial first aid and are on property 24 hours a day.

There are two hospitals in close proximity to The Fairmont Empress:

Royal Jubilee Hospital 1952 Bay Street Victoria, BC Tel.: +1.250.370.8000	Victoria General 1 Hospital Way Victoria, BC Tel.: +1.250.727.4212
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A walk-in medical clinic is located one block from The Fairmont Empress:

Downtown Medical Centre
622 Courtney Street
Tel.: +1.250.380.2210
Hours: Monday–Friday, 8:00 a.m. – 5:00 p.m.

Guest Program

Guests wishing to participate in the Welcome Guest Brunch and enjoy use of the Guest Lounge must have registered in advance or onsite. Guests wishing to attend any of the receptions, luncheons or other ticketed events must purchase tickets.

No formal group tours are planned. Gray Line West maintains a tour desk in the lobby of The Fairmont Empress hotel where you may buy individual tour tickets. Tours depart daily from the Victoria Bus Depot located at the rear entrance of the hotel.

All Guest Program events take place at The Fairmont Empress.

Sunday, June 17

Welcome Brunch

The Fairmont Empress • Balmoral
9:00 a.m.

Enjoy a lavish brunch buffet while meeting other guests attending the ASBC meeting. Representatives from the Victoria Office of Tourism and Gray Line West tour operators will provide brochures and an overview of things to do around Vancouver Island and the city of Victoria.

Ticket is included in the guest registration fee. Advance registration is required.

Guest Lounge Open

Buckingham Room
1:00 – 3:00 p.m.

Welcome Reception

Royal British Columbia Museum
7:00 – 9:30 p.m.

Ticket is included in the guest registration fee. Advance registration is required.

Monday, June 18

Guest Lounge Open

Buckingham Room
9:00 a.m. – 3:00 p.m.

Tuesday, June 19

Guest Lounge Open

Buckingham Room
9:00 a.m. – 3:00 p.m.

Afternoon Tea at The Fairmont Empress

Tea Lobby
2:00 p.m.

Indulge in one of Victoria's grandest traditions—Afternoon Tea at The Fairmont Empress. For almost a century, the majestic lobby of this landmark hotel has played host to England's most beloved ritual—the taking of afternoon tea.

Sample Menu: Proprietary Tea at The Empress tea blend; seasonal fresh fruit; assortment of sandwiches; and pastries, including classic raisin scones with Devon-style clotted cream and strawberry preserves.

Optional ticket. Advance registration is required; seating is limited to 30 guests.

Wednesday, June 20

Guest Lounge Open

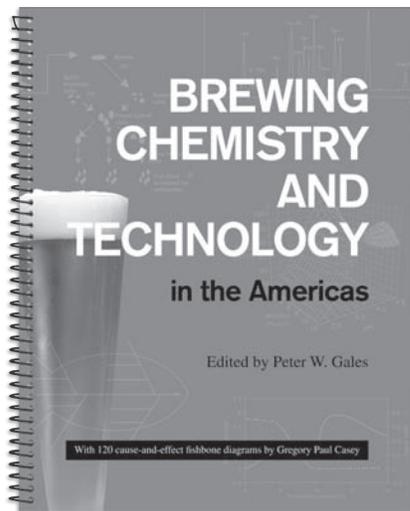
Buckingham Room
9:00 a.m. – 3:00 p.m.

Closing Reception

The Fairmont Empress
7:00 – 10:00 p.m.

Optional ticket. Advance registration is required.

NEW and On SALE



Fifty-eight brewing scientists present up-to-date solutions in an easy-to-read Q&A format.

This essential reference includes 120 Cause-and-Effect Fishbone Diagrams to improve process control and product quality.

In *Brewing Chemistry and Technology in the Americas* 58 brewing science experts answer the “Who,” “What,” “How,” and “Why” of brewing chemistry today. This book provides a simple and easy-to-understand overview of the current science underlying the brewing processes and functions that exist across nearly any size operation. It will quickly build bridges of brewing chemistry knowledge among these specialists.



Greg Casey

Don't miss the book signing!

Book Signing – Tuesday, June 19
10:15 a.m.-11:30 a.m.
Near the ASBC Registration Desk

Meet Greg Casey the author of the Fishbone Diagrams and get an autographed copy of the book signed by Greg Casey and the editor Peter Gales.



Peter Gales, editor

Greg Casey's 120 Cause-and-Effect Fishbone Diagrams add years of troubleshooting experience to your brewing operation.

As a brewing scientist, Greg Casey is renowned for his educational lectures on process control using his Cause-and-Effect Fishbone Diagrams. These diagrams are a visual way of representing the relationship between an “effect” of interest to a maltster or brewer (e.g., beer flavor stability) and observed “causes” influencing or correlating with the stated effect, e.g., time, temperature, total in package oxygen.



AMERICAN SOCIETY OF
Brewing Chemists

Visit the ASBC Registration Desk during the meeting to purchase this new book at the **SALE** price.

#IASBC-2014

Schedule at a Glance

Saturday, June 16	Sunday, June 17	Monday, June 18	Tuesday, June 19	Wednesday, June 20
<p>Board of Directors Meeting 8:00 a.m. – 5:00 p.m.</p> <p>ASBC Short Course: Modern Day Applications of EPR/ESR Technology in Malting, Brewing, Packaging, and Beer Flavor Stability 1:00 – 5:00 p.m.</p> <p>Registration 2:00 – 5:00 p.m.</p> <p>Hospitality 4:00 – 11:00 p.m.</p> <p>Past Presidents/First Timers/Students Reception 6:00 – 7:00 p.m.</p>	<p>Speaker Orientation/Breakfast (Orals 1-5, Posters 36-55) 7:00 – 8:00 a.m.</p> <p>Registration/Silent Auction 7:00 a.m. – 5:00 p.m.</p> <p>Program Committee Meeting/Breakfast 8:00 – 8:30 a.m.</p> <p>Local Section Officers Meeting/Breakfast 8:00 – 9:00 a.m.</p> <p>Past Presidents Meeting/Breakfast 8:00 – 9:00 a.m.</p> <p>Guest Welcome Brunch 9:00 a.m.</p> <p>ASBC General Session and Opening Keynote Presentation: Alcohol and Cardiovascular Conditions in 2007 9:15 – 10:45 a.m.</p> <p>Technical Subcommittee Meeting 11:00 a.m. – 12:00 p.m.</p> <p>Beer, Cheese, and Glassware Workshop 1:00 – 3:00 p.m.</p> <p>Welcome and Technical Session I – Hops/Barley/Malt 1:00 – 3:30 p.m.</p> <p>Exhibits/Posters and Hospitality 3:30 – 6:30 p.m. Authors Present: 4:30 – 5:30 p.m.</p> <p>New Products and Services Session 3:40 – 4:30 p.m.</p> <p>Welcome Reception 7:00 – 9:30 p.m.</p> <p>Hospitality 9:00 – 11:00 p.m.</p>	<p>Speaker Orientation/Breakfast (Orals 6-14, Posters 56-69) 7:00 – 8:00 a.m.</p> <p>ASBC-MBAA Steering Committee Meeting 7:00 – 8:00 a.m.</p> <p>Silent Auction 7:00 a.m. – 1:50 p.m.</p> <p>Registration 7:00 a.m. – 3:00 p.m.</p> <p>Quality Effectiveness Workshop 8:00 – 10:00 a.m.</p> <p>Technical Session II – Yeast I 8:00 – 10:00 a.m.</p> <p>Exhibits and Hospitality 10:00 a.m. – 12:00 p.m.</p> <p>Poster Session 10:00 a.m. – 12:00 p.m. Authors Present: 10:00 – 10:30 a.m. (even numbers) 11:30 a.m. – 12:00 p.m. (odd numbers)</p> <p>Technical Subcommittee Meetings 10:30 – 11:30 a.m.</p> <p>Recognition Lunch 12:15 – 1:45 p.m.</p> <p>Technical Session III – Yeast II 2:00 – 4:25 p.m.</p> <p>Beer Design Workshop 2:00 – 4:00 p.m.</p> <p>Emerging Issues Open Forum 4:30 – 5:30 p.m.</p> <p>Hospitality 4:30 – 11:00 p.m.</p>	<p>Speaker Orientation/Breakfast (Orals 15-25) 7:00 – 8:00 a.m.</p> <p>Registration 7:00 a.m. – 3:00 p.m.</p> <p>Technical Session IV – Alternate Ingredients 8:00 – 9:20 a.m.</p> <p>Packaging Workshop: Off-flavor Notes in Beer from Aluminum Can Packaging – Fact or Fiction 8:00 – 9:30 a.m.</p> <p>Technical Session V – Micro 9:35 – 10:30 a.m.</p> <p>Poster Session 10:30 a.m. – 1:00 p.m. Authors Present: 10:30 – 11:00 a.m. (odd numbers) 12:00 – 12:30 p.m. (even numbers)</p> <p>Exhibits and Hospitality 10:30 a.m. – 1:00 p.m. Lunch 11:30 a.m. – 1:00 p.m.</p> <p>Technical Subcommittee Meetings 11:00 a.m. – 12:00 p.m.</p> <p>Technical Session VI – Process/Quality 1:00 – 2:20 p.m.</p> <p>Guest Afternoon Tea 2:00 p.m.</p> <p>Technical Session VII – Analytical I 2:35 – 3:50 p.m.</p> <p>Organic Workshop 3:55 – 5:30 p.m.</p> <p>Hospitality 4:00 – 11:00 p.m.</p> <p>Gourmet Food and Beer Pairing Dinner Event 7:00 p.m.</p>	<p>Speaker Orientation/Breakfast (Orals 26-35) 7:00 – 8:00 a.m.</p> <p>Technical Committee Meeting/Breakfast 7:00 – 8:00 a.m.</p> <p>Registration 7:00 a.m. – 12:00 p.m.</p> <p>Technical Session VIII – Analytical II 8:00 – 9:20 a.m.</p> <p>Technical Session IX – Flavor/Sensory I 9:35 – 10:55 a.m.</p> <p>Program Committee Meeting/Lunch 11:30 a.m. – 1:15 p.m.</p> <p>Publications Committee Meeting/Lunch 11:30 a.m. – 1:15 p.m.</p> <p>Technical Committee and Subcommittee Chairs Meeting/Lunch 11:30 a.m. – 1:15 p.m.</p> <p>Technical Session X – Flavor/Sensory II 1:30 – 3:15 p.m.</p> <p>Closing Keynote Presentation: The Devil Hop: A History of Brewing on Vancouver Island 3:30 – 4:15 p.m.</p> <p>Closing Reception 7:00 – 10:00 p.m.</p> <p>Hospitality 9:00 – 11:00 p.m.</p>

Program

Friday, June 15

8:00 a.m. – 5:00 p.m.	Technical Committee Meeting	Fairmont Empress Library
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Saturday, June 16

8:00 a.m. – 5:00 p.m. 1:00 – 5:00 p.m.	Board of Directors Meeting ASBC Short Course: Modern Day Applications of EPR/ESR Technology in Malting, Brewing, Packaging, and Beer Flavor Stability	Fairmont Empress Buckingham Victoria Conference Centre Esquimalt
2:00 – 5:00 p.m. 3:00 – 5:00 p.m.	Registration Exhibit/Poster Set Up	Victoria Conference Centre Level 1 Victoria Convention Centre Carson Hall
4:00 – 11:00 p.m. 6:00 – 7:00 p.m.	Hospitality Past Presidents/First Timers/Students Reception	Fairmont Empress Palm Court Fairmont Empress Buckingham

Saturday Session

Pre-annual Meeting Short Course Modern Day Applications of EPR/ESR Technology in Malting, Brewing, Packaging, and Beer Flavor Stability

1:00 – 5:00 p.m.
Victoria Conference Centre Esquimalt Room

Three experienced chemists will present EPR/ESR information and practical examples of how this technology has been used in brewing situations to improve flavor stability of beer. Each will cover certain areas of how this technique is used with respect to chemistry and theory, sample preparation, T150 and lag time determinations, and many examples of EPR successes in malt extract, wort boiling, fermenting, dark and pale beers, flavor, and packaging material studies. Also, a display of EPR/ESR lag time data graphs will be compared with informal tasting results of fresh and stale beers during the session. Registration is required to attend the short course.



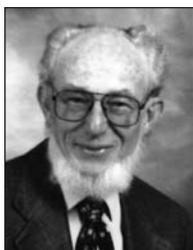
Sunday, June 17

7:00 – 8:00 a.m.	Speaker Orientation and Breakfast: Orals 1–5, Posters 36–55	Victoria Convention Centre Royal View
7:00 a.m. – 5:00 p.m.	Registration	Victoria Convention Centre Level 1
7:00 a.m. – 5:00 p.m.	Silent Auction Open	Victoria Convention Centre Level 1
8:00 – 8:30 a.m.	Program Committee Meeting and Breakfast	Victoria Convention Centre Saanich 2
8:00 – 9:00 a.m.	Local Section Officers Meeting and Breakfast	Victoria Convention Centre Metchosin
8:00 – 9:00 a.m.	Past Presidents Meeting and Breakfast	Victoria Convention Centre Colwood 1
9:00 a.m.	Guest Welcome Brunch	Fairmont Empress Balmoral
9:00 – 11:00 a.m.	Exhibit/Poster Set Up	Victoria Convention Centre Carson Hall
9:15 – 10:45 a.m.	ASBC General Session and Opening Keynote Speaker Dr. Arthur L. Klatsky	Victoria Convention Centre Lecture Theatre
10:45 – 11:00 a.m.	Break	Victoria Convention Centre Prefunction 1

11:00 a.m. – 12:00 p.m.	Technical Subcommittee Meeting Coordination of New and Alternate Methods of Analysis	Victoria Convention Centre Esquimalt
1:00 – 3:00 p.m.	Beer, Cheese, and Glassware Workshop	Victoria Convention Centre Saanich 1
1:00 – 3:30 p.m.	Welcome and Technical Session I – Hops/Barley/Malt Moderator: Mary-Jane Maurice, International Malting Co., Milwaukee, WI	Victoria Convention Centre Lecture Theatre
1:05 – 1:30 p.m.	O-1. Antioxidant properties of hop polyphenols. Thomas H. Shellhammer, Oregon State University, Corvallis, OR	
1:30 – 1:55 p.m.	O-2. Transcriptional profiling of <i>Fusarium</i> mycotoxin biosynthesis. Arja Laitila, VTT Technical Research Centre of Finland, Espoo, Finland	
1:55 – 2:20 p.m.	O-3. Effect of operational parameters on the determination of laboratory extract and associated wort quality factors. Yin Li, North Dakota State University, Fargo, ND	
2:20 – 2:40 p.m.	Break	Victoria Convention Centre Prefunction 1
2:40 – 3:05 p.m.	O-4. New insights into the molecular causes of lower glucan contents in malt and wort. Michael Voetz, VLB, Berlin, Germany	
3:05 – 3:30 p.m.	O-5. Miniaturizing the fermentation assay: Effect of fermenter size and fermentation kinetics on premature yeast flocculation. R. Alex Speers, Dalhousie University, Halifax, NS, Canada	
3:30 – 6:30 p.m.	Exhibits/Posters and Hospitality (Authors Present 4:30 – 5:30 p.m.)	Victoria Convention Centre Carson Hall
3:40 – 4:30 p.m.	New Products and Services Session Moderator: Gregory Casey, Coors Brewing Co., Golden, CO	Victoria Convention Centre Lecture Theatre
3:45 – 3:50 p.m.	Energy and Water Usage Auditing, BRI	
3:51 – 3:56 p.m.	EZ-Tox™ DON Reagent Test, Diagnostix Ltd.	
3:57 – 4:03 p.m.	The GEM Liquid-Phase Calibrators, HEADMASTER LIMITED	
4:04 – 4:09 p.m.	A New Dry Yeast to Produce Mifeweizen Beers, Lallemand Inc.	
4:10 – 4:15 p.m.	Advanced Instrument, GPR-1200 PPM Oxygen Analysis, Profamo Inc.	
4:16 – 4:21 p.m.	A Rapid, Non-destructive Microbiology System for the Brewing Industry, Rapid MicroBiosystems	
4:22 – 4:27 p.m.	Automatic Steinfurth Torque Tester TMS 5000, Steinfurth Inc.	
7:00 – 9:30 p.m.	Welcome Reception	Royal British Columbia Museum First Peoples & Modern History Galleries Third Floor
9:00 – 11:00 p.m.	Hospitality	Fairmont Empress Palm Court

Sunday Sessions

Opening Keynote Presentation



Alcohol and Cardiovascular Conditions in 2007

Dr. Arthur L. Klatsky
Senior Consultant in Cardiology
Kaiser Permanente

Victoria Convention Centre Lecture
Theatre
9:15 – 10:45 a.m.

It is easy to oversimplify an approach to the relation of alcohol drinking with cardiovascular conditions. Alcohol can be either good or bad for the heart, depending on amount and pattern

of drinking and which cardiovascular condition is considered. This presentation will review these disparities with respect to cardiomyopathy (heart muscle disease), hypertension (high blood pressure), stroke (hemorrhage from or blockage of brain blood vessels), arrhythmias (heart rhythm disturbances), coronary artery disease (the usual cause of “heart attack”), and heart failure (a syndrome due to impaired heart pumping). The evidence for protection provided by moderate drinking against coronary disease (the most common cardiovascular condition) will be reviewed, as well as possible differences related to beverage choice (wine, liquor, or beer). Finally, problems related to defining a sensible drinking limit and to giving advice to concerned persons will be considered.

Sunday Sessions continued

Beer, Cheese, and Glassware Workshop

Victoria Convention Centre Saanich 1

1:00 – 3:00 p.m.

Anheuser-Busch's Nathaniel Davis will lead us through intriguing combinations of beers and cheeses to delight the palate. Five beer-and-cheese pairs have been selected to highlight what we all know—that beer is a natural choice for so many culinary occasions! There are as many cheeses as there are beer brands, ranging from the casual to the sophisticated, and paired appropriately, beer-and-cheese duos may complement or contrast one another in surprising ways. In addition, a selection of glassware will be utilized to demonstrate how choosing the appropriate glass size and shape can set the stage for the beer style and drinking occasion and impact a beer's taste and aroma profiles.

Separate registration is required for this event. Seating is limited.

New Products and Services Session

Victoria Convention Centre Lecture Theatre

3:40 – 4:30 p.m.

Welcome Reception

Royal British Columbia Museum First Peoples & Modern History Galleries Third Floor

7:00 – 9:30 p.m.

Ticket is included in the guest registration fee. Advance registration is required.

Monday, June 18

7:00 – 8:00 a.m.	ASBC-MBAA Steering Committee	Victoria Convention Centre Metchosin
7:00 – 8:00 a.m.	Speaker Orientation and Breakfast: Orals 6–14, Posters 56–69	Victoria Convention Centre View Royal
7:00 a.m. – 1:50 p.m.	Silent Auction Open	Victoria Convention Centre Prefunction 1
7:00 a.m. – 3:00 p.m.	Registration	Victoria Convention Centre Level 1
8:00 – 10:00 a.m.	Quality Effectiveness Workshop	Victoria Convention Centre Saanich
8:00 – 10:00 a.m.	Technical Session II – Yeast I	Victoria Convention Centre Lecture Theatre
8:05 – 8:30 a.m.	Moderator: Chris Powell, Lallemand, Montreal, QC, Canada O-6. Colloidal examinations of yeast fermented in wort causing premature yeast flocculation. Jaydeep K. Patel, Dalhousie University, Halifax, NS, Canada	
8:30 – 8:55 a.m.	O-7. Investigations on malts causing premature yeast flocculation. Joseph C. Lake, Dalhousie University, Halifax, NS, Canada	
8:55 – 9:10 a.m.	Break	Victoria Convention Centre Prefunction 1
9:10 – 9:35 a.m.	O-8. Zinc interactions with yeast: Physiology, fermentation and transcriptional responses. Graeme M. Walker, University of Abertay Dundee, Dundee, Scotland, UK	
9:35 – 10:00 a.m.	O-9. Yeast metabolism and flavor generation—Formation of gammanonalactone. Leif A. Garbe, TU Berlin, Berlin, Germany	
10:00 a.m. – 12:00 p.m.	Exhibits and Hospitality	Victoria Convention Centre Carson Hall
10:00 a.m. – 12:00 p.m.	Poster Session Authors Present: Even numbers 10:00 – 10:30 a.m.; Odd numbers 11:30 a.m. – 12:00 p.m.	Victoria Convention Centre Carson Hall
10:30 – 11:30 a.m.	Technical Subcommittee Meetings Method for Reference Standard for Total Package Oxygen PCR Applications to Brewing Soluble Starch Check Services Method for Measurement of Resistance of Free-Radical Oxidation in Beer by Electron Paramagnetic Resonance	Victoria Conference Centre Oak Bay 1 Victoria Convention Centre Oak Bay 2 Victoria Convention Centre Esquimalt Victoria Convention Centre Sidney Victoria Convention Centre Colwood

12:15 – 1:45 p.m.	Recognition Lunch	Fairmont Empress Crystal Ballroom
2:00 – 4:00 p.m.	Beer Design Workshop	Victoria Convention Centre Saanich 1
4:30 – 11:00 p.m.	Hospitality	Fairmont Empress Palm Court
2:00 – 4:25 p.m.	Technical Session III – Yeast II Moderator: John Piening, Samuel Adams Brewery Co. Ltd., Cincinnati, OH	Victoria Convention Centre Lecture Theatre
2:05 – 2:30 p.m.	O-10. An array comparative genomic hybridization and polymerase chain reaction method for discriminating between brewing yeast strains. Hideyo Tadami, Asahi Breweries, Ltd., Ibaraki, Japan	
2:30 – 2:55 p.m.	O-11. Differentiation of species belonging to <i>Saccharomyces sensu stricto</i> using a loop-mediated isothermal amplification method. Nobuyuki Hayashi, Kirin Brewery Co., Ltd., Yokohama, Japan	
2:55 – 3:20 p.m.	O-12. The function and stability of mitochondrial DNA during fermentation. Katherine A. Smart, University of Nottingham, Loughborough, UK	
3:20 – 3:35 p.m.	Break	Victoria Convention Centre Prefunction 1
3:35 – 4:00 p.m.	O-13. Studies on the production of sulfite and hydrogen sulfide during fermentation in lager yeast. Masahide Sato, Sapporo Breweries, Ltd., Shizuoka, Japan	
4:00 – 4:25 p.m.	O-14. Differentiation of yeast strains and detection of mutants using genetic methods. Sylvie M. Van Zandycke, Lallemand Brewing, Montreal, QC, Canada	
4:30 – 5:30 p.m.	Emerging Issues Open Forum	Victoria Convention Centre Lecture Theatre
4:30 – 11:00 p.m.	Hospitality	Fairmont Empress Palm Court

Monday Sessions

Quality Effectiveness Workshop

Victoria Convention Centre Saanich
8:00 – 10:00 a.m.

The effectiveness of a brewery's quality organization depends on its quality system, which by definition consists of the whole interdependent organization of policies, programs, processes, procedures, measurements, roles, responsibilities, and resources that support the achievement of quality. A comprehensive review of quality systems that are used to protect and build a brewer's brands and reputation will be discussed and debated during this workshop, providing insight into quality structures and quality programs deployed at various breweries.

Beer Design Workshop

Victoria Convention Centre Saanich 1
2:00 – 4:00 p.m.

Join a panel of renowned brewmasters as they talk about their unique points of view regarding the design of award-winning examples of German specialty beers. This workshop will be filled with information unique to German specialty styles, including Kolsch, Weizenbier, and more. If you've ever wanted to learn more about German-style beers, don't miss this panel!



Tuesday June 19

7:00 – 8:00 a.m.	Speaker Orientation and Breakfast: Orals 15–25	Victoria Convention Centre View Royal
7:00 a.m. – 3:00 p.m.	Registration	Victoria Convention Centre Level 1
8:00 – 9:30 a.m.	Packaging Workshop: Off-flavor Notes in Beer from Aluminum Can Packaging – Fact or Fiction	Victoria Convention Centre Saanich 1
8:00 – 9:20 a.m.	Technical Session IV – Alternate Ingredients	Victoria Convention Centre Lecture Theatre
8:05 – 8:30 a.m.	Moderator: Sue Kay, Miller Brewing Co., Milwaukee, WI O-15. Response surface methodology as a tool to optimise the malting of buckwheat. Florian Huebner, National University of Ireland, Cork, Ireland	
8:30 – 8:55 a.m.	O-16. Palatinose in beer production—Research results. Roland H. Pahl, VLB Berlin, Berlin, Germany	
8:55 – 9:20 a.m.	O-17. Glutenfree beer—A review. Beatus D. Schehl, National University of Ireland, Cork, Ireland	
9:20 – 9:35 a.m.	Break	Victoria Convention Centre Prefunction 1
9:35 – 10:30 a.m.	Technical Session V – Micro	Victoria Convention Centre Lecture Theatre
	Moderator: Bob Taylor, Miller Brewing Co., Milwaukee, WI	
9:40 – 10:05 a.m.	O-18. MicroStar-RMDS-SPS (ATP-bioluminescence method): Rapid biological monitoring for practical use. Hajime Kanda, Sapporo Breweries Ltd., Sizuoka, Japan	
10:05 – 10:30 a.m.	O-19. The effect of antimicrobial steels and photocatalytic coatings on the microbial load on filler surfaces. Erna Storgårds, VTT Technical Research Centre of Finland, Espoo, Finland	
10:15 – 11:30 a.m.	Book Signing Meet Greg Casey, fishbone diagram contributor, and Peter Gales, editor of the new ASBC book <i>Brewing Chemistry and Technology in the Americas</i> (on sale during the meeting)	Near ASBC Registration
10:30 a.m. – 1:00 p.m.	Exhibits and Hospitality (11:30 a.m. – 1:00 p.m. lunch available in Exhibit Hall)	Victoria Convention Centre Carson Hall
10:30 a.m. – 1:00 p.m.	Poster Session Authors Present: Odd numbers 10:30 – 11:00 a.m.; Even numbers 12:00 – 12:30 p.m.	Victoria Convention Centre Carson Hall
11:00 a.m. – 12:00 p.m.	Technical Subcommittee Meetings TBA Test as an Indicator for Flavour Stability MOA Methods Review Determination of Alpha-Amylase by Automated Flow Analysis Craft Brewers Can Packaging Methods Sensory	Victoria Convention Centre Oak Bay 1 Victoria Convention Centre Oak Bay 2 Victoria Convention Centre Esquimalt Victoria Convention Centre Sidney Victoria Convention Centre Colwood Victoria Convention Centre Saanich 1
1:00 – 2:20 p.m.	Technical Session VI – Process/Quality	Victoria Convention Centre Lecture Theatre
	Moderator: Fred Strachan, Sierra Nevada Brewing Co., Chico, CA	
1:05 – 1:30 p.m.	O-20. The status and challenge in quality assurance with the Chinese brewing industry. Jianjun Dong, Tsingtao Brewery Co. Ltd, Qingdao City, China	
1:30 – 1:55 p.m.	O-21. A comparison of the cost, quality, and environmental impacts of conventional brewing versus possible future brewing methods. Stephen T. Russell, University of California, Davis, CA	

1:55 – 2:20 p.m.	O-22. The importance of gage reproducibility and repeatability (Gage R&R) in the lab setting. Brad A. Rush, Briess Malt & Ingredients Co., Chilton, WI	
2:00 p.m.	Guest Afternoon Tea	Fairmont Empress Tea Lobby
2:20 – 2:35 p.m.	Break	Victoria Convention Centre Prefunction 1
2:35 – 3:50 p.m.	Technical Session VII – Analytical I Moderator: Adrienne Caruso, Anheuser-Busch Inc., St. Louis, MO	Victoria Convention Centre Lecture Theatre
2:35 – 3:00 p.m.	O-23. Development of a technique to evaluate the foam potential of protein in beer. Eiichi Jimbo, Asahi Breweries, Ltd., Moriya, Japan	
3:00 – 3:25 p.m.	O-24. A reexamination of SRM as a means of beer color specification. Andrew J. deLange, Zeta Associates, Fairfax, VA	
3:25 – 3:50 p.m.	O-25. The assessment of the susceptibility of beer foam to damage by lipids. Charles W. Bamforth, University of California, Davis, CA	
1:00 – 4:00 p.m.	Exhibit/Poster Take Down	Victoria Convention Centre Conference Hall
3:55 – 5:30 p.m.	Organic Workshop	Victoria Convention Centre Lecture Theatre
4:00 – 11:00 p.m.	Hospitality	Fairmont Empress Palm Court
7:00 p.m.	Gourmet Food and Beer Pairing Ticketed Event	Spinnakers BrewPub

Tuesday Sessions

Packaging Workshop: Off-flavor Notes in Beer from Aluminum Can Packaging – Fact or Fiction

Victoria Convention Centre Saanich 1

8:00 – 9:30 a.m.

As brewers produce their product for consumers, one of the most important (if not the most important) aspects is beer flavor. Most breweries monitor flavor at several steps during the process to ensure a consistent, high-quality product is being produced. However, packaging influence on flavor is usually an area that is given little attention to ensure that the consumer gets the best-tasting product possible. Many factors can influence the flavor of a beverage packaged in an aluminum can. This workshop reviews the manufacturing process through which aluminum coil is cut, shaped, cleaned, and fashioned to form an aluminum can. Each step in the manufacturing process is then examined more closely, as well as details on how changes at each step will affect the flavor of a beverage. The areas to be covered in detail are the incoming coil, bodymaker, washer system, deco, deco oven, internal coating (IC), IC oven, necking, palletizing, shipping, and storage. Lastly, some of the off-flavors that have been falsely associated with aluminum cans and beer will be discussed.

Organic Workshop

Victoria Convention Centre Lecture Theatre

3:55 – 5:30 p.m.

The organic production and certification processes continue to evolve worldwide as organic production becomes more established and, therefore, more regulated. Representatives from Canada, the United States, and the European Union will discuss the approaches they take and the issues they face. A brewer will discuss what they must deal with from a processing perspective.

Gourmet Food and Beer Pairing Event – Celebration of Craft Brewing in Victoria

Spinnakers BrewPub

7:00 p.m.

As the oldest brewpub in Canada and proponent of artisan Vancouver Island Cuisine, Spinnakers will present a tasting dinner showcasing the richness of Victoria's craft brewing community, pairing each beer with locally grown or produced food items representing the best of Canada's West Coast. Joining Spinnakers proprietor Paul Hadfield and Master of Ceremonies Greg Evans will be brewers from participating breweries and brewpubs who will introduce their beers and tell guests their stories about the local, award-winning industry.

Separate registration is required for this limited-seating available event.

Wednesday, June 20

7:00 – 8:00 a.m.	Speaker Orientation and Breakfast: Orals 26–35	Victoria Convention Centre View Royal
7:00 – 8:00 a.m.	Technical Committee Breakfast	Victoria Convention Centre Metchoshin
7:00 a.m. – 12:00 p.m.	Registration	Victoria Convention Centre Level 1
8:00 – 9:20 a.m.	Technical Session VIII – Analytical II Moderator: Kendra Bowen, Anheuser-Busch Inc., St. Louis, MO	Victoria Convention Centre Lecture Theatre
8:05 – 8:30 a.m.	O-26. Identification of new volatile thiols with strong emphyreumatic aromas in beer. Minoru Kobayashi, Brewing Research & Development Laboratory, Asahi Breweries, Ltd., Ibaraki, Japan	
8:30 – 8:55 a.m.	O-27. Turbidimetric titration of haze-active polyphenol in beer. Karl J. Siebert, Cornell University, Geneva, NY	
8:55 – 9:20 a.m.	O-28. The EAP determination and BAX value—Powerful tools to determine differences in brewing technology. Frank-Juergen Methner, Berlin University of Technology, Berlin, Germany	
9:20 – 9:35 a.m.	Break	Victoria Convention Centre Prefunction 1
9:35 – 10:55 a.m.	Technical Session IX – Flavor/Sensory I Moderator: Bob Foster, Coors Brewing Co., Golden, CO	Victoria Convention Centre Lecture Theatre
9:40 – 10:05 a.m.	O-29. Evaluation of aroma compounds contributed to beer aging flavor. Akira Wanikawa, Asahi Breweries, Ltd., Moriya, Japan	
10:05 – 10:30 a.m.	O-30. Advantages of using stir bar sorptive extraction and GC-TOFMS for the analysis of beer flavor and off-flavor chemicals. Ray T. Marsili, Rockford College, Rockford, IL	
10:30 – 10:55 a.m.	O-31. Sensory panel management—Revisiting challenges, defining opportunities. Paul S. Hughes, Heriot-Watt University, Edinburgh, UK	
11:30 a.m. – 1:15 p.m.	Program Committee Meeting and Lunch	Victoria Convention Centre Metchoshin
11:30 a.m. – 1:15 p.m.	Publications Committee Meeting and Lunch	Victoria Convention Centre Saanich 2
11:30 a.m. – 1:15 p.m.	Technical Committee and Subcommittee Chairs Meeting and Lunch	Victoria Convention Centre View Royal
1:30 – 3:15 p.m.	Technical Session X – Flavor/Sensory II Moderator: Tom Shellhammer, Oregon State University, Corvallis, OR	Victoria Convention Centre Lecture Theatre
1:35 – 2:00 p.m.	O-32. Control of off-flavor like pickled vegetable in happoshu. Takeshi Teranishi, Suntory Ltd., Osaka, Japan	
2:00 – 2:25 p.m.	O-33. The nature of astringency perception in acidic beverages. Karl J. Siebert, Cornell University, Geneva, NY	
2:25 – 2:50 p.m.	O-34. Redox protein contributions to beer stability. Peter J. Rogers, Griffith University, Australia	
2:50 – 3:15 p.m.	O-35. Beer drinkability. Rubens Mattos, Kerry Bio-science, Campinas, Brazil	
3:15 – 3:30 p.m.	Break	Victoria Convention Centre Prefunction 1
3:30 – 4:15 p.m.	Closing Keynote Presentation with Greg Evans	Victoria Convention Centre Lecture Theatre
7:00 – 10:00 p.m.	Closing Reception	Fairmont Empress Crystal Ballroom
9:00 – 11:00 p.m.	Hospitality	Fairmont Empress Palm Court

Wednesday Sessions

Closing Keynote Presentation



The Devil Hop: A History of Brewing on Vancouver Island

Greg Evans, Maritime Museum of British Columbia

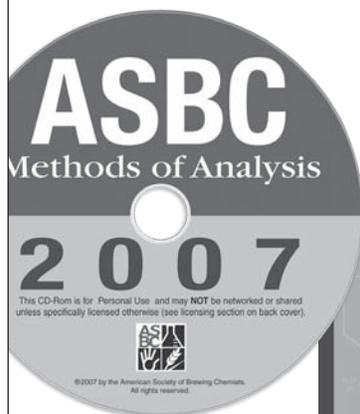
Victoria Convention Centre
Lecture Theatre
3:30 – 4:15 p.m.

Commercial brewing in Western Canada has its historical roots on Vancouver Island. In 1858, William Steinberger, an immigrant from Cologne, Germany, established the Victoria Brewery on the outskirts of the city—the first commercial brewery west of the Great Lakes. From the pioneer brewers of almost 150 years ago to the recent renaissance of craft brewing, Vancouver Island enjoys a unique place in the history of Canadian brewing. This illustrated presentation will introduce the adventurous men and women who created the industry, the breweries they operated, their products, the fame they garnered far from Canadian shores, the effect of prohibition, and the ingenuity they applied to the production of the “best long drink in the world.” Vancouver Island’s unique place in the history of commercial hop production will also be covered, as the industry in western Canada actually started in Victoria. Finally, we’ll take a look at more recent developments and how the highly regarded local industry of today sees its future.

Thursday, June 21

8:00 a.m. – 12:00 p.m. Board of Directors Meeting

NEW and ON SALE at the ASBC Annual Meeting



Scientific Principles of
**MALTING
AND
BREWING**
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Relax and Enjoy Your Stay: Sightseeing and Recreation Opportunities

To see all the sights in Victoria and the surrounding area, stop by the Gray Line tour desk located in the lobby of The Fairmont Empress hotel. All Gray Line tours depart from the Victoria Bus Depot located behind The Fairmont Empress. The Gray Line desk is open daily from 9:00 a.m. to 5:00 p.m. No reservations are required. Daily departures to Butchart Gardens, City Tours, Butterfly Garden, and Craigdarroch Castle are just some of the tour opportunities.

Willow Stream Spa

Willow Stream Spa is a luxurious spa facility exclusive to Fairmont hotels. The soothing spa design enchants guests with nature's elements. A calming waterfall welcomes guests, inviting them to experience the healing mineral waters. The spa is open daily at 8:30 a.m. (including holidays), with appointments starting at 9:00 a.m.

Golf

Arbutus Ridge Golf & Country Club, with its signature island green, and Olympic View Golf Club, the only golf club on Vancouver Island visited by Tiger Woods, are two of the island's premiere golf clubs. Check with the hotel's concierge for play times and fees.

Butchart Gardens

Butchart Gardens is 55 acres of horticultural beauty, located 45 minutes from The Fairmont Empress hotel. Summer at the gardens brings ravishing floral splendor and the added attractions of nightly summer musical entertainment, magnificent evening illuminations, and a Saturday night fireworks display. A gift shop, visitor services, and two restaurants are onsite.



Butterfly Garden

Release your inner child! The Butterfly Garden is a lush, indoor tropical garden where exotic flowers are always in bloom and butterflies are free to flutter about! See butterflies in various stages of development, as well as some of the most exotic and colorful butterflies on the planet.

Whale Watching

Located at 812 Wharf Street, just under the Visitor's Centre, the Prince of Whales whale-watching tours feature expert wildlife personnel on all their cruises. Departures are every half-hour in Zodiac-style boats.

Craigdarroch Castle

Set in the historic Rockland neighborhood, Craigdarroch Castle was built between 1887 and 1890 as a lavish residence for Robert Dunsmuir and his family. The mansion features the best collection of residential stained and leaded glass on the West Coast of Canada, magnificent woodwork, and period furnishings.

Maritime Museum

For the sailor in everyone, this historic building offers an important pictorial and model exhibit of the Canadian West Coast's maritime history and is located a short stroll up Government Street. Pick up your discounted admission coupons at the ASBC registration desk.

Royal BC Museum

Rated one of the best museums in North America, this facility offers an incredible opportunity to learn about the natural history of British Columbia. The Ice Age, First Nations, and Early Settlement displays provide valuable insight into our past. Pick up your discounted admission coupons at the ASBC registration desk.

Shopping

Market Square offers more than 45 specialty stores and restaurants, featuring original and off-beat shopping and dining in an eclectic old town setting. The Victoria Bay Centre is Victoria's largest shopping mall, located just a few blocks north of The Fairmont Empress hotel on Government Street and is open 7 days a week. Antique enthusiasts will spend hours browsing on Antique Row, located on Fort Street, where you'll find everything from rare books and maps to 18th century furniture from Britain.

Sea Kayaking

Discover the beauty of Canada's West Coast from a sea kayak. Explore intricate shorelines while gliding past sandy beaches. Join a sea-kayaking course that ranges from a 3-hour evening clinic to full-weekend adventures. Indulge yourself in the joys of sea kayaking on a guided tour. Check with the hotel's concierge for local outfitters.

Posters

Moderator: Kelly Tretter, Coors Brewing Co., Golden, CO

- P-36.** Comparison of analytical methods to analyze the “color” of liquid adjuncts. Scott T. Helstad, Cargill, Inc., Dayton, OH
- P-37.** New optical technology for measuring dissolved oxygen gains acceptance by brewing industry. Roy Johnson, Haffmans North America, Machesney, IL
- P-38.** Determination of ochratoxin A in beer by immunoaffinity cleanup and liquid chromatography tandem mass spectrometry. Masayuki Omote, Asahi Breweries, Ltd., Ibaraki, Japan
- P-39.** Inductively coupled plasma mass spectrometry (ICP-MS) for trace element analysis in beer and raw material. Laurence Gijs, InBev, Leuven, Belgium
- P-40.** Novel online sensor for measuring dissolved CO₂ using attenuated total reflectance (ATR) technology. Frederick M. Cash, Thermo Fisher Scientific Process Instruments, Minneapolis, MN
- P-41.** A new method for color determination of laboratory mashed wort utilizing a NTU turbidity correction equation. Adrienne N. Caruso, Anheuser-Busch, St. Louis, MO
- P-42.** Sampling of sulfurs in beer by membrane extraction and analysis using GCMS. Shannon J. Coleman, Wasson-ECE Instrumentation, Fort Collins, CO
- P-43.** *qGPC6H*, a gene that increases starch content in barley grain. Tom Blake, Montana State University, Bozeman, MT
- P-44.** Glucans in barley (*Hordeum vulgare* L.) and malt: The influence of steeping time. Evangelina Sevilla, INIFAP, Chapingo, Mexico
- P-45.** Characteristics of thiol oxidase in malt. Makoto Kanauchi, Miyagi University, Miyagi, Japan
- P-46.** Plant brewing extract decrease in summer period and possible origins. Luc Didierjean, Technical Centre, Strasbourg, France
- P-47.** Osmolyte concentration in green and kilned malts as indicators of finished malt quality. Cynthia A. Henson, USDA-ARS, Madison, WI
- P-48.** The ultrastructure of barley and proso millet during malting observed by scanning electron microscopy. Beatus D. Schehl, National University of Ireland, Cork, Ireland
- P-49.** Barley CAP: A multi-disciplinary research effort to apply genomics approaches to the genetics of malting barley quality. Paul B. Schwarz, North Dakota State University, Fargo, ND
- P-50.** How can varieties and rainfed production environments affect malting quality in spring barley? Steven E. Ullrich, Washington State University, Pullman, WA
- P-51.** Cellulosic ethanol from barley agricultural waste: Can the “other” ethanol expand the revenue potential for barley growers? Victoria C. Blake, Montana State University, Bozeman, MT
- P-52.** Dielectric study of brewer’s spent grain for frequencies between 2.5–3.5 gigahertz. Sing K. Ng, Manchester Metropolitan University, Manchester, United Kingdom
- P-53.** Improving the flavor stability of beer by using a polymer. Martina Gastl, Technische Universitat Muenchen, Freising, Germany
- P-54.** The qualitative and temporal bitter differences of the reduced and non-reduced iso-alpha-acids in lager beer. Annette N. Fritsch, Oregon State University, Corvallis, OR
- P-55.** Large-scale isolation of pure individual iso-alpha-acids from isomerized hop extract. Alfi Khatib, Leiden University, Leiden, Netherlands
- P-56.** Impact of mashing-off temperature and alternative kettle hopping regimes on hop alpha acids isomerization and bitterness profile. Barbara Jaskula, KaHo Sint-Lieven, Ghent, Belgium
- P-57.** Determination of the varietal pedigree of commercial hop using microsatellite DNA markers. Lin F. Yan, Tsingtao Brewery Co. Ltd., Tsingtao, People’s Republic of China
- P-58.** Rye malt as an ingredient for beer. Florian Huebner, University College, Cork, Ireland
- P-59.** Evaluation of malting barley quality with a fuzzy-logic model. Yueshu Li, Canadian Malting Barley Technical Centre, Winnipeg, MB, Canada
- P-60.** Improving the cost efficiency of quality assurance screening for microbial safety and quality of malting barley. Mandeep Kaur, University of Tasmania, Hobart, Tasmania, Australia
- P-61.** Controlled mixed culture refermentation of spontaneous fermented lambic beer: A reliable process to facilitate the production of “old gueuze.” Koen Goiris, KaHo Sint-Lieven, Gent, Belgium
- P-62.** PCR-based approach for monitoring the hygienic status of well water for brewing purposes. Michael Voetz, VLB Berlin, Berlin, Germany
- P-63.** Multiplex PCR for putative *Lactobacillus* and *Pediococcus* beer-spoilage genes and ability of gene presence to predict spoilage. Monique C. Haakensen, University of Saskatchewan, Saskatoon, SK, Canada
- P-64.** Permeation of volatile organic compounds (VOCs) through plastic bottles and closures. Leif A. Garbe, TU Berlin, Berlin, Germany

- P-65. A new alternative to increase the flavor stability of the beer. Marc Maudoux, University Catholique de Louvain, Louvain-la-Neuva, Belgium
- P-66. Studies of particle sizes in beer treated with a proline-specific protease which prevents chillhaze in beers. Harry D. Craig, DSM, Netherlands
- P-67. Mash application of glucoamylase and the effect on attenuation and wort separation. Neville M. Fish, Danisco, Stockport, United Kingdom
- P-68. The use of a lab-scale reference fermentation method to evaluate the impact of yeast-related variables on fermentation profiles. Simon A. Ahlgren, New Belgium Brewing, Fort Collins, CO
- P-69. Synthesis and metabolism of allylic hydroxy fatty acid in *Saccharomyces cerevisiae*. Leif A. Garbe, TU Berlin, Berlin, Germany



ASBC Is Your Industry Resource

ASBC membership benefits include

- Reduced membership pricing for the Annual Meeting
- 10% discount on ASBC books
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- Connection to a network of industry professionals
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Phone: +1.651.454.7250

E-mail: csundquist@scisoc.org

Cheers to you, ASBC Corporate Members!

ASBC Corporate Members contribute their knowledge, expertise and professional involvement to ensure the continued strength of ASBC and promote excellence in the science and technology of brewing. We appreciate their support of ASBC and encourage you to contact them directly for detailed information on their company-specific products.

AcquiData Inc	J Boag & Son Brewing Ltd
Alaskan Brewing Co	John I Haas Inc
AMC Technologies Inc	Kalsec Inc
American Tartaric Products Inc	Karl Strauss Brewing Co
Analysis Laboratory	Kirin Australia Pty Ltd
Anheuser-Busch Inc	Kirin Brewery Co Ltd
Anton Paar USA	METTLER TOLEDO
Astoria Pacific Inc	Ingold
BASF Corporation	Miller Brewing Co
Beer Ind Assoc Shandong China	Molson Breweries
Bio-Chem Lab Inc	Moosehead Breweries Ltd
Briess Malting Co	Neogen Corp
Bruker BioSpin Corp	Niro Inc
Busch Agric Resources Inc	Novozymes North America Inc
Cargill Malt	optek-Danulat Inc
Carlsberg Research Center	Pacific Western Brewing Co
Carmi Flavors	Pall Corporation
Casco Inc	Profamo Inc
China Natl Research Inst of Food & Fermentation Ind	Pure Malt Products Ltd
Coors Brewing Co	Rahr Malting Co
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DB Breweries Ltd	Romer Labs Inc
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EcoLab Inc	Skalar Inc
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Firestone Walker Brewing Co	Sleeman Brewing and Malting
Foss North America	The PQ Corporation
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Hach Ultra	Vicam Group of Waters Technologies Corp
Haffmans North America	World Minerals Inc
High Falls Brewing Co LLC	Wyeast Laboratories Inc
International Malting Co	Yakima Chief Inc
Intl Specialty Products	Yuengling Brewing Co of Tampa Inc

Exhibition

Victoria Convention Centre – Carson Hall

ASBC welcomes the 2007 Annual Meeting Exhibitors and thanks them for their participation at this year's meeting.



Exhibit Hall Activities

The Exhibition showcases the latest products and services in the brewing industry. Exhibitors will demonstrate items ranging from ingredients and instruments to equipment and services. In addition to serving as your resource to leading industry suppliers, the Exhibit Hall provides a great opportunity to network with peers over refreshments.

On Monday, following the close of exhibits, attendees and exhibitors are invited to ASBC's annual Recognition Lunch in The Fairmont Empress Crystal Ballroom. A buffet lunch will be served in the exhibit hall on Tuesday.

Prize Drawings

Drawings for prizes will take place in the exhibit hall at random times throughout the exhibit hours. You must be present to win!

Exhibit Hours

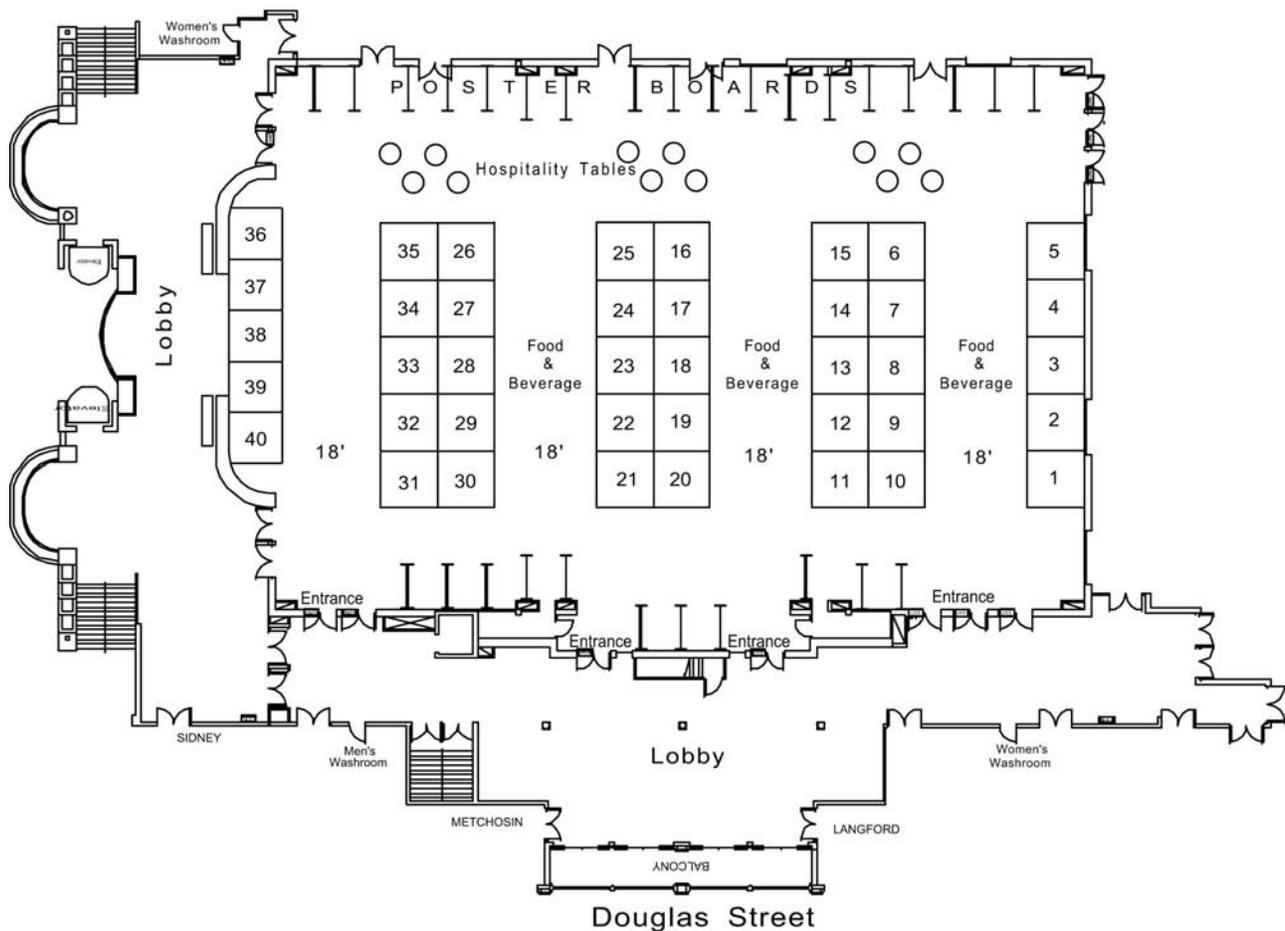
Show your support for the contributions of these suppliers by visiting the exhibits at every opportunity.

Sunday, June 17 3:30 – 6:30 p.m.

Monday, June 18 10:00 a.m. – 12:00 p.m.

Tuesday, June 19 10:30 a.m. – 1:00 p.m.

Exhibit Hall Floor Plan



2007 ASBC Exhibitors Numerical Listing

- | | |
|--|---|
| 1 Thermo Scientific – A Part of Thermo Fisher Scientific | 20 Novozymes |
| 2 Hach Ultra | 21 Gusmer Enterprises, Inc. |
| 3 Oregon Tilth | 22 Cargill, Inc. |
| 4 Palatinit GmbH | 23 Siebel Institute of Technology & World Brewing Academy |
| 5 VLB Berlin | 24 Danisco USA Inc. |
| 6 Norit Haffmans | 25 Skalar, Inc. |
| 7 DSM Food Specialties USA, Inc. | 26 Anton Paar USA |
| 8 AcquiData, Inc. | 27 Ecolab, Inc. |
| 9 White Labs, Inc., Pure Yeast & Fermentation | 28 Bruker BioSpin Corp., EPR Division |
| 10 optek-Danulat, Inc. | 29 ISP – International Specialty Products |
| 11 Mettler-Toledo Ingold | 30 Diagnostix Ltd. |
| 12 Kalsec, Inc. | 31 Enzyme Development Corp. |
| 13 Pall Corporation | 32 BRI |
| 14 LECO Corporation | 33 American Tartaric Products, Inc. |
| 15 Carmi Flavors | 34 International Society of Beverage Technologists |
| 16 BASF Corporation | 35 Canongate Technology, Inc. |
| 17 Steinfurth, Inc. | 40 Rapid Micro Biosystems |
| 18 Profamo Inc. | |
| 19 Bio-Chem Laboratories, Inc. | |

As of April 26, 2007

2007 ASBC Annual Meeting Exhibitors

Meet with representatives from these companies who will answer your questions and share the most up-to-date information on their products and services.

* *Indicates Corporate Member*

* 08 AcquiData, Inc.

400 Garden City Plaza, Ste. 445, Garden City, NY 11530; Telephone: +1.516.408.3585X126, Fax: +1.516.408.3586, Website: www.acquidata.com. Are there lots of data entry sheets on clipboards in your quality lab? Is someone spending hours typing all that data into a spreadsheet? Stop! Get rid of your paper forms and build a beer quality database instead! AcquiData Inc. will be demonstrating Testream®/CS, its premier lab automation system. Fully user-configurable, Testream®/CS delivers browser-based data acquisition capabilities to automate the collection of beer quality data directly from any lab instrument—balances, pH meters, spectrophotometers, beer analyzers, etc.—as well as offering keyboard entry for any characteristic. Testream®/CS also comes with a complete set of data reporting/analysis tools so you can quickly see trends, relationships, cumulate data over any time period, etc. Also, a large library of interfaces to production information systems ensures that Testream®/CS can be a fully integrated component of any brewery system.

* 33 American Tartaric Products, Inc.

1865 Palmer Ave., Larchmont, NY 10538; Telephone: +1.815.357.1778, Fax: +1.815.357.6221. American Tartaric Products, Inc. is the largest supplier to the wine industry and is now proud to present a range of products to the brewing industry. Our product range includes brewing process aids, encompassing yeast nutrients, enzymes, brewhouse antioxidants, foam stabilizers, filtration aids, clarifiers, stabilizers, fine chemicals, bottling equipment, benchtop and handheld analytical equipment, filter sheets, filter elements, cartridges, dosing units, and filtration equipment and pasteurizers. Some of the suppliers that ATP represents include AEB/Spindal Group, Carlson, CFM, EaglePicher, Hanna Instruments, ISP, and TMCI Padovan. Our objective is to become your one-stop shopping center with prompt technical service; if we don't have it, we will get it.

* 26 Anton Paar USA

10215 Timber Ridge Dr., Ashland, VA 23005; Telephone: 1.800.722.7556, Fax: +1.804.550.9074, Website: www.anton-paar.com. Anton Paar specializes in developing and producing highly accurate instrumentation to measure CO₂, alcohol, and real and original extracts of beer, both online and in the lab. Our density meters, sound velocity sensors, and carbonation meters are designed for the most demanding environments. We offer an accurate and easy-to-use viscometer for measuring the dynamic viscosity of congress wort (MEBAK approved). Our high-quality, high-performance products deliver reliable and accurate results, ensuring control of product quality within tight tolerance limits.

* 16 BASF

100 Campus Dr., Florham Park, NJ 07932; Telephone: +1.800.527.9881, Fax: +1.973.245.6843, Website: www.divergan.basf.de. BASF's high-quality Divergan® PVPP products protect two of the most important aspects of your beer: flavor and appearance. Divergan® F and Divergan® RS eliminate chill-haze and lengthen shelf life. Divergan® HM removes beer-soluble iron (BSI) and prevents oxidation. Contact your BASF representative to learn how we can help make your beer better.

* 19 Bio-Chem Laboratories, Inc.

1049 28th St. SE, Grand Rapids, MI 49508; Telephone: +1.616.248.4900, Fax: +1.616.248.4904, Website: www.bio-chem.com. Bio-Chem Laboratories, Inc. is a full-service laboratory providing a variety of services to the brewing industry. Bio-Chem delivers quality analytical testing in a timely manner through the use of state-of-the-art technology with a goal of providing customer service that exceeds the expectations of our clients.

* 32 BRI

Coopers Hill Road, Nutfield, Surrey RH14HY, United Kingdom; Telephone: +44 1737 822 272, Fax: +44 1737 822 747, Website: www.bri-advantage.com. BRI is the premier technology and information provider to the global brewing, malting, and wine industries, offering consulting and membership services. BRI Consulting provides sustainability, energy auditing and monitoring/saving advice, consumer research, flavor evaluation, analysis, troubleshooting, new product development, research, benchmarking, dispense and microbiological services, and training. BRI also offers label declaration and food ingredients and product legislative advice. BRI Membership is like an insurance policy, including an international beer safety information and alert service, a safety research portfolio, 24/7 emergency response, health information and research, and the world's most comprehensive technical information database available on the web.

* 28 Bruker BioSpin Corporation, EPR Division

44 Manning Rd., Manning Park, Billerica, MA 01821; Telephone: +1.978.663.7406, Fax: +1.978.670.8851, Website: www.bruker-biospin.com. Bruker BioSpin Corporation manufactures EPR spectrometers for use in flavor-stability applications. Bruker's EMX spectrometer is a high-throughput research system for both liquid and solid samples. The e-scan bench top spectrometer provides rapid, automated analysis for optimizing your beer's shelf life. The lagtime assay is used by several major breweries (worldwide) to determine and control the oxidative shelf life of lager beer. The EMX and e-scan spectrometers provide both the hardware and software to automate the lagtime assay.

35 Canongate Technology

2045 S. Arlington Heights Rd., Arlington Heights, IL 60005; Telephone: +1.847.593.1832, Website: www.canongatetechnology.com. Canongate Technology manufactures in-line sensors for numerous applications in the brewing industry from the brewhouse to the packaging lines. The company will exhibit their full line of sensors, offering measurement and control of dissolved carbon dioxide (CO₂), dissolved oxygen (O₂), Plato, and alcohol. Included in the range is CarboCheck. With well over 1,000 sensors supplied for beer production and packaging lines worldwide, CarboCheck is the instrument of choice for carbonation of the best-known beer brands. It enables brewers to reliably achieve, verify, and maintain today's demanding quality standards in-line, in-tank, and in-package.

*** 22 Cargill, Inc.**

15407 McGinty Rd. W., Wayzata, MN 55391; Telephone: +1.937.237.1236, Fax: +1.937.428.7574, Website: www.cargill.com. Cargill is a leading provider of malt, liquid, and solid brewing adjuncts and innovative solutions to the worldwide brewing industry. Products featured include the world's most complete line of high-maltose and Clearbrew liquid adjuncts, IsoClear 42 and 55% high-fructose corn syrups, highly fermentable dextrose syrups, and refined grits (brewing starch). All products can be shipped anywhere beer or a beverage is made. Let the Cargill team help you create great beverages for your customers. Visit the Cargill booth at the ASBC Annual Meeting or call us!

*** 15 Carmi Flavors & Fragrances Co. Inc.**

212-1515 Broadway St., Port Coquitlam, BC V3C 6M2, Canada; Telephone: +1.604.468.9800, Fax: +1.604.468.9801, Website: www.carmiflavors.com. Carmi Flavors has been offering high-quality flavors to the food and beverage industries for over 25 years. We have a no minimum requirement policy, and our stock flavors are shipped within one week. For your complimentary samples, please contact your local branch: British Columbia: +1.604.468.9800; Ontario: +1.905.563.6300; Quebec: +1.450.645.2500; or U.S.: +1.323.888.9339 or e-mail us at cnsales@carmiflavors.com.

24 Danisco USA Inc.

4 New Century Parkway, New Century, KS 66031. Telephone: +1.913.764.8100, Fax: +1.913.764.8239, Website: www.danisco.com. Danisco is one of the world's leading producers of ingredients for foods and other consumer products. Danisco's broad technology platform and product portfolio include antimicrobials, antioxidants, cultures, emulsifiers, enzymes, flavors, hydrocolloids, tailored blends, and sweeteners. Produced mainly from natural raw materials, its broad product range is backed by top technical services. An extensive knowledge of food ingredients and how they interact lies behind the company's proactive approach to the development of new products and concepts tailored to international market needs. Some 10,000 people are employed within Danisco's sales and production companies and innovation centers in 40 countries.

*** 30 Diagnostix Ltd.**

2845 Argentia Rd., Unit 5, Mississauga, ON L5N 8G6, Canada; Telephone: +1.905.286.4290, Fax: +1.905.286.5260, Website: www.diagnostix.ca. Diagnostix, part of Thermo Fisher Scientific, has introduced the EZ-Tox DON test kit designed for rapid, quantitative on-site determination of deoxynivalenol in grain samples. The kit is a homogeneous enzyme immunoassay incorporating ready-to-use liquid reagents in a simple three-step procedure. The EZ-Tox DON test kit does not require wash steps and timed incubations, resulting in a considerably faster and simpler process than conventional ELISA testing. The EZ-Tox DON test kit is approved for use by USDA/GIPSA, and the test reagents are manufactured in a FDA-compliant ISO 9001 certified facility.

*** 07 DSM Food Specialties USA, Inc.**

45 Waterview Blvd., Parsippany, NJ 07054; Telephone: +1.816.803.7104, Fax: +1.913.390.6435, Website: www.dsm.com. DSM celebrates 100 years of enzyme production and innovation. A completely new concept and extremely effective method of beer stabilisation is being presented. Brewers Clarex, launched in 2005, is a proline-specific endo protease that has gained worldwide acclaim and is now being regularly used on four continents. Brewers Clarex is a natural product that is added to the cooled wort prior to fermentation in extremely small amounts, making the use of silica gels and PVPP redundant. With Brewers Clarex there is no bulky powder handling or disposal, no beer losses, and no oxygen pick-up problems. Harsh chemicals to regenerate PVPP are eliminated. Steve Rhodes and Brian Fatula, DSM-USA will be joined by Harry Craig, DSM's global brewing specialist, to answer any questions.

*** 27 Ecolab Inc.**

370 Wabasha St. N., St. Paul, MN 55102; Telephone: +1.651.293.2233, Fax: +1.651.293.2260, Website: www.ecolab.com. Ecolab is the leading provider of critical environment sanitation products and systems to the brewery industry, delivering superior brand protection and improved operational efficiencies. Products and programs include brewhouse cleaning, fermentation and maturation cleaning, bottle cleaning, conveyor lubrication technologies, and CIP-engineered systems and services.

*** 31 Enzyme Development Corporation**

360 West 31st St., Ste. 1102, New York, NY 10001-2727; Telephone: +1.212.736.1580, Fax: +1.212.279.0056, Website: www.enzymedevelopment.com. Enzyme Development Corporation has been serving the needs of enzyme users since 1953. Team members are stationed across the country with the head office in New York City and primary production in Scranton, PA. Our people provide technical analysis to help you select the best options. Whether you need multiple truckloads or only a few kilograms, the care, the attention, and the commitment are the same. We offer a full range of enzyme solutions for enhanced brewing performance.

*** 21 Gusmer Enterprises, Inc.**

1165 Globe Ave., Mountainside, NJ 07092; Telephone: +1.908.301.1811, Fax: +1.908.301.1812, Website: www.gusmerenterprises.com. For more than 80 years, Gusmer Enterprises has been dedicated to providing service with knowledge to the brewing industry. Gusmer Enterprises supplies the brewing, malting, and distilling industries with a wide variety of products. Instrumentation, malt mills, malting equipment, filtration media, processing aids, and spent-grain handling equipment are just a few examples of our product line. Gusmer Enterprises represents the product lines of Aber Instruments, AB Vickers, Cellulo, D.D. Williamson, Mettler-Toledo Millipore, Novozymes, Paguag Schlauchtechnik, PQ Corporation, Ponndorf, and Schmidt-Seegeer AG.

*** 02 Hach Ultra**

481 California Ave., Grants Pass, OR 97526; Telephone: +1.541.472.6500, Fax: +1.541.479.3075, Website: www.hachultra.com. Hach Ultra provides complete dissolved gas measurement solutions for the brewing industry. From the hot side of brewing to the filled package, Hach has a complete array of process and portable instrumentation measuring dissolved oxygen, TPO carbon dioxide, and nitrogen.

34 International Society of Beverage Technologists

3340 Pilot Knob Rd., St. Paul, MN 55121; Telephone: +1.651.454.7250, Fax: +1.651.454.0766, Website: www.bevtech.org. ISBT is a global, non-commercial, non-profit technical society of beverage professionals. It is the only organization whose sole interests are the technical and scientific aspects of soft drinks and beverages. ISBT provides a forum of technical committees, sub-committees, and general assembly presentations for development and sharing. In addition, ISBT offers resources, including membership, manuals, and meetings.

*** 29 ISP – International Specialty Products**

1361 Alps Rd., Wayne, NJ 07470; Telephone: +1.973.872.4403, Fax: +1.973.628.3886, Website: www.ispcorp.com. ISP is recognized worldwide for its Polyclar line of products (PVPP) used for stabilization and clarification of beer. The line includes products to remove haze-causing polyphenols (Polyclar 10 and Polyclar Super R) and for the simultaneous balanced removal of haze-causing polyphenols and proteins (Polyclar Plus 730). ISP is also a basic supplier of alginates (PGA) that enhance and stabilize foam in beer. Polyclar Brewbrite is a new addition to our product line; it is a wort clarifier and stabilizer and also gives higher wort yields, reduced fermentation times, and longer filter runs.

*** 12 Kalsec, Inc.**

P.O. Box 50511, Kalamazoo, MI 49005-0511; Telephone: +1.269.349.9711, Fax: +1.269.382.3060, Website: www.kalsec.com. Kalsec, Inc. is the world's leading producer of isomerized and reduced hop acids to obtain beer bitterness, foam enhancement, and light stability. Its light-stable core hop products are Reduced Isolone®, Tetralone®, and Hexalone®, while Isolone® is designed to admit bitterness only. In addition,

Kalsec provides hop acid blends and hop acid/hop oil blends to be added to beer post-fermentation for aroma and flavor enhancement and distinction. If kettle hopping is required, Kalsec has developed KAE's consisting of NAR, hop oil, and Reduced Isolone®, which allows the production of a beer with light-stable kettle hopping only.

14 LECO Corporation

3000 Lakeview Ave., St. Joseph, MI 49085; Telephone: +1.269.983.5531, Fax: +1.269.980.8977, Website: www.leco.com. LECO offers a full line of instruments for moisture, ash, fat, and elemental organic analysis, including nitrogen/protein in foods, feeds, plants, soils, fertilizers, and energy. The DI-PAL liquid autosampler, available for the TruSpec® series nitrogen/protein determinator, reduces downtime and increases productivity in the laboratory by providing seamless automation for the analysis of liquid samples. LECO also offers a complete selection of instrumentation for the analysis of complex samples using GC- and LC-MS technology, including the Pegasus® HT TOFMS, Pegasus® 4D GCxGC-TOFMS, and the Unique® HT TOFMS.

*** 11 Mettler-Toledo Ingold**

36 Middlesex Turnpike, Bedford, MA 01730; Telephone: +1.781.301.8800, Fax: +1.781.301.8701, Website: www.mt.com/pro.

*** 06 Norit Haffmans**

1330 Anvil Dr., Machesney Park, IL 61115; Telephone: +1.815.639.0322, Fax: +1.815.639.1135, Website: www.haffmans.nl. Norit Haffmans manufactures a wide range of quality control equipment to measure CO₂, O₂, foam, and turbidity and monitor pasteurization and bottle and keg washing processes. Haffmans has also developed the first-ever combined CO₂/O₂ unit, enabling brewers to measure these vital quality parameters with one instrument. The Norit Group also offers CO₂ recovery systems, beer membrane filtration, membrane bioreactor and water reuse systems, and a wide range of process valves.

*** 20 Novozymes**

77 Perry Chapel Church Rd., Franklinton, NC 27525; Telephone: +1.919.494.3000, Fax: +1.919.494.3415, Website: www.novozymes.com. The key to reducing costs are malt quality, lautering, and beer filtration times. Brewing enzymes from Novozymes provide the solutions you need to expand your options for your brewing operations and reduce your costs—even with the best of malts. Use enzymes to improve capacity and efficiency while retaining the high quality of the beer in every brew. Enzymes are natural processing aids and the key to ensuring consistent processes and results. Breweries have used enzyme solutions from Novozymes for over 40 years.

*** 10 optek-Danulat, Inc.**

N118 W18748 Bunsen Dr., Germantown, WI 53022; Telephone: +1.888.837.4288, Fax: +1.262.437.3699, Website: www.optek.com/brewing. optek's inline UV-VIS-NIR absorption-based photometers and scattered-light turbidimeters monitor and control color, haze, and concentration. Real-time measurements provide process optimization and control in fermentation, filtration, separation, yeast pitching, wort color and clarity, DE and PVPP dosing, and more. Achieve uninterrupted processing of your best possible product with reduced product loss, improved profitability, and greater efficiency. To receive further information on the highest precision and quality in process photometry for use in breweries today, please contact Al Worley at info@optek.com or call 1.888.837.4288.

03 Oregon Tilth

470 Lancaster Dr. NE, Salem, OR 97301; Telephone: +1.503.378.0690, Fax: +1.503.378.0809, Website: www.tilth.org. Oregon Tilth offers fully integrated organic certification services with a high level of service and commitment. Oregon Tilth was founded in 1974 and has been offering organic certification services to the industry for over 30 years. Helping to develop the National Organic Standards of the USDA, Oregon Tilth was one of the first to gain accreditation and begin offering organic certification under the USDA organic regulations. Oregon Tilth offers certification services to producers, manufacturers, food handlers, and others, both nationally and internationally. Oregon Tilth is the most respected name in organic certification. Our goal is to help make the certification process enjoyable and educational. Let us help you bring your organic product to market.

04 Palatinit

Gottlieb-Daimler Str. 12, 68165 Mannheim, Germany; Telephone: +69.621.421150, Fax: +69.621.421160, Website: www.palatinit.com. Palatinit is presenting the innovative functional carbohydrate Palatinose™. It is derived from sucrose, yet exhibits a milder sweetness. Palatinose™ is more slowly digested than sucrose, which leads to a very low glycemic response and a prolonged energy supply. These benefits combined with excellent technological properties make Palatinose™ an ideal carbohydrate to develop new kinds of healthful and functional drinks. In beer products Palatinose™ improves the sensorial profile and contributes to a better shelf life, because it cannot be fermented by common beer yeasts and typical beer contaminants. Palatinit is a 100% subsidiary of Südzucker AG and is located in southwestern Germany.

*** 13 Pall Corporation**

25 Harbor Park Dr., Port Washington, NY 11050; Telephone: +1.866.905.7255, Fax: +1.516.625.3610, Website: www.pall.com. Pall Corporation is the largest and most diverse filtration, separations, and purifications company in the world. You can rely on Pall for a proven solution to all your filtration or separations needs. We design, develop, and manufacture an unparalleled range of advanced filter media, associated equipment, separation systems, and membrane processes.

For the food and beverage industries, Pall has developed filtration and advanced filtration systems that meet market needs for reliability and cost-effectiveness. Easy to install and simple to use, the space-saving systems satisfy a wide variety of filtration requirements. Pall filters remove particulate contamination, ensure the absence of spoilage microorganisms, and provide high-quality air and gases. Membrane processes can additionally concentrate products without heat, purify and clarify, selectively remove components, and even deal with process effluent.

*** 18 Profamo Inc.**

7506 Albert Tillinghast Dr., Sarasota, FL 34240; Telephone: +1.941.379.8155, Fax: +1.941.379.8699, Website: www.profamo.com. Profamo Inc. is pleased to present at the 2007 ASBC Annual Meeting some of its fine line of equipment from its various manufacturing partners, including, among others, the new GEM line of Headmaster's dissolved oxygen and CO₂ calibrators; the Digox 6 portable dissolved oxygen meter from Dr. Thiedig; Advanced Instrument's CO₂ purity and oxygen deficiency analyzers; Rotech's keg monitoring system; ACM's degasser and in-line beer monitor, Pfeuffer's tannometer, friabilimeter, and sortimat; Lg Automatic's foam tester, mash bath, sampling device, bottle turner, and hazemeter; Keofitt's sterile sampling systems; and Gerhardt's systems for sample digestion, distillation, shakers, and hot plates.

*** 40 Rapid Micro Biosystems**

1 Oak Park Dr., Bedford, MA 01730. Telephone: +1.781.271.1444, Fax: +1.781.271.9905. Rapid Micro Biosystems is developing groundbreaking products that address significant unmet needs in the production of beer, pharmaceuticals, and personal care products. In 2007, the company will launch its first product, the Growth Direct™ system, the first and only system to rapidly detect bacterial, mold, and fungal contaminants without destroying the microbes—enabling subsequent microbial identification. This new tool requires minimal changes to the current culture-based testing methods to accelerate implementation and derived manufacturing efficiencies.

*** 23 Siebel Institute of Technology & World Brewing Academy**

1777 N. Clybourn Ave., Ste. 2F, Chicago, IL 60614; Telephone: +1.312.255.0705, Fax: +1.312.255.1312, Website: www.siebelinstitute.com. Siebel Institute of Technology is pleased to offer a wide range of products and services for the brewing industry. We offer services like yeast banking and maintenance and yeast DNA fingerprinting through our Montreal-based Microbiology Services Division, while our Chicago-based Laboratory Services Division features advanced services like staling aldehyde analysis that will give you critical information about the staling that has occurred in your beer. We also offer the widest range of brewing courses of any school in the world, including our TwinTrack Brewing Microbiology program and our web-based training courses, which allow students to take professional-level brewing courses without the cost of travel.

* 25 Skalar, Inc.

5995 Financial Dr., Ste. 180, Norcross, GA 30071; Telephone: +1.800.782.4994, Fax: +1.770.416.6718, Website: www.skalar.com. Come to the Skalar booth to see the malt/beer automated analyzer for fast and accurate automation of time-consuming and difficult wet-chemistry methods. Skalar offers complete automation for simultaneous determination of any combination of alpha-amylase, anthocyanogen, bitterness, carbon dioxide, color, density, diacetyl, diastatic power, ethanol, free amino nitrogen, beta-glucan, pH, polyphenols, sulfur dioxide (total and free), thiobarbituric acid value, turbidity, and viscosity. Skalar also manufactures the Primacs-SN analyzer for total nitrogen/protein analysis of malt and wort samples. Last, the Formacs TN is available for a TKN alternative (no reagents).

17 Steinfurth, Inc.

530 Means St. Suite 120, Atlanta, GA 30318; Telephone: +1.404.586.6817, Fax: +1.404.586.6824, Website: www.steinfurthinstruments.com. Steinfurth, specialist for customized quality control instruments, will be presenting its automatic foam stability tester and the SF-PastControl system (pasteurisation logger). The effective instruments are very easy to operate and can be placed to use in the laboratory or directly on the filling line. Steinfurth's range of products for the beverages industry comprises CO₂ measuring systems, devices for calibrating pressure and temperature, torque testers, loggers for pressure, temperature and pasteurisation, packaging testing devices, measuring systems for beer quality, laboratory carbonisation systems, and sampling devices.

* 01 Thermo Scientific – A Part of Thermo Fisher Scientific

501 – 90th Ave. NW, Minneapolis, MN 55433; Telephone: +1.763.783.2500, Fax: +1.763.780.2315, Website: www.thermo.com. Thermo Scientific's CrystalVision Systems replace conventional, manual methods of measuring CO₂ concentration. Even in-line instruments that require consumables such as diaphragms or membranes are now not necessary. By utilizing the CrystalVision sensor, users can experience freedom of maintenance, higher accuracy, easy deployment, and a depth of information that comes only from an in-line sensor. Visit www.thermo.com/crystalvision for full details. Also on display will be Thermo Scientific's InScan X-ray Inspection Systems. InScan ensures that you are never over- or underfilling product, irrespective of the type of container cans, bottles, or jugs. InScan is safe, accurate, and can help control costs by minimizing rejects and rework and controlling waste. InScan can also detect missing or misaligned caps and inspect products for solid contaminants. Visit www.thermo.com/inscan for full details.

05 VLB Berlin

Seestrasse 13, Berlin 13353, Germany; Telephone: +49.30.45080255, Fax: +49.30.45080210, Website: www.vlb-berlin.org. Versuchs- und Lehranstalt fuer Brauerei in Berlin (VLB) has provided research, teaching, consulting, information, and service for the brewing, malting, and beverage industries since 1883. VLB Berlin (Research and Teaching Institute for Brewing in Berlin, Germany) is an independent German institute providing training, research, and service for the brewing and beverage industries. Customers all around the world take advantage of our training courses and our broad experience in the fields of research, analysis, and consulting.

09 White Labs, Inc. Pure Yeast & Fermentation

7564 Trade St., San Diego, CA 92121; Telephone: +1.888.593.2785, Fax: +1.888.693.1026, Website: www.whitelabs.com. White Labs produces certified pure liquid yeast for brewers, wineries, and distillers. Our full-service laboratory provides beer and microbial analyses, yeast banking, lab media, supplies, quality control kits, and brewing accessories. We have partnered with Frings America to supply a specialty yeast propagation system with a unique aeration system. Frings America also provides consulting and training services for yeast propagation.

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The following individuals, through their leadership on the Board of Directors, generously donate their time and talents to guide ASBC. Board members play a major role in determining what programs and services should be provided by ASBC to advance the industry and profession. ASBC is an association run by the members, for the members—an association where your voice is considered vital. If you have input, please contact a board member or staff member.

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Thank You

ASBC volunteer members tackle important issues, keep members informed, manage the details, and basically make things happen.

A sincere thanks to everyone who has given their time and talents to make a difference in ASBC and the brewing industry!

ASBC especially thanks the following committee and section chairs:

David P. Barr, *Method for Measure of Resistance of Oxidation in Beer by EPR*
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2007–2008 ASBC Foundation Scholarship Recipients

Scholarships are supported by funds from the ASBC Foundation and annual contributions by individuals and companies. ASBC congratulates all scholarship recipients on their accomplishments! The Foundation Board also thanks the donors for making these scholarships possible.

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2007 Eric Kneen Memorial Award Recipient



Paul Hughes

The Eric Kneen Memorial Award is given to a member who authored the year's best paper in the *ASBC Journal*. Paul S. Hughes won for his article, "Differences in the UV-Spectra of the Hop-Derived *cis*- and *trans*-Iso- α -Acids," published in *ASBC Journal*, Vol. 64, No. 1, pages 47-51.

2007 Annual Meeting Abstracts

O-1

Antioxidant properties of hop polyphenols

THOMAS H. SHELLHAMMER (2), Takeshi Kunimune (2), Annette Fritsch (2), Robert T. Foster II (1)
(1) Coors Brewing Company; (2) Oregon State University

Polyphenolic compounds from plant materials have demonstrated antioxidant properties. Published work in beer systems is conflicting as hop and barley polyphenols have reportedly had both positive and negative effects on flavor stability. We hypothesized based on evidence of the antioxidative properties of phenolic compounds in other food systems that hop-derived polyphenols should exhibit antioxidant capabilities in beer. Hop-derived polyphenols extracted from spent Galena hop powder were added to an unhopped lager beer in increasing amounts and produced increasing ferric reducing antioxidant potential (FRAP) values, thereby confirming our initial hypothesis of a positive antioxidant effect of hop polyphenols in beer. Contrary to these data, electron paramagnetic resonance (EPR) analysis indicated the opposite effect. Further metal analysis identified high chelated copper and iron levels in the hop polyphenol extracts. Our thoughts for this pro-oxidative EPR response from these hop polyphenol fractions centers around the likelihood of increased free radical activity from these trapped transition metals (i.e. -iron and copper, and manganese) via the Fenton and Haber-Weiss pathways. Examining various acid and EDTA treatments, we significantly reduced the metal ion levels in the polyphenol extracts. These EDTA-chelated extracts yielded positive FRAP and similar EPR results compared to a non-treated control beer. These data offer evidence of both the pro-oxidative, antioxidative, and metal chelating power of hop polyphenols dosed into beer.

Dr. Shellhammer is the Nor'Wester Professor of Fermentation Science and Associate Professor of Brewing and Food Engineering in the Department of Food Science at Oregon State University. He received his B.S. in Fermentation Science and Ph.D. in Food Engineering from the University of California, Davis. He currently serves as a member of the ASBC Foundation Board and co-chair of the 1st International Brewers Symposium on Hop Flavor and Aroma in Beer.

O-2

Transcriptional profiling of *Fusarium* mycotoxin biosynthesis

ARJA LAITILA (2), Jari Rautio (2), Wilhelmson Annika (2), Kokkonen Meri (1), Marika Jestoi (1), Silja Home (2), Reetta Satokari (2)
(1) EVIRA Finnish Food Safety Authority, Helsinki, Finland;
(2) VTT Technical Research Centre of Finland, Espoo, Finland

Several *Fusarium* species are capable of producing highly toxic secondary metabolites, mycotoxins, in the field or during malting. Trichothecenes comprise a large, structurally diverse group of sesquiterpenoids produced by different *Fusarium* fungi. The most common are deoxynivalenol, nivalenol, 3-acetyldeoxynivalenol, HT-2 and T-2 toxin. Most of the toxin-producing

Fusarium fungi are capable of producing a variable range of two or even more toxins. The induction of mycotoxin synthesis is still largely unknown. The biosynthesis of trichothecenes involves a complex pathway. VTT has developed a method called TRAC (Transcriptional analysis with the aid of affinity capture) for rapid and multiplex quantification of nucleic acids. This approach enables us to monitor the expression of several genes simultaneously from a large number of samples. In the present study TRAC was used to study regulation of trichothecene biosynthesis genes. Probes for transcripts of genes in the secondary metabolic pathways to toxins will not only indicate the presence of potentially dangerous fungi, but can tell whether they are actively producing toxins. Early detection of *Fusarium* activity and preventive actions are essential to assure and improve the safety in the barley-to-beer chain.

Arja Laitila is a Research Scientist (Microbiologist) at the VTT Technical Research Centre of Finland. She graduated from the University of Helsinki with a M.Sc. degree in Food Microbiology in 1994. She has participated in several national and international projects related to microbes in cereal-based bioprocesses. Her particular expertise is malting and brewing microbiology.

O-3

Effect of operational parameters on the determination of laboratory extract and associated wort quality factors

YIN LI (1), Paul Schwarz (1)
(1) Department of Plant Science, North Dakota State University

Mashing for the determination of malt extract is one of the most fundamental analyses performed in malting and brewing laboratories, and values for laboratory extract are central to malt quality control and trade, as well as to formulation in brewing. ASBC Malt Method-4 (Congress Mash) was originally developed for the estimation of extract potential, and only methods for fine/coarse-grind extract and wort color were included in the 4th edition (1944) of the ASBC Methods of Analysis. However in the subsequent sixty years to the 9th edition, this method has gained secondary importance in supplying wort for an ever increasing battery of analytical tests, including soluble nitrogen, free amino nitrogen (FAN), beta-glucans and wort viscosity. The passage of time since the Congress procedure was adopted, and the increased spectrum of laboratory wort analyses can sometimes lead to misinterpretation. In some cases there are greater expectations for the prediction of actual brewhouse values or performance. This is difficult in that operational conditions of laboratory mashing in terms of grind, gravity, and temperature profile differ considerably from those of commercial mashing. As such, an understanding of how operational parameters influence the results of wort analysis is essential in the interpretation of laboratory data. The objective of the current study was to evaluate the impact of operational parameters on the laboratory determination of malt extract, and associated wort quality parameters for modern malting barley cultivars. Samples of B1202 and Merit were malted to varying

degrees of modification. The malts were extracted by modifications of the Congress mash and Hot Water Extract procedures using a RCBD with factorial arrangement. Treatments included barley genotype, malt modification, grind, temperature profile and grist:water ratio. Stepwise linear regression showed that 73% of the observed variation in extract could be explained by genotype, grind, modification, and mash temperature profile. These same factors explained 81 and 60% of the observed variation in wort color and viscosity, respectively. Grind and mash temperature profile alone explained 82% of the observed variation in wort protein. The only standard quality parameter for which grist:water ratio made a significant contribution to the stepwise model was FAN (83%). Additional factors evaluated included wort beta-glucans and fermentable sugars (HPLC).

Dr. Yin Li is a Post-Doctoral Research Associate in Dr Paul Schwarz's lab in Plant Sciences at NDSU. He received his Ph.D. from the School of Biotechnology at Southern Yangtze University in Wuxi, China, working on research in the area of malting and brewing. He has published more than 20 papers in international peer-review journals. Recently, he is interested in arabinoxylans, extract, and organic acid in malting and brewing science.

O-4

New insights into the molecular causes of lower glucan contents in malt and wort

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Malts with an insufficient cell-wall modification can lead to serious processing problems in the brewery. The degree of glucan degradation is of special significance with regard to the lautering and filtration properties. The molecular causes for an especially good or a particularly poor cytolysis have not been thoroughly researched up till now. By an extensive comparison of varieties it could be shown that barley cultivars with poor brewing quality are characterized by (I) a delayed start in beta-glucanase synthesis after steeping, (II) a generally low level in the quantity of enzyme accumulated during the germination process, and (III) an insufficient supply of enzyme to the distal region of the grain. Green malt samples were taken at various stages of malting starting at 24 hours after the first water steeping and analyzed for their beta-glucanase activity. As expected, the enzyme activities measured correlated well with conventional cytolytic malt analysis parameters such as friability, modification, homogeneity and wort beta-glucan content. However, during the comparison of various winter barley cultivars, it was especially noticeable that the varying amounts of beta-glucan in the malt and wort could not be explained solely by the differing amounts of beta-glucanase present. Numerous unmalted barley samples were then analyzed for glucan content, and a particular variety with a significantly lower value was identified. Progenies of this variety were also examined for this important criteria which was found to be inherited. We assume that quantitative differences in the availability of particular proteins or enzymes, required for glucan synthesis, are responsible for the considerably varied quantities of glucan in barley varieties. The transcription rates of individual genes

during the development of the grain must be responsible for such an effect. For this reason, messenger RNA isolated from the developing grains of various cultivars was examined for differentially expressed genes. With the help of subtractive suppression hybridization, a gene could be identified which was transcribed at a 500 times lower rate in genotypes with low glucan contents than in varieties with higher glucan values. The sequence of this gene was determined and compared to known sequences in the data bank. No matching homologue could be found. Thus the function of the protein coded for by this gene and which is obviously relevant for the malting quality remains unknown at present. Within that gene a DNA polymorphism between high and low glucan varieties could be detected, and the design of a selective PCR primer is in progress.

Michael Voetz, born in 1964, received a diploma in biology from the University of Cologne in 1991. He earned a Ph.D. in plant molecular biology from the University of Cologne/Max-Planck-Institute for Breeding Research in 1995. From 1995 to 2000, he was a scientific collaborator at the Research Department of the Weissheimer Malzfabrik in Andernach, working in the field of barley biotechnology. Since 2000, he has been head of the biotechnology/PCR laboratory at the Research Institute for Raw-Materials within VLB in Berlin. Since 2005 he has been a lab manager in this institute.

O-5

Miniaturizing the fermentation assay: Effect of fermenter size and fermentation kinetics on premature yeast flocculation

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This paper reports on fermentation assays used to test the fermentability of malt, especially malt implicated in premature yeast flocculation (PYF). No standard small scale method currently exists. In 1963, the E.B.C. yeast group recommended use of a 5 cm diameter by 102 cm working height fermenter to give a good indication of yeast performance at the brewery scale. When discussing small scale fermenters, Findlay (1971) stated that, "...whatever vessel is used, the column of wort must be at least 50 cm in depth as in shallower vessels insufficient circulation takes place and the yeast falls to the bottom." The current study involved 12°C fermentations with three vessel configurations, a 4.4 cm high spectrophotometer cuvette, a 12.5 cm high test tube and a 122 cm high "tall" tube fermenter. Worts tested were made from control and PYF malts. We included in our experiments the method of Jibiki et al. (2006) using wort supplemented with 4% glucose. The Plato decline at 21°C was fit with a sigmoidal model. The model parameters and fermenter height were used to estimate CO₂ evolution and average turbulent shear rates. We confirmed that both fermenter height and fermentation speed are the major independent variables determining CO₂ evolution and agitation within the fermenting wort. In examining the fermentation data, it was evident that the yeast did not stay equally suspended in all three fermentation vessels. When fermented at 12°C, yeast fell out of solution rapidly in both the cuvette and test tube fermenters.

In the tall tubes, the yeast remained in suspension as expected. The 21°C test tube fermentations, supplemented with glucose, had profiles similar to the “tall” tube fermentations but were complete in less than 72 hours. It is notable that these profiles could be used to distinguish PYF and control malts. The critical shear rate required to keep yeast suspended was determined to be between 4 and 7.5/sec. Thus, when downscaling a fermenter test and reducing the fermenter height, the rate of fermentation must be increased to maintain adequate rates of shear. We confirmed that the PYF fermentation assay could be reduced to 15 mL, resulting in reduced labor, time and material costs.

Alex Speers received his graduate education in Food Science at the University of British Columbia, Vancouver, BC. He is Professor in the Food Science and Technology program at Dalhousie University, Halifax, NS, Canada, where he instructs students in Brewing Science, Quality Assurance and Food Product Development. In the past, Alex has been employed in the Quality Assurance departments of both Labatt and Molson Breweries. His research interests focus on brewing science and the physical chemistry of various food systems. Dr. Speers' current research interests include various aspects of the brewing process, including yeast flocculation, premature yeast flocculation and the properties (and problems created by) beta-glucan and arabinoxylan polymers. He has organized and/or presented brewing workshops in China (1997, 2004, 2005) and Toronto (2002). In 2001 and 2002 Alex spent short sabbaticals at CUB/Fosters in Melbourne Australia. He formerly instructed at the Siebel Institute of Technology, Chicago, IL. Dr. Speers belongs to several professional societies, including the ASBC, MBAA and IBD. Alex is a member of the editorial boards of Food Research International, the Journal of the ASBC, the MBAA Technical Quarterly, and the Journal of the Institute of Brewing. He has published and presented over 100 papers.

O-6

Colloidal examinations of yeast fermented in wort causing premature yeast flocculation

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Premature Yeast Flocculation (PYF) is a problem in the brewing industry with serious economic implications. This research reports on a study of PYF phenomena through the use of colloidal techniques. A Control wort inducing normal flocculation as well as wort causing PYF was fermented for 120 h in “tall” tube fermentors. One lager yeast strain was used to ferment a Control wort and a PYF wort and subsequently analyzed for cell wall properties: zeta potential, cell separation force (F_r) and orthokinetic capture coefficient (α_o). After 72 h, upon visual inspection, yeast collected from the PYF wort exhibited more flocculation than the yeast from the Control wort. Yeast zeta potential was measured in Control and PYF fermented worts after filtration through 0.2 μm filter. The PYF fermentation yielded a yeast with less negative surface charge compared to the Control yeast at 48 h of fermentation and thereafter ($p < 0.001$). When both yeasts were resuspended in the same 120

h wort (which had been filtered through a 10-kDa cut off filter), there was no difference in the surface charge of the control or PYF fermented yeast ($p > 0.05$). This implied the presence of wort components and/or trub particles larger than 10 kDa caused a reduction in surface charge. Thus, there were less repulsive forces between PYF fermented yeasts presumably encouraging PYF. Interestingly, zeta potentials of trub from Control and PYF worts were similar when suspended in an acetate buffer. The orthokinetic capture coefficients of Control and PYF yeast were measured in fermented wort as a function of shear rate (18.7–465/sec). There was a significant difference in capture coefficient values between both the yeast suspensions, with the PYF capture coefficient values being higher at 96 and 120 h of fermentation ($p < 0.05$). Furthermore, the capture coefficients of these suspensions were directly proportional to the inverse of shear rate. The separation force was estimated by examining floc breakup of Control and PYF yeast after passage through a capillary (0.45 mm x 75 mm). The PYF yeast flocs showed higher separation forces compared to Control yeast flocs after 72 h of fermentation. At 120 h of fermentation, the Control and PYF yeast separation forces in wort were 3.24×10^{-9} N and 1.52×10^{-8} N, respectively. When suspended in a pH 4.0 sodium acetate buffer the Control and PYF separation forces were 5.87×10^{-9} N and 1.26×10^{-8} N, respectively.

Jaydeep Patel obtained a M.Sc. in Microbiology from South Gujarat University, Surat, India, in 2001. He began his employment with Torrent Gujarat Biotech Ltd. in India in 2001 and worked on the production of penicillin G by fermentation. Subsequently, Jaydeep accepted a QA position with Glenmark Pharmaceuticals Ltd. Currently he is finishing his M.Sc. in Food Science at Dalhousie University, Halifax, NS, Canada, and plans to graduate this spring. His research focuses on examining premature yeast flocculation using colloidal techniques.

O-7

Investigations on malts causing premature yeast flocculation

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Premature yeast flocculation (PYF) can be qualitatively defined as the early flocculation of yeast from the wort before the desired consumption of available fermentable sugars, leaving the beer under-attenuated. PYF is a sporadic problem in the brewing industry that can cause major monetary losses. However, very little of the underlying mechanisms of PYF are understood. To determine if PYF is caused by metabolic interference of yeast, a novel fermentation assay conducted in cuvettes was employed. Due to insufficient shear in the cuvette, yeast settles immediately. Thus, the cuvette assay eliminated fermentation differences due to variable flocculation patterns of PYF and “normal” wort. Results showed no metabolic differences between the PYF and control worts as monitored by the decline in °Plato ($p < 0.05$). This led to the hypothesis that PYF is caused by a physical interaction. A small 15 mL fermentation assay capable of segregating PYF malt from “normal” malt was adapted by spiking wort with 4% glucose (w/v) and fermenting

at ~21°C. To determine if PYF activity could be reduced by removing PYF causing “factors,” both PYF and control worts were filtered through two different membrane filters (0.45 µm and 100 kDa) prior to fermentation. Yeast stayed in suspension longer in PYF wort filtered through the 100-kDa membrane compared to unfiltered and 0.45-µm filtered worts. Filtration had no discernable effect on the control wort fermentations. End of fermentation zeta potential measurements of yeast in buffer displayed an interesting pattern, becoming more negatively charged after a 0.45-µm filtration, but becoming less negatively charged after a 100-kDa filtration (Control: Unfiltered = -4.6 mV, 0.45 µm = -5.9 mV, 100 kDa = -5.1; PYF: Unfiltered = -5.9 mV, 0.45 µm = -6.1 mV, 100 kDa = -5.2 mV).

Joseph Lake obtained an Honours Co-op B.Sc. in Marine Biology from Dalhousie University, Halifax, NS, Canada, in 2004. Joseph is currently working toward a Ph.D. in Food Science and Technology. His research focus is premature yeast flocculation but also includes other yeast/fermentation topics. In the summer of 2005 Joseph had the opportunity to spend four months in industry at Prairie Malt Limited, in Biggar, SK, Canada, examining barley and malt. He plans to graduate in late 2008.

O-8

Zinc interactions with yeast: Physiology, fermentation and transcriptional responses

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Yeast growth and metabolism is influenced by several parameters, including temperature, oxygen availability and nutrients. Zinc is a micronutrient that influences physiology of brewing yeasts. Bioavailability of zinc for yeast in malt wort may be compromised due to low zinc content of barley and following wort production processes. As a consequence, yeast fermentation performance and beer flavor may be adversely affected. In this study, we have investigated zinc uptake and fermentation performance by a lager brewing yeast strain in small-scale fermenters. Experiments were also carried out in a brewery pilot plant, where investigations were extended to evaluate the influence of wort zinc on beer flavor. Variable zinc levels were found to affect ester and higher alcohol profiles in green beer. On pitching, wort zinc levels rapidly decreased with concomitant rapid accumulation of zinc by yeast cells. This was mediated by a metabolism-dependent mechanism and, thereafter, zinc was localized in the yeast cell vacuole. In contrast, the uptake of other divalent cations (magnesium and calcium) at fermentation onset was not as pronounced compared with zinc. At the end of fermentation, yeast cells became zinc depleted due to dilution of zinc to daughter cells following growth and cell division. This may result in impaired yeast performance in subsequent fermentations if yeast is repitched into low zinc media. Although optimum zinc concentrations in wort may be defined for a particular yeast strain, Zn-preconditioned yeast cells may effectively ferment low-zinc worts. Studies conducted in zinc-limited chemostat cultures with a laboratory strain of *Saccharomyces cerevisiae* allowed us (using DNA microarrays)

to identify specific transcripts that were either up- or down-regulated. Putative molecular biomarkers of zinc deficiency in yeast have been identified, and these may potentially be used to determine the intracellular status of zinc in brewing yeast. This study provides a deeper insight into the role of zinc in yeast physiology, metabolism and gene expression that has significance for brewing fermentations.

Graeme Walker graduated with a B.Sc. in Brewing & Biochemistry in 1975 and completed his Ph.D. in Yeast Physiology (1978), both from Heriot-Watt University, Edinburgh. His professional career has included Royal Society/NATO Postdoctoral Fellow at Carlsberg Foundation, Copenhagen; Lecturer in Biochemistry at Otago University, New Zealand; lecturer in Biotechnology at Dublin City University; Senior Lecturer in Microbiology at Dundee Institute of Technology; and Reader in Biotechnology at the University of Abertay Dundee, Scotland. He is currently Professor at Abertay University where he directs a research group investigating the physiology of industrial yeasts. He is an active member of the IBD and ASBC. Prof. Walker has published around 100 articles, including the textbook Yeast Physiology and Biotechnology published by J. Wiley (1998). He acts as a consultant for international brewing and biotechnology companies.

O-9

Yeast metabolism and flavor generation—Formation of gamma-nonlactone

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The flavor and off-flavor of beer and beverages is in general strongly affected by oxygen. Since oxygen works as a radical, it needs activation or catalysis to interact with non-radical molecules like fatty acids. Lipoxygenases (LOX) play a key role in activating oxygen. Resulting hydroperoxides can undergo cleavage reactions into aroma active components like 2E-non-enal, 2,4-decadienal, hexanal, etc. However, lipoxygenases are ubiquitous in nature, and each organism utilizes this class of enzymes to gain important secondary metabolites or to activate degradation reactions. During germination, LOX-2 induces the beta-oxidation to gain energy for barley seeding. LOX-1 from barley transforms linoleic acid into 9-hydroperoxide. A subsequent reaction is the formation of 9S,12S,13S-trihydroxy-10E-octadecenoic acid, an antifungal and antiviral compound which is found in beer; another one is the formation of aroma active carbonyls. In yeasts, the metabolism of fatty acids and oxygenated fatty acids proceeds inside the peroxisomes, but not in the mitochondria. The peroxisomes contain hydrogen peroxide that can further oxidize compounds leading to new metabolites. We have intensively studied the yeast metabolism of mono-, di-, and trihydroxy fatty acids, as well as epoxy fatty acids, and their degradation pathways now are widely disclosed. Usually, beta-oxidation of any natural fatty acid can only lead to metabolites which have an even number of carbon atoms. One interesting metabolite found in beer, however, is gamma-nonlactone, a cyclic ester with an odd number of carbon atoms. We have determined two pathways starting from the precursors 9- and 13-hydroxyoctadecadienoates in yeast. The odd number of carbon atoms in gamma-nonlactone can be explained in

two ways: on one hand a cleavage of the carbon chains at C-9, analogous to the 2E-nonenal formation, and on the other hand an alpha-oxidation step of 5-hydroxydecanoic acid into 4-hydroxynonanoic acid and lactonization into gamma-nonalactone. The two ways were distinguished by analyzing the stereo-configuration of the lactone.

Leif-Alexander Garbe graduated from the Technische Universität Berlin (TUB), Germany, with a diploma in chemistry in 1996. Afterward he worked at the Research and Teaching Institute for Brewing in Berlin (VLB). From 1997 to 2002 he was working on his Ph.D. thesis, entitled "Metabolic Pathways of Mono- and Dihydroxyfatty Acids in Yeast" (written in German) and received his Ph.D. (Dr. rer. nat.) in April 2002. During this time he was also working as a scientific assistant in the Department of Biotechnology, reporting to Prof. R. Tressl (TUB, chemical and technical analysis). His work included the supervision of undergraduate and graduate students in biotechnology and brewery. In 2002 he established a new research group at the TUB focusing on Microbial-, Enzymatic- and Chemical Formation and Cleavage Reactions of C-C, C-N and C-O bonds. In cooperation with the VLB he is performing new techniques to analyze trace compounds and impurities, especially in malt, wort and beer, by GC-MS, LC-MS and isotope dilution assays.

O-10

An array comparative genomic hybridization and polymerase chain reaction method for discriminating between brewing yeast strains

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We have developed a new analytical method to discriminate between brewing yeast strains, based on the whole-genome sequencing of bottom-fermenting yeast. A whole-genome shotgun approach was initially used to determine the sequence. This was followed by data assembly, which revealed a total contig length of about 23 Mb. The results demonstrated that the bottom-fermenting yeast contains three types of chromosome: an Sc-type originating from *Saccharomyces cerevisiae*, an Sb-type originating from *Saccharomyces bayanus*, and a hybrid of the two. On the basis of the genome sequence and structure, we developed a new technique that used array-based comparative genomic hybridization (CGH) and polymerase chain reaction (PCR) to discriminate between brewing yeast strains. Array CGH allowed copy-number changes to be detected on the chromosomes of the brewing yeast strains. Such changes occur in different regions among the various brewing yeast strains, and are associated with altered levels of gene expression in the corresponding chromosome regions. In addition, PCR effectively detected balanced reciprocal translocations and identified differences among the brewing yeast strains. Recent studies have indicated that copy-number variations (CNVs) in the human genome contribute to nucleotide diversity to a greater extent than single-nucleotide polymorphisms (SNPs) and influence phenotypic variation. Our current study identified CNVs on both Sc-type and Sb-type chromosomes in brewing yeast strains.

Hideyo Tadami received a M.S. degree in agricultural chemistry from the University of Tokyo, Japan. She joined Asahi Breweries, Ltd. in April 1990 as a brewing scientist. She is at the Brewing Research & Development Laboratory. In November 2005, she started to serve the Brewery Convention of Japan (BCOJ) on its Program Committee.

O-11

Differentiation of species belonging to *Saccharomyces sensu stricto* using a loop-mediated isothermal amplification method

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Saccharomyces yeasts such as *Saccharomyces cerevisiae*, *S. pastorianus*, and *S. bayanus* are widely used for the production of alcoholic beverages, including beer, wine, whisky, and sake. These yeast strains belong to a taxonomic group "*Saccharomyces sensu stricto*," and because their phenotypes are very similar it is difficult to distinguish among them. To date, several molecular approaches have been developed to distinguish species of *Saccharomyces sensu stricto*; however, these techniques are time-consuming and can require expensive equipment. Our analysis of chromosomal structures of *S. pastorianus* suggested that *S. pastorianus* may be a natural hybrid of *S. bayanus* and *S. cerevisiae*. In the genome of the *S. pastorianus* strain, some translocation was found between the chromosomes of "Sc" (originated from *S. cerevisiae*) and "Lg" (perhaps originated from *S. bayanus*) types by chromosomal replacement or rearrangement. It is speculated that these structures of the chromosomes are specific in *S. pastorianus*. We determined some positions of junctions between the chromosomes of the Sc and Lg types and applied the structures to identify each species of *S. cerevisiae*, *S. pastorianus*, and *S. bayanus*. For this, we used a loop-mediated isothermal amplification (LAMP) method that has good specificity, high sensitivity and ease of operation. The LAMP primers developed in this study could distinguish the target species from other *Saccharomyces* yeasts, several yeasts of other genus, and various wild yeasts. Our LAMP technique with the primers has proved useful to assure the yeast strain for beer production and thus control the production process and the quality of the final product.

Nobuyuki Hayashi is a researcher at the Research Laboratories for Brewing, Kirin Brewery Co., Ltd. He graduated from Yamanashi University in 1990 with an M.S. in fermentation technology and joined Kirin Brewery. He has made various presentations of his work: on yeast flocculation at the 1995 ASBC meeting; on a genetic marker of beer spoilage lactic acid bacteria at the 6th Symposium on Lactic Acid Bacteria in 1999; in applied microbiology and biotechnology in 2001; and at the EBC Congress in 2003. From 2002 to 2004 he worked on yeast technology as a guest researcher in the Lehrstuhl für Technologie der Brauerei I, at Munich TU and presented related work at the EBC Congress in 2005.

O-12

The function and stability of mitochondrial DNA during fermentation

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It is generally accepted that brewery yeast mitochondrial DNA may be damaged during serial repitching, leading to an increased incidence in petite mutations. In this paper we demonstrate that the frequency and propensity to form mitochondrial mutants is strain dependent and the formation of these mutants occurs toward the end of fermentation when yeast collects in the cone of the vessel. Evidence for this comes from the observation that the location of petites closely mirrors the temperature profile of the population within the cone. Since brewing yeast cells can exhibit 20–50 copies of mitochondrial DNA the impact of copy number on propensity to form petites will be discussed. Furthermore a model for the mechanism of the accumulation of mitochondrial DNA damage, and therefore the mechanism by which petites are formed, will be proposed. Finally when the percentage of petites within the population reaches significant proportions aberrant fermentation profiles and impaired product quality can result. Evidence from mitochondrial DNA gene expression using DNA microarray analysis during production scale lager fermentation will be presented and discussed in the context of the role of mitochondria during fermentation.

Katherine Smart completed a B.Sc. (Hons) in Biological Sciences at Nottingham University and a Ph.D. in Brewing Yeast Physiology at Bass Brewers, Burton-on-Trent. After a two-year research fellowship at Cambridge University she held academic appointments at Oxford Brookes University. In 2005 Katherine moved to the University of Nottingham, where she became the SABMiller Professor in Brewing Science. Awards for her research include IBD Cambridge Prize, Royal Society Industrial Fellowship, Enterprise Fellowship and the Save British Science Award. She is the youngest ever Fellow of the IBD and has served on editorial and executive boards of the IBD, ASBC, SGM and IUMS.

O-13

Studies on the production of sulfite and hydrogen sulfide during fermentation in lager yeast

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Lager yeast is generally known to produce higher levels of sulfur compounds compared with those of ale yeast, whose mechanism has not yet been clarified. In our previous study, we performed a genome-wide gene expression analysis using the shotgun DNA microarray (SDM) of lager yeast during fermentation. Upon the addition of 70 μ M and 140 μ M methionine, five genes, that is, *MET3*, *MET5*, *MET10*, *MET6* and *CYS4* were

annotated as down-regulated genes from about 20,000 spotted clones. Further gene expression analyses of the two types (*Saccharomyces cerevisiae* (s.c.) and *Saccharomyces bayanus* (s.b.) types) of *MET3*, *MET5* and *MET10* genes by RT-PCR showed that the s.c. type of the *MET10* gene was not or very weakly expressing, indicating that the corresponding sulfite reductase of the s.c. type was not fully activated. In the upper stream of the methionine metabolism pathway, two types of *MET3* genes, which encode the enzyme catalyzing the reduction of sulfate to adenosine 5'-phosphosulfate (APS), were doubly activated. We concluded that the gene expression balance of *MET3* and *MET10* leads to production of higher levels of sulfite in the lager yeast. During further studies on the production of sulfur compounds in lager yeast, we found that hydrogen sulfide was only very slightly detected during the main fermentation, whereas in the final product, the level of hydrogen sulfide increased according to the level of sulfite at the end of the main fermentation. Furthermore, during the fermentation trial using several lager yeasts, which showed clear differences in the level of the sulfite excretion, a correlation between the levels of hydrogen sulfide in the final product and sulfite at the end of the main fermentation was observed. These results may imply that the pathway from sulfite excreted in the fermenting wort to hydrogen sulfide is activated during the second fermentation in the lager yeast.

Masahide Sato was born in 1965. Sato studied Agricultural Chemistry at Tohoku University, Japan (1988) and attended the Graduate School of Agricultural Science, Tohoku University (1988–1990), obtaining a Ph.D. in Applied Microbiology from Tohoku University in 2002. From 1990 to 2002 Sato was a Microbiologist in Brewing Research Laboratories, Sapporo Breweries Ltd., Japan, and from 2002 to the present has been the Lead Microbiologist in Frontier Laboratories of Value Creation, Sapporo Breweries, Ltd.

O-14

Differentiation of yeast strains and detection of mutants using genetic methods

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Compared to ale strains, which are believed to have been used by the Egyptians many centuries ago, lager strains form a relatively new group of yeast. It is widely acknowledged that the genome of lager yeast has not evolved as much as for ale strains, and these yeast are typically less genetically and phenotypically diverse. During the last 20 years a number of genetic methods have been developed to obtain discriminant profiles or “fingerprints” which can be used to differentiate between yeast strains. Due to their close genetic heritage, differentiation of lager strains has typically been more of a challenge than for ale strains, in particular because the level of discrimination differs greatly according to the method used. Irrespective of their brewing classification, some yeast strains are also more susceptible to developing nuclear or mitochondrial variants during serial repitching and storage. These mutations can cause various changes in terms of fermentation performance and the quality of the final product.

Although noticeable these phenotypic changes are sometimes difficult to identify genetically as they often arise as a result of minor changes within the genome. Given the importance of employing a specific strain for the maintenance of brand quality and the disruptive effects of employing genetically unstable yeast, methods that can differentiate yeast strains and identify mutants within a culture can provide important information to the brewer. Here a variety of different genetic methods were compared for their ability to differentiate ale and lager yeasts and to detect mutations in industrial strains. Each of the 8 yeast strains was analyzed using RAPD-PCR of inter- δ sequences, PFGE (CHEF) karyotyping, RFLP of yeast transposons, mitochondrial DNA RFLP, and microsatellite PCR with 6 primer pairs. It was observed that ale strains were readily differentiated using RAPD-PCR, which was also the quickest and least time-consuming method assessed. In contrast, no single method was able to differentiate between a set of lager strains specifically selected due to their high degree of genetic similarity, or between a mother strain and derived variants. However, by applying a combination of methods, complete differentiation of all of these yeasts could be achieved. A comparison of the efficacy of each method to discriminate between closely related strains and a number of variants suggested that microsatellite PCR may be the most discriminant method currently available. The techniques described in this study provide insightful information regarding brewing yeast cultures, and it is anticipated that they may find use within the industry for quality control purposes.

Sylvie studied biochemical engineering and fermentation at the Institute Meurice (Brussels, Belgium); she completed her degree in September 1996. During that time, she obtained an Erasmus studentship for a 6-month project on brewing yeast cell aging at Oxford Brookes University. She obtained her Ph.D. on oxidative stress and ageing in Saccharomyces cerevisiae in July 2000 at Oxford Brookes University. From March 2000, Sylvie was employed as Project Manager for SMART Brewing Services. She was involved in contract research, microbiological analysis and development of methods and kits for the brewing industry. She also took part in organizing international courses, symposia and congresses for the brewing industry. In 2004 Sylvie left the UK 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 microorganism identification and characterization, as well as detection of contaminants in alcohol production processes. Since February 2007, Sylvie occupies the position of Brewing Fermentation Manager for Lallemand to service and support the brewing industry worldwide.

O-15

Response surface methodology as a tool to optimize the malting of buckwheat

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Buckwheat (*Fagopyrum esculentum*) is a pseudocereal from the family Polygonaceae. Traditionally the plant has been grown

in South-East Asia and Central and Eastern Europe; today's main producers are China, Russia and the Ukraine. Interest in buckwheat has grown during the last decade due to its favorable nutritional properties. Besides starch as a main compound, the buckwheat kernel contains high-quality protein and polyunsaturated fatty acids. Buckwheat is rich in antioxidants and minerals and, therefore, is recommended as an ingredient for functional food products. Furthermore buckwheat is glutenfree and, therefore, acceptable for the diet of sufferers of celiac disease, who cannot consume products containing proteins from wheat, barley and rye. Malting of buckwheat has been studied intensely in our group, and favorable conditions for malting as well as mashing have been proposed. In the present study response surface methodology (RSM) was used to model the changes for several parameters important for brewing purposes. Using the model malting conditions for every single parameter or a combination of parameters with weighted importance can be calculated. Buckwheat was malted in a Joe White micro malting plant. Buckwheat was steeped at 15°C to a water content of 45% and germinated for 2 to 6 days at 10 to 20°C. Kilning conditions were 45°C for 5h and 50°C for 15h. The malts were analyzed for extract content, fermentability and viscosity using the Congress mashing system. Total nitrogen (TN), soluble nitrogen (SN) and free amino nitrogen (FAN) were also determined. Activities of alpha- and beta-amylase and protease in the malts were measured. The analytical results revealed that the extract content was only slightly influenced by the changes in the malting conditions, higher contents were found in samples germinated for 4 days at low temperatures. Fermentability of the extract was low in comparison to barley and was highest in the malts germinated for longer than 4 days. At the long germination condition, it was found that the amylolytic enzyme activities were highest. Wort's viscosity decreases with higher temperatures and longer germination time. TN was not influenced by malting, neither time nor temperature, while SN was higher with short germination times. FAN increased steadily with longer germination time and temperature, the levels were sufficient to support the growth of yeast. The levels of all these parameters were found to be in the same range as in previous studies. This study shows that RSM is an excellent tool for optimizing malting conditions of grains. The complex data analysis allows an in-depth correlation between the different parameters evaluated, e.g. enzyme activities and protein and starch degradation.

Florian Huebner studied Food Technology at the University of Stuttgart Hohenheim and has been working on a Ph.D. thesis since 2006 in the Department of Food & Nutritional Sciences, University College Cork.

O-16

Palatinose in beer production—Research results

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The new carbohydrate Palatinose™ is the only low glycemic and low insulinemic sugar that provides prolonged energy in

the form of glucose. It therefore offers considerable physiological advantages which make this sugar highly attractive to use in human alimentation. In the presented research work the possibilities of implementing Palatinose™ in the brewing process have been studied. It has proven to be applicable for the improvement of specialty beers concerning taste and palatability. Moreover due to the reducing power of Palatinose™ positive influences on flavor stability have been found using the newest analytical measurement systems. From the literature it is known that Palatinose™ is not or only very limitedly metabolized by a lot of microorganisms in nature, including human dental flora. Therefore one focus of this research work was put on the metabolization of Palatinose™ by beer-relevant microorganisms, especially beer-spoiling microorganisms. A liquid growth medium that contains only Palatinose™ as a carbohydrate was developed to test the ability of microorganisms to utilize Palatinose™. Parameters such as extract-decrease were measured to detect metabolization of Palatinose™ by the tested microorganisms. Additionally some of the beer-typical factors that improve beer's stability against microbiological spoilage were added. The purpose was to find out whether metabolization of Palatinose™ is influenced by the presence of hop bitter substances, alcohol, etc. Furthermore so called "beer-mixed" drinks were produced that were made of one part beer and one part lemonade and filled in plastic bottles. Different beers were used, and the lemonade-part differed in the sweetener used (sucrose, Palatinose™ and sweeteners). These beer-mixed drinks were then contaminated with spoilage microorganisms. To measure deterioration, the formation of turbidity and the deformation of the plastic bottles due to gas formation were determined. Additionally the behavior of brewing yeasts fermenting Palatinose™-containing worts have been studied, bringing about interesting results regarding fermentation by-products.

Roland Pahl was born in 1972 and made an apprentice as brewer and maltster in Berlin in the early 1990s. After that he began employment as a brewer in the Schultheiss Brewery in Berlin. After finishing his studies as a graduate engineer for brewing technology at the University of Technology in Berlin (Diploma Thesis, "Influence of Different Barley and Malt Varieties on the Nonenal-Potential of Wort and Beer") he was employed as a scientific assistant at VLB Berlin in the Research Institute for Technology of Brewing and Malting. In 2004 he changed to the Research Institute of Engineering and Packaging of VLB where he is currently working doing research, consulting and teaching.

O-17

Glutenfree beer—A review

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Celiac Disease (CD) is an auto-immune disease with a broad range of symptoms, including diarrhea, constipation and anemia. The condition is triggered by the ingestion of gluten which induces an inflammatory response, resulting in the destruction of the villous structure of the small intestine. Gluten is a protein fraction found in wheat, rye and, for the brewing industry most importantly, barley. The effects of oat proteins are still being

discussed. Due to better methods of diagnosis the diagnosed number of sufferers strongly increased in recent years. According to screening data about 1 in 100 individuals in the USA might be affected. The only known treatment to avoid the symptoms of CD is a total life-long abstinence from gluten, leading to a diet considerably different from the ones commonly found in the Western world. WHO/FAO's *Codex Alimentarius* gives limits of 200 ppm and 2 ppm for food products to be called "rendered gluten-free" and "naturally gluten free," respectively. It was assumed that malting is a way to decrease toxicity due to breakdown of proteins. However, beers brewed from barley, wheat, rye and oat are not considered safe by celiac societies, as many sufferers still show symptoms after consuming beer. Consequently, the only way to produce safe malt-based beverages for celiacs is to use malt from grains which do not contain gluten or gluten-like proteins at all. Producing glutenfree beers is a challenge for the brewing industry as well as an opportunity. There is a need to find cereals or pseudocereals with favorable malting properties, and processes must be optimized for the new raw materials. On the other hand a range of new products with respect to taste and appearance can be developed in order to attract new customers. In this review an overview of CD and the consequences for the diet of affected persons will be given. Examples of glutenfree beers with a long tradition, e.g., maize beers from the Americas and beers made from sorghum in sub-Saharan Africa, will be presented. Finally, the potential of cereals and pseudocereals not commonly associated with malting and brewing, e.g. millet, buckwheat, quinoa and amaranth, will be discussed. Special emphasis will be placed on the work performed in the area by UCC.

Beatus Schehl studied Food Technology at the University of Stuttgart-Hohenheim, Germany. Schehl's Dr-Thesis (PhD) focused on the application of genetically modified yeast strains in spirit production at the Department of Beverages and Fermentation Technology, Stuttgart-Hohenheim, Germany. Since 2005 Schehl has been working as a Post-Doc on glutenfree foods and beverages (mainly focused on beverages, e.g., glutenfree beer) at the Department of Food and Nutritional Sciences, University College Cork, Ireland.

O-18

MicroStar-RMDS-SPS (ATP-bioluminescence method): Rapid biological monitoring for practical use

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(1) Frontier Laboratories of Value Creation, Sapporo Breweries, Ltd., Shizuoka, Japan

Since draft beer (filter-sterilized beer) has the majority of the beer market, the biological monitoring of beer-spoilage microorganisms has great meaning. Conventional cultivation methods take 3–7 days to form visible colonies; therefore, the demand for rapid detection methods has been increasing. We launched joint research with Nihon Millipore K.K. in 1992 and have developed MicroStar-RMDS-SPS (RMDS), which enables rapid detection and determination of the number of microorganisms trapped on a membrane filter and is based on the ATP-bioluminescence method. Through reducing the signal/noise (S/N) ratio, developing an automatic system, establishing a calibration method, organizing a maintenance rule, training inspec-

tors, performing validation, etc., we made possible detection of beer-spoilage microorganisms in 2 days. The RMDS was implemented work in all of our breweries in 1998, and it is now indispensable for the timely release of our products. We will report on the difficulties in establishing a stable operation over the last nine years.

Hajime Kanda received a master's degree from the Department of Agricultural and Environmental Biology, Tokyo University. He found employment with Sapporo Breweries, Ltd. in April 2006 as a microbiologist in the Frontier Laboratories of Value Creation.

O-19

The effect of antimicrobial steels and photocatalytic coatings on the microbial load on filler surfaces

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Material science has lately introduced a range of coating materials for surfaces that could be useful for hygiene management in the brewing industry. Antimicrobial stainless steels are alloys containing metals that are poisonous to microorganisms, thus combining the advantageous properties of stainless steel with repelling or killing characteristics. The effect of photocatalytically active surfaces is based on two different cleaning mechanisms, namely oxidation and super hydrophilicity. On photocatalytic titanium dioxide surfaces, organic matter is oxidized to carbon dioxide and water. Exposure to UV light (wavelengths < 388 nm) makes the surface super hydrophilic, allowing water to penetrate below the dirt and remove it. We studied antimicrobial steels containing silver or copper and photocatalytic TiO₂-coated steel on brewery filler surfaces for 6 months on 3 bottling lines. Both silver containing steel and photocatalytic TiO₂ coatings proved to reduce the total microbial load on the filler surfaces markedly (by 2–5 log units). However, the effect of photocatalytic coatings persisted longer and were effective for at least 6 months. An obstacle in the use of photocatalytic materials is the requirement of UV light to activate the surfaces. By combining photocatalytic surfaces with antimicrobial metals we were able to overcome this problem. We studied photocatalytic TiO₂ surfaces improved by a low concentration of silver ions and found that they further improved the effect of TiO₂. In this way we were able to reduce the total microbial load significantly in production environment where the illumination is based on day light and luminescent lamps. When introducing new materials into beverage production areas, it is important to ensure not only that the total microbial load is reduced but also that the population does not consist of more harmful microbes than before. By analyzing the bacterial populations adhering onto the functional materials using PCR-DGGE (polymerase chain reaction-denaturing gradient gel electrophoresis), we were able to show that the variation between samples was generally more dependent on the site than on the material. The antimicrobial steels endured the wear and the cleaning chemicals in the production environment well

without any observable changes in composition as examined by scanning electron microscopy, energy dispersive spectrometer and x-ray diffractometer. The benefits of functional materials are still largely unexploited in brewing equipment. Functional surfaces at critical sites of the process could reduce or slow down the attachment of microorganisms and dirt, and facilitate their removal in cleaning operations.

Erna Storgårds holds a Ph.D. in microbiology from Helsinki University. She joined VTT in 1988, where as a team leader she is now responsible for research activities dealing with application and control of microbes in food processes. Her special expertise is brewery microbiology and process hygiene. She has been a member of the EBC Microbiology Group, later the EBC Brewing Science Group, since 1992 and has been its chair since 2004, chair of the EBC Microbial Contaminants Subgroup from 1993 to 2004 and a member of the Microbiology Subcommittee of the EBC Analysis Committee since 1998. She has been a member of ASBC since 2004.

O-20

The status and challenge in quality assurance with the Chinese brewing industry

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The Chinese brewing industry has matured after 100 years of development. The total beer production for 2005 was 306.1 million hectoliters; beer production and sales obtained the number 1 position in the global beer market for the past 4 years. Thus the development of quality assurance plays an important role in improving beer quality. There are some characteristics for the QA status of the Chinese brewing industry. First, standards and analytical methods of beer and raw material were published, such as GB/T7416-2000 for Brewing Barley Analytical Methods, GB/T1686-1993 for Brewing Malt and GB/T4928-2001 for Beer Analytical Methods. All these analytical methods have been developed in reference to ASBC and EBC analytical methods and modified for the Chinese brewery. Second, most of the big breweries are equipped with internationally advanced automatic equipment and instruments. Therefore key quality parameters can be checked online and controlled. More and more traditional manual analytical tests are being replaced by modern instruments. Third, most big breweries have their own strict QA systems, including standard operation procedures (SOP), uniform instruments, and regular data review systems. Of course, QA in the Chinese brewing industry still has some challenges. Firstly, current quality analytical methods cannot meet the requirements along with beer quality improvement. For example, dissolved oxygen in beer is a very important indicator; however, current DO meters have differing check theories, precision and accuracy. There has been no one standard method and instrument for checking DO until now, including those of China, ASBC or EBC. Second, the QA development level in Chinese breweries is unbalanced. There are many middle- and small-scale breweries with poor QA levels due to historic reasons. Many areas of QA remain to be addressed in order to keep up with the increasing demand of this fast growing industry.

Fan Wei is the Chief Brewmaster of Tsingtao Brewery Co. Ltd, one of the biggest brewers in China, holding 50 breweries. In this position, Fan manages all aspects of quality and production. He is also taking on responsibility for some industrial business work as Deputy Secretary of the China Alcoholic Drinks Industry Association and Vice President of the Shandong Brewing Industry Association. Fan began his career with Tsingtao No. 1 brewery in July 1982. He has worked in the positions of Deputy Manager of Malting, Packaging, Brewing Department and Deputy Chief Brewmaster of Tsingtao No. 1 Brewery. Then, Fan was assigned as Deputy Director of the Corporate Technology Department of Tsingtao Brewery Co. Ltd in July 1993. He was promoted to Deputy General Manager and Brewmaster at Tsingtao Brewery No. 2 in March 1994. In 1996, Fan was moved back to corporate and named as Chief Brewmaster of Tsingtao Brewery Co. Ltd. Fan received a B.S. in Fermentation Engineering from Shandong Institute of Light Industry. During his career, he has been sent to Germany to study brewing science at Doemens (1987–1988).

O-21

A comparison of the cost, quality, and environmental impacts of conventional brewing versus possible future brewing methods

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The majority of modern food industries seek to increase production efficiency through the implementation of new technologies; however, the brewing industry shows a marked resistance to this trend. Due to this reticence some aspects of the brewing process are inefficient and subject to inconsistencies. These issues lead to co-product production, namely spent grains and surplus yeast, as well as the consumption of excess energy and water during processing. This review aims to quantitatively compare the cost, quality, and environmental impacts of conventional brewing versus condiment brewing. The parameters that were selected for comparison include co-product production, water usage and sewer load, carbon dioxide production and usage, fuel usage, and energy usage. This direct comparison will provide data for an objective analysis of condiment brewing, instead of an outright rejection based on tradition.

Stephen Russell is a masters candidate in the Food Science Department at the University of California in Davis. Previously he obtained a B.S. in chemical engineering from Oklahoma State University in Stillwater.

O-22

The importance of Gage reproducibility and repeatability (Gage R&R) in the lab setting

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Variation in analytical equipment is an accepted fact in the process of analysis. The real question is how much variation is allowable and what are the other factors that can impact analytical variation. One extremely valuable Six Sigma tool for the evaluation of equipment for analysis is a Gage repeatability and

reproducibility (Gage R&R) study. The Gage R&R module is a powerful tool that will not only evaluate the equipment but the technician's ability as well. Gage R&R identifies and quantifies the different sources of variation that can impact the measurement system and provide data that are questionable. In this presentation I will discuss the importance of Gage R&R studies and all associated variables that can impact the analysis of a product. Stability, bias, precision and accuracy are all areas that are addressed with Gage R&R studies of analytical equipment. As part of this presentation I will attempt to address some of the common questions asked when conducting variable and attribute Gage R&R testing. In addition to addressing common questions, I will also discuss how to design a Gage R&R study, perform testing, interpret the data, and how to address systems that are in need of improvement. I will discuss the importance for lab managers to have confidence in their equipment and staff and to have supporting data when addressing issues or procedures.

Brad Rush received his B.Sc. degree in environmental analysis from Carroll College, Waukesha, WI, and is also a graduate of the quality engineering program at the Milwaukee School of Engineering. Brad is currently a certified organic inspector with the Independent Organic Inspectors Association (IOIA) and is currently studying at the University of Wisconsin–Madison Business School. Brad is also certified as a Six Sigma – Green Belt. Brad has worked as a brewer and in research and operations at Leinenkugel and Miller brewing companies. Since August 2002, Brad has been manager of quality, safety, health and environmental at Briess Malt & Ingredients Company, Chilton, WI. Brad has been a frequent presenter and an active member of the MBAA and ASBC.

O-23

Development of a technique to evaluate the foam potential of protein in beer

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The NIBEM method is an important foam stability evaluation technique that is widely employed as a quality control index of beer products. However, the NIBEM method measures foam that is produced by carbon dioxide dissolved in beer, and it is difficult to measure its stability during the brewing process or to investigate the causes of problems with foam. We have developed a simple evaluation technique using the NIBEM method that can measure the foam potential during processing steps and identify the materials that influence it. The proteins that affect the foam are collected from rough and bright beer by the ethanol precipitation method and are added to carbonated water along with iso-alpha-acid compounds and ethanol. After bottling, the foam stability is measured by the NIBEM method. This evaluation technique was used to investigate the decreases in foam stability caused by yeast protease and by high-gravity brewing. Reductions in the amount of foam active protein appeared to cause the foam stability to decrease in both cases. This hypothesis was supported by analytical results from techniques such as sodium dodecyl sulfate-polyacrylamide gel electrophoresis (SDS-PAGE). The decrease in foam stability

caused by yeast protease was attributed to a reduction in the 10-kDa protein, lipid transfer protein 1 (LTP1). The decrease in foam stability during high-gravity brewing was not attributed to the 40-kDa protein Z or the 10-kDa protein identified by SDS-PAGE. This foam potential evaluation technique makes it possible to determine easily whether decreased foam stability is the result of decreased amounts of protein.

Eiichi Jimbo received a M.S. in environmental sciences from Tsukuba University in Japan. He joined the Brewing Research and Development Laboratory, Asahi Breweries, Ltd. in April 1991. He researched the material in SAKE as a guest researcher in Jozo Shikenjyo of the National Tax Agency in 1992–1994. Then, he worked in the product development section. Since September 1997, he has researched foam and flavor stability in the brewing science section.

O-24

A reexamination of SRM as a means of beer color specification

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The apparent shortcomings of the SRM method (ASBC MOA-10A) for beer color specification are well known. The major objection is that color cannot be adequately modeled by a single number. The newer MOA (Beer 10-C), while it reports a tristimulus (3 parameter) L^*a^*b color, does so for only one specific set of observing conditions. In this investigation principal components analysis of the transmission spectra of an ensemble of 59 imported, domestic and homebrewed beers showed that the SRM measurement conveyed 95.6% of the spectral variation and that the first two principal components (PCs) of the spectra when normalized by SRM conveyed most of the rest (0.03% remaining unmodeled). This suggests that a specification of the SRM value plus 2 PCs may be used to reconstruct the entire transmission spectrum of a beer from which L^*a^*b color can be calculated for *any* set of viewing conditions (including those of Beer-10C). Working in this way we found that we could reproduce the tristimulus colors of the beers in the ensemble with rms accuracies of about 1 L^*a^*b color unit (ΔE) for 1 and 5 cm paths and under various illuminants. The advantages of being able to retain the familiar SRM number are clear. This presentation proposes a new color MOA which processes spectral data in a manner very similar to that of Beer-10C but which reports SRM and two principal component numbers. The new method does not replace Beer-10C but rather augments it as spectra derived from the new method can be inserted into Beer-10C to compute tristimulus values. We touch on modifications to Beer-10C which would enable it to compute tristimulus values for other viewing conditions. These concepts are illustrated using the ensemble data and accuracy considerations are discussed.

A. J. deLange is a practicing electrical engineer with 40 years experience in radar, signal processing, and estimation theory. He holds Bachelors and Masters degrees in electrical engineering from Cornell University. As a home brewer he particularly enjoys applying the disciplines used in his professional life to his hobby. Today's presentation is an example of this.

O-25

The assessment of the susceptibility of beer foam to damage by lipids

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Equipment supplied by Steinfurth has been demonstrated to generate consistent values for the assessment of the foam stability of beers. It has been shown that there is good correlation between foam stability as assessed by this method and foam quality as judged by individual observers. The method has been used to compare the ability of beers to withstand the impact of linoleic acid as a foam inhibitor. Beers display differing robustness in this regard, and there does not appear to be a simple correlation with style of beer. The study has been extended to investigate whether the beers show the same sensitivity to the detergent used to clean beer glasses.

Charlie Bamforth, Ph.D., D.Sc. is Chair of the Department of Food Science & Technology and Anheuser-Busch Endowed Professor of Malting & Brewing Sciences at the University of California, Davis. He has been part of the brewing industry since 1978. 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. Charlie is a Fellow of the Institute of Brewing & Distilling and Fellow of the Institute of Biology. Bamforth is Editor-in-Chief of the Journal of the American Society of Brewing Chemists and has published innumerable papers, articles and books on beer and brewing. In a previous life he was also a prolific soccer writer.

O-26

Identification of new volatile thiols with strong empyreumatic aromas in beer

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Volatile thiols are known to contribute to flavors, even at low concentrations; however, the influence of this type of sulfur compound on beer aroma is not yet fully understood. Off-flavors, such as “burnt” and “light-struck,” occur occasionally in beer, especially during the brewing of the low-malt beers known as *Happoshu*. At the 2006 American Society of Brewing Chemists Annual Meeting, we reported on the contribution of 3-methyl-2-butene-1-thiol to the burnt flavor of beer, and on the factors that affect the formation of 3-methyl-2-butene-1-thiol during the brewing process. Furthermore, our gas chromatography/olfactometry (GC/O) analysis of beer extracts revealed the presence of three unidentified sulfur compounds, which contributed to flavors reminiscent of burning and roasting. The aim of the current study was to identify the characteristic empyreumatic aromas other than 3-methyl-2-butene-1-thiol, and to reveal their contribution to the aroma of beer. Volatile thiols were specifically extracted from beer using a *p*-hydroxymer-

curibenzoate solution, and were purified by percolation through a Dowex 1 column. Benzenemethanethiol, which has not previously been detected in beer, 2-mercaptoethyl acetate and 2-furfurylthiol were identified by GC/mass spectrometry (MS) analysis based on the spectrum obtained in the scan mode, or olfactometry on the three different columns by comparison of the odor and retention index with the reference compound. GC/O and GC/MS analyses, along with sensory threshold determination, confirmed the contributions of 2-mercaptoethyl acetate and 2-furfurylthiol to the burnt rubber and roasted coffee aromas, respectively. Benzenemethanethiol had a strong smoky aroma and was a potent odorant detected by CharmAnalysis™, which can quantitate the intensity of an aroma detected at a GC sniff port. The perception threshold of this thiol was relatively low (1.7 ng/L). These results suggested that benzenemethanethiol contributed to the eumyrcenic aromas of beer.

Minoru Kobayashi is a scientist at the Brewing Research and Development Laboratory, Asahi Breweries Ltd. He received his M.S. degree in applied biological chemistry from Tokyo University in Japan, where he majored in analytical chemistry. He has been engaged in the analytical technology laboratory since 1998, especially in analytical chemistry section. Since September 2003, he has worked in brewing science section, especially in beer flavors.

O-27

Turbidimetric titration of haze-active polyphenol in beer

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Determining haze-active (HA) polyphenol in beer is problematic for a number of reasons. The concentration present is very low, and most of the HA polyphenol in beer is bound to HA protein. Methods that determine total polyphenol are not satisfactory, as only a small proportion of the total polyphenol is HA. The most specific approaches operate by adding a HA protein or HA protein-like substance (e.g. soluble polyvinyl pyrrolidone, PVP) to induce haze that is then measured turbidimetrically. The problem with this approach is that results are significantly influenced by the amount of endogenous HA protein in a sample. Chapon showed long ago that turbidimetric titration provides more information than a single point method, and this approach has been used in at least two commercial instruments, the Tannometer and the PT-standard. As those instruments are relatively expensive, it was of interest to study the utility of manual turbidimetric titration. Equal increments of PVP solution were added to model systems containing HA protein (gliadin), non-HA protein (lysozyme), HA polyphenol (tannic acid, TA) or non-HA polyphenol (epicatechin) and combinations of these. After each addition the resulting mixture was stirred, and its turbidity was determined. Increasing levels of TA led to higher turbidity peaks that occurred at greater volumes of added titrant. Epicatechin and lysozyme produced practically no haze. The initial gliadin solution had modest haze and, surprisingly, this decreased with increasing PVP.

The effects of adding fixed amounts of epicatechin, lysozyme or gliadin to TA were examined. Epicatechin and lysozyme produced little change. The response with gliadin and TA was complicated. Experiments were also carried out with unchill-proofed beer treated with differing amounts of silica and PVPP.

Karl Siebert received a Ph.D. in biochemistry from Penn State in 1970. He joined the Stroh Brewery Company in Detroit where he spent 18 years and held positions from Research Associate to Director of Research. In January of 1990, Dr. Siebert joined Cornell University as Professor of Biochemistry in the Department of Food Science and Technology. He served five years as department chair and now has a predominantly research commitment. Prof. Siebert is active as a consultant in beverage technology and chemometrics. He twice received MBAA Presidential Awards, and he and his colleague, Penny Lynn, have received the ASBC Eric Kneen Memorial Award three times. Dr. Siebert was made an Honorary Professor of the Moscow (Russia) State Academy of Food Processing in 1996, and in 1999 he received the ASBC Award of Distinction. He is currently a member of the ASBC Journal Editorial Board. Dr. Siebert's research interests involve foam and haze in beverages, the application of chemometric methods in food science, and assessment of microbiological risk.

O-28

The EAP determination and BAX-value—Powerful tools to determine differences in brewing technology

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The new analysis method for determination of the endogenous antioxidative potential of beer samples using EPR spectroscopy (EAP determination) was employed to further analyses of different factors which affect the oxidative stability of beer. The results gained by this method show in comparison to established lag-time determination, new insights into radical based reactions. The EAP determination leads to a significantly higher accuracy of results regarding different factors affecting the endogenous antioxidative potential of a beer, which can be depicted in more detail. Additionally the Beverage Antioxidative Index (BAX-value) was used to show influencing factors on the endogenous antioxidative potential. Regarding wort an optimized method for determination of the DPPH reducing activity was used (EPR) to give better information on antioxidants in wort. Tests in which oxygen was added to beer showed that the effect on the EAP value in relation to storage time may be described as an exponential relationship, contrary to the results gained by the conventional lag-time method. When using the EAP determination method, it was also possible to show a linear relationship between the EAP value and the SO₂ content of a beer sample. This linear relationship, however, varies from beer to beer, which results in different EAP values for the same SO₂ contents. By adding SO₂, this relationship can be used to determine the new created BAX-value of a beer sample. The BAX-value indicates how fast the SO₂ of a beer is degraded. The SO₂ consumption is strongly influenced by the beer matrix, and therefore varies depending on the beer and production

procedures. The BAX-value can be employed to estimate the EAP consumption in relation to the storage time. Furthermore it is also suitable to show factors affecting the EAP value. By comparing different production procedures like kieselguhr- and cross-flow membrane filtration, packaging materials, pH value and different beer ingredients, e.g. O₂-content, SO₂-content, metal ions, ascorbic acid, etc., the influence on flavor stability and antioxidatives could be shown using the EAP- and BAX-value. Because of the better resolution of the new method, even small differences could be shown compared to the conventional lag-time method. Some of the factors affecting the endogenous antioxidative potential, which could be deduced from these results, can be employed to obtain higher oxidative beer stability using suitable brewing technology. It should be used not only to try to obtain the highest possible endogenous antioxidative potential, but mainly to delay the consumption of the initial BAX-value.

From 1975 to 1981 Frank-Juergen Methner studied in Brewing Science at Berlin University of Technology (TU), after which he worked as an operating supervisor at the Schlösser Brauerei. From 1982 to 1986 Methner was a scientific assistant with teaching duties at the Research Institute for Brewing and Malting Technology of the VLB in Berlin. He has also conducted research projects. His Ph.D. thesis was "Aroma Formation of Berliner Weissbier with Special Focus on Acids and Esters." For 18 years, starting in 1987 Methner held a leading position as a Director at the Bitburger Brauerei, Bitburg, with responsibilities in fields such as technology and quality assurance. Beginning with winter semester 2004/2005 he took over the chair of Brewing Science at TU and is the head of the Research Institute of Technology for Brewing and Malting of the Research and Teaching Institute for Brewing (VLB). Since 2005 he has been Vice-Chair of the EBC Brewing Science Group.

O-29

Evaluation of aroma compounds that contribute to beer aging flavor

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Little is known about the aging flavors of beer, although several volatiles have been suggested to contribute to aromas. Moreover, although Dalglish plots have been used to summarize the sensory changes that occur in beer during storage, previous reports have failed to reveal the compounds that contribute to aging character, with the exception of "bitter" and "cardboard" flavors. We predicted that a number of compounds would contribute to aging flavors through enhancing and/or masking effects, even though there is little published information on sensory estimation of the way in which multiple compounds affect the aging character. The current study investigated the contribution of volatiles through sensory analysis using construct, additional and omission testing. We analyzed 40 volatile compounds in fresh and aged beer using gas chromatography-mass spectrometry (GC-MS). Our approach consisted of solvent-assisted flavor evaporation followed by GC-olfactometry (GC-O) analysis, based on the previously published literature.

We initially performed sensory analysis comparing beer that had been aged for 1 month at 25°C with fresh beer to which we had artificially added compounds thought to accumulate during storage. The scores for the beer with the added compounds were similar to those of the naturally aged beer. This suggested that the added compounds contributed to aging aromas. We then further evaluated the compounds using a modified omission test, and identified at least nine that appeared to contribute to aging flavors: (*E*)-2-nonenal, gamma-nonalactone, dimethyltrisulfide, 3-methylthiopropionaldehyde, (*E*)-beta-damascenone, ethyl 2-methylpropionate, ethyl 2-methylbutyrate, sotolon and 3-methyl-2-butene-1-thiol. Among these, only four compounds ((*E*)-2-nonenal, gamma-nonalactone, 3-methyl-2-butene-1-thiol and 3-methylthiopropionaldehyde) were present at levels above the relevant thresholds after storage. These findings suggest that the aging aromas of beer are made up of several constituents, some of which fail to increase above threshold values during storage.

Akira Wanikawa received a B.S. in agricultural chemistry from Hokkaido University in Japan. He joined The Nikka Whisky Distilling in April 1987. He was transferred to the R&D Institute in 1992, and then to the Brewing R&D Laboratory of Asahi Brewery in April 2001. He earned a Ph.D. in agriculture chemistry from Hokkaido University in 2002. He received the Technical Award from the Brewing Society of Japan in 2004 on flavors in whisky. His current work involves research on several flavor compounds of alcoholic beverages.

O-30

Advantages of using stir bar sorptive extraction and GC-TOFMS for the analysis of beer flavor and off-flavor chemicals

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Several analytical procedures have been used to extract flavor and off-flavor chemicals from beer prior to GC-MS analysis. This work describes the advantages of using stir bar sorptive extraction (SBSE) in conjunction with gas chromatography and time-of-flight mass spectrometry (GC-TOFMS) detection. Chromatograms of several types of beer samples will be used to illustrate the effectiveness of SBSE to extract a wide variety of flavor-impact chemicals and how the Pegasus GC-TOFMS can be used to identify and accurately quantitate coeluting flavor-significant chemicals. As analytical flavor chemists apply increasingly sophisticated techniques that extract more analytes and higher concentrations of analytes, the problem of GC peak coelution increases. The peak deconvolution capability of the Leco Pegasus TOFMS was found to be critical to the detection and accurate quantitation of key off-flavor chemicals in beer. Compared to fresh control beer, increases in furfural, furfuryl ethyl ether, furyl hydroxymethyl ketone, 2,4-dodecadienal, (*E,E*), benzeneacetic acid ethyl ester, beta-damascenone and 3-pyridinecarboxylic acid ethyl ester (aka nicotinic acid ethyl ester) were observed in beer samples incubated 12 wks at 30°C and increases in dimethyl disulfide, dimethyltrisulfide and benzeneacetaldehyde occurred in beer samples exposed to sunlight for 8 hrs. The capability of the technology to detect maltol, 3-methyl-2-butene-1-thiol and other compounds will

also be discussed. The partnering of SBSE with GC-TOFMS provides a new tool for detecting ultra trace levels of significant flavor-impact chemicals in beer. Combining this new tool with olfactometry experiments, model system sensory studies, chemometrics and other techniques available to beer researchers should provide the industry with a better understanding of the chemicals most influencing staling off-flavors in beer, how they form and how they may be reduced.

Ray Marsili has published over 30 papers on food and flavor chemistry in refereed chemistry journals, as well as over 100 technical papers for trade publications and numerous chapters for flavor chemistry books. He has edited three books on flavor, fragrance and odor analysis (Techniques for Analyzing Food Aroma [1997]; Flavor, Fragrance and Odor Analysis [2002]; and Sensory-Directed Flavor Analysis [2006]) and is working on a fourth book. He has over 30 years' experience as an R&D analytical laboratory manager/flavor chemist for major national and international food and ingredient companies. Today, he is an independent analytical flavor consultant, with a laboratory at Rockford College, Rockford, IL.

O-31

Sensory panel management—Revisiting challenges, defining opportunities

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Information derived from sensory panels is used in many companies to assess the fitness of their products for the market and to make reward decisions for production staff. Typically “expert” panels are convened from a larger pool of experts. However, despite training, individual panelists perform tasks such as magnitude estimation in different ways. Crucial to this behavior is the scale used by the sensory analyst to extract magnitude estimation data and the subsequent data analysis applied. In this paper, I will explore the benefits of maintaining a large group of experts, most notably for the convenience of bringing a quorate panel together, and compare this with the downside, which is more diffuse summary statistics such as mean and variance. In particular, the biases on panels imposed by arbitrary changes to scales and the inclusion of occasional panelists, will be examined using simple probabilistic approaches, and a method for compensating for individual behaviors will be highlighted. It is proposed here that such compensation can substantially enhance the resolving power of panel responses to similar products. This is expected to enhance the quality of information derived from sensory panels thereby facilitating better decision-making. Additionally, alternative, well-established scaling approaches will be presented that help in linearizing the relationship between analytical data and magnitude estimates, which in turn improves the brewer’s ability to directly relate sensory and analytical data.

Paul Hughes gained his degree and Ph.D. in chemistry from the University of London. After nearly two years with the Health and Safety Executive, Paul joined the Brewing Research Foundation in 1990. In 1999, Paul took up the position as principal scientist with Heineken Technical Services, where he led proj-

ects on beer quality- and integrity-related issues. In October 2005, Paul was appointed professor of brewing at Heriot-Watt and subsequently appointed director of the International Centre for Brewing and Distilling at Heriot-Watt in May 2006. Paul holds the Diploma of Brewing and an MBA. He is a member both of the EBC Brewing Science group and the Editorial Board of the ASBC Journal. Paul was recently appointed as the International Director to the ASBC Board. In 1998, Paul was awarded the IBD Cambridge Prize for research on the properties of hop bitter acids.

O-32

Control of off-flavors like pickled vegetable in happoshu

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Once in a while a pickled vegetable-like flavor is found in beer, especially in Happoshu. However, the cause of this off-flavor has not been identified. Therefore, it was not easy to improve this negative flavor in the brewing process. The purpose of this study is to obtain an indicator of the flavor and to control the flavor in beer. The cause of the pickled vegetable-like flavor itself is known to be sulfur-containing compounds. So, sulfur-containing compounds in happoshu were focused on and studied. In our results, we found that there is a good correlation between the amount of methionol and the sensory score for pickled vegetable-like flavor. Methionol could be the indicator of this flavor. In order to reduce the concentration of methionol in beer, various fermentation conditions were studied, such as wort aeration and counter pressure during fermentation, etc. The conditions that suppress methionine metabolism were effective for reducing the flavor. In our small scale fermentation (2 L) trials, the concentration of methionol was successfully reduced by 16% compared with the control. The sensory evaluation proved that the pickled vegetable-like flavor of test sample was lower. In this presentation, we will show the appear reason for pickled vegetable-like flavor and how to control it in the brewing process.

Takeshi Teranishi graduated from Kyoto University with a degree in Plant Breeding in 2002. He joined Suntory in 2002 and was engaged mainly in fermentation process in the Kyoto brewery. In 2005 he moved to the Beer Development Department, and he works for the improvement of yeast management to produce better beer quality.

O-33

The nature of astringency perception in acidic beverages

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We previously proposed that the reasons acids are astringent is that they decrease saliva pH, which results in a stronger interaction between polyphenols in saliva and salivary proline-rich proteins, leading to a stronger perception of astringency (Siebert and Chassy, “An Alternate Mechanism for the Astringent Sensation of Acids,” Food Qual. & Pref. 15:13-18, 2003).

This presumes that polyphenols are normally present in saliva, which was demonstrated by results obtained with a single individual. Experiments were carried out with a sensory panel in which different concentrations of dilute acid were used. The panel abstained from tea drinking for one week, drank two cups of green tea per day for one week and abstained for the third week. Identical sensory tests with three dilute acid concentrations were carried out seven times during the three week period and the total polyphenol content of saliva collected from each panelist was determined with a modified Folin-Ciocalteu method. It was shown that the average polyphenol content of panelists' saliva increased significantly ($p < 0.05$) during the week of tea drinking, and the increased level persisted into the third week. The panel sensitivity to astringency also increased with tea drinking. It is clear that polyphenols are normally present in saliva and that the level is affected by dietary habits (baseline levels between different individuals were considerably different). It was also shown that increased salivary polyphenol levels led to stronger astringency sensations. Acidic beverages have greater astringency intensity than would be expected from their polyphenol content alone.

Karl Siebert received a Ph.D. in biochemistry from Penn State in 1970. He joined the Stroh Brewery Company in Detroit where he spent 18 years and held positions from Research Associate to Director of Research. In January of 1990, Dr. Siebert joined Cornell University as Professor of Biochemistry in the Department of Food Science and Technology. He served five years as department chair and now has a predominantly research commitment. Prof. Siebert is active as a consultant in beverage technology and chemometrics. He twice received MBAA Presidential Awards, and he and his colleague, Penny Lynn, have received the ASBC Eric Kneen Memorial Award three times. Dr. Siebert was made an Honorary Professor of the Moscow (Russia) State Academy of Food Processing in 1996, and in 1999 he received the ASBC Award of Distinction. He is currently a member of the ASBC Journal Editorial Board. Dr. Siebert's research interests involve foam and haze in beverages, the application of chemometric methods in food science, and assessment of microbiological risk.

O-34

Redox protein contributions to beer stability

PETER J. ROGERS (1), Frank M. Clarke (1)

(1) Griffith University

S-rich beer proteins can exert a profound effect on beer staling. Some beer proteins have reactive vicinal thiols, neighboring pairs of thiol groups, that undergo reversible oxidation-reduction ($2[-SH] \rightleftharpoons [-S-S-] + 2H^+ + 2e^-$). The reverse reaction is driven by sulfitolysis, in which SO_2 provides the reducing power. Provided SO_2 is available the protein structure remains intact and acts as a localized source of reducing power—to quench free radicals, peroxide, and reduce aldehydes. Protein matrices may entrap and destroy reactive oxygen species produced at the dithiol centers and at protein sites where Fe^{++} and Cu^+ ions are bound. Beer proteins therefore limit the diffusion of reactive species and reduce indiscriminate oxidation at other locations. In an expanded model, other reductants apart from

SO_2 would provide the reducing power. We previously reported the positive synergistic effects of beer proteins and SO_2 on the destruction of hydroxyl free radicals in lager beers. This paper extends the model. Lager beer stability during force testing was assayed using ESR, peroxide challenge tests and sensory analysis. Proteins were analyzed for redox active thiols and disulfides and carbonyls using MPB and DNP-antibody reagents, respectively. Lagers with variable SO_2 :protein ratio and variable levels of protein were analyzed. Changes in protein structure and function were compared to changes in the perceived sensory and physico-chemical stability of the beer. We now report: i) free radical quenching by beer exhibits saturation kinetics consistent with a limited number of reactive catalytic protein sites; ii) beer protein structural integrity is protected as long as the sulfitolysis exchange can be sustained; iii) protein oxidation accelerates abruptly once thiol oxidation is no longer reversible, and signals the accumulation of staling compounds; iv) this leads to the accrual of protein carbonyls and disulfides as predicted, and ultimately to the complete loss of reactive thiols. Protein oxidation was used subsequently to monitor and predict the shelf life of packaged beers. Since the protein oxidation tests can be reduced to 96 well-plate format, rapid and inexpensive throughput analysis can be performed. In the long term it seems preferable to retain functional protein in beer, and to aim at extending the donor reductants (apart from SO_2) to sustain the thiol-disulfide redox cycle.

Peter Rogers, Ph.D., joined Fosters in 1997 and manages technology transfer in beer and wine making, largely driven by stiffening regulatory requirements and the allure of age-proof beer and wine. Some recent developments include an isinglass finings replacement and a wine finings extension, gene expression guided fermentation control, and fast throughput analysis of beer ROS-suppressive character. He is presently Foster's Australia's National Manager Research and is an honorary professor at RMIT and Griffith Universities.

O-35

Beer drinkability

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Drinkability is widely used as one of many attributes available to describe the characteristics of a beer. A problem arises when one intends to describe what is the real meaning of the word drinkability when used for beers. Some research papers have been published in which drinkability is a response variable, despite the fact that drinkability itself is not a sufficiently studied issue. A beer that has a good drinkability is the one which invites the drinker to another glass either in the same or in a future drinking session. Methods of measuring drinkability are proposed and beer aspects responsible for its drinkability are also discussed. This presentation aims to broaden the current knowledge on the subject and was based on an article published by the author in the *MBAA Technical Quarterly* 42:13-15, 2005.

Rubens Mattos is from Brazil and graduated as a Chemical Engineer in 1991. Rubens received an M.Sc. degree in Chemical Engineering in 1995, studying glucoamilase production by

fermentation. In 1994 he joined Brahma Brewing Company in Brazil, where he stayed until 2001 when it was already AmBev. He was granted a Master Brewer diploma from the University of California-Davis in 1996, the same year that he received a distinction from the Associated Membership Examination of the Institute of Brewing (IOB). In 2004 he joined BASF, becoming the Technical Manager for Beverage Processing Polymers for the Americas. His research on beer flavor stability at the State University of Campinas (UNICAMP-Brazil) resulted in his Ph.D. degree in 2007.

P-36

Comparison of analytical methods to analyze the “color” of liquid adjuncts

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The color of a liquid adjunct can be easily determined by a visual examination. However, if a specification is established, a reliable method to quantitatively measure color must be put in place. There are a variety of methods to analyze the color of liquid adjuncts and syrups used in the brewing and food industries. The majority of these methods are not an ASBC method. This paper will present the current analytical methods available for use by the food and beverage industries and compare these methods to the ASBC method for color analysis of beer and adapted for liquid adjuncts and syrups.

Scott Helstad is currently the Technical Services Manager, National Accounts, for Cargill's Corn Milling business unit. Scott has been with Cargill for 23 years, 19 of those spent in technical services. While Scott technically supports the entire food industry, he has been particularly active with the brewing industry. Scott is a member of the ASBC, MBAA, IFT, AACC International, and a number of other food industry trade organizations. Scott has a B.A. degree in Chemistry from St. Olaf college. He resides in Dayton, OH, with his wife and two children.

P-37

New optical technology for measuring dissolved oxygen gains acceptance by brewing industry

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(1) Haffmans North America

Required quality for acceptable taste and flavor stability are continuously under discussion in the brewing industry. Oxygen plays the most important roll as it causes a rapid decline. Breweries control and measure the quantities of O₂ continuously during the production steps of their beverages to prevent even low oxygen pick-ups. This leads to beers with very low dissolved oxygen levels, consistent quality and high flavor stability during its complete shelf life. The principle of new optical O₂ measurement is based on the effect of dynamic luminescence quenching by molecular oxygen. The measurement excels through high accuracy at even at very low oxygen values, fast response, and long-term stability. These are the reasons why this new optical O₂ measuring technology is useful for the brewing industry. The latest results on validation of oxygen

measurement by an independent institute are shared. Combined with CO₂ measurement, the new oxygen measurement enables breweries to control the two most important gasses in a very efficient way.

Roy Johnson began his career with Miller Brewing Company at the Fulton, NY, brewery in 1983 as a QA Packaging Analyst. He transferred to Miller's Ft. Worth, TX, brewery as a QA Packaging/Product Supervisor in 1987. In 1990, Roy moved into the Ft. Worth Brewing Department, where he worked in the brewing, fermentation, aging, and package release areas as a Brewing Supervisor. Roy was later transferred to Miller's Trenton, OH, brewery in 1994 where he was a Brewing Area Team Manager until 1995. In 1995, Roy accepted a position with The PQ Corporation as a national account manager handling beer stabilization sales to key brewing accounts in North America. Early in 2006, Roy joined Haffmans North America as their Sales Manager for Quality Control instrumentation and units. Roy graduated from Pennsylvania State University in 1982 with a B.S. Degree in food science and a business emphasis. He obtained an M.B.A. from the University of Texas in Arlington in 1994. Roy is active in MBAA as the current president of District Cincinnati. He is also the current national Membership Chair for MBAA and the BOG rep for District Cincinnati.

P-38

Determination of ochratoxin A in beer by immunoaffinity cleanup and liquid chromatography tandem mass spectrometry

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Ochratoxin A (OTA) is a nephrotoxic and carcinogenic mycotoxin produced mainly by *Aspergillus ochraceus* and *Penicillium verrucosum*. OTA is found in various foods and beverages including cereals, beans, dried fruits, coffee, wine and beer, and several countries have their own regulations for OTA content in several food commodities. As CODEX intends to establish regulations for OTA in cereals in the near future, OTA is one of the most significant chemical substances in the beer industry. In this situation, we attempted to develop a simple and sensitive method for analyzing OTA using liquid chromatography tandem mass spectrometry to investigate the OTA content in beer products and raw materials. We were able to determine OTA in beer products with a simple pretreatment process that includes immunoaffinity column purification. In the case of malt and corn, extraction with acetonitrile/water was needed before immunoaffinity cleanup. As a result, we have established an analysis method for OTA with high sensitivity, and the detection limit was found to be 0.001 mg/L in beer products and 0.01 mg/kg in raw materials. We analyzed domestic beer products and confirmed that almost all beer products analyzed contained OTA, but detection levels were very low. We also examined raw materials: some malt contained small amounts of OTA, but all the malt analyzed complied with EU regulations.

Masayuki Omote is a researcher at Analytical Technology Laboratory, Asahi Breweries Ltd. He graduated from the Graduate School of Pharmaceutical Science of Kyoto University and joined Asahi Breweries Ltd. in 2000. He has been engaged in research and development of analytical technology since 2000.

P-39

Inductively coupled plasma mass spectrometry (ICP-MS) for trace element analysis in beer and raw material

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(1) Science & Technology Development, InBev, Leuven, Belgium; (2) Science & Technology Research, InBev, Leuven, Belgium

Inductively coupled plasma mass spectrometry (ICP-MS) is undoubtedly the fastest-growing trace element technique available today, carrying out applications in diverse fields including environmental, geological, semiconductor, biomedical and nuclear. The major reason for such success is that ICP-MS not only offers very low detection limits in ppt, but also enables quantification at the ppm level. This unique capability makes the technique very attractive compared to other trace metal techniques such as atomic absorption spectroscopy (AAS) or inductively coupled plasma optical emission spectroscopy (ICP-OES). ICP-MS has other clear advantages such as speed of analysis, multi-element determination and isotopic capability. The multi-element detection importantly allows an increase in sample throughput compared to AAS which is a mono-element technique. The economies while rising counterbalanced the very high cost of the instrument. The major disadvantage of ICP-MS is the creation of polyatomic interferences due to the presence of argon ions (e.g. $^{40}\text{Ar}^{35}\text{Cl}^+$ interfering with $^{75}\text{As}^+$). Fortunately constructors developed technical solutions to get rid of these interferences. All the advantages and the efficacy of the dynamic reaction cell (DRC) convinced us to invest in ICP-MS. Developing a method for trace element analysis in raw material (malt, maize, rice, etc.) and beer was a challenge due to the presence of potential interference initiators and alcohol in beer. Elements like C, O, Na, S, P and Cl present in both kind of matrix interfere with the analysis of K, Cr, Fe, Cu, Zn, Ca and As. However the DRC technology was used successfully to prevent the formation of these interferences before the mass analysis step. Finally, for the first time in the brewery, methods have been validated for the quantification of 25 elements in both types of matrix. We are now able to quantify B, Ba, Be, Bi, Ag, Al, As, Cd, Cr, Cu, Fe, Mn, Ni, Pb, Se, Sb, Sn, Sr, Tl, U and Zn at the ppb level, and Ca, K, Na and Mg at the ppm level. Unfortunately, two different methods were mandatory in order to determine ppb and ppm levels with good repeatability and reproducibility standard deviations. The quantification of mercury was not satisfactory with the ICP-MS and needs to be done using another method. Despite these constraints, the sample throughput has been considerably increased compared to AAS. This new analytical tool allows us to have a good overview of the elemental composition of our raw materials and beers and to anticipate possible modifications of the legislation (lowering maximal accepted level, including new element, etc.).

Laurence Gijs received a M.Sc. in Bioscience Engineering in 1996 and a Ph.D. in Agronomy Science and Bio-engineering in 2003 from the Catholic University of Louvain (UCL, Louvain-la-Neuve, Belgium). Her Ph.D. research was partly sponsored by Belgian Brewers. From 1998 to 2003, she was a teaching assistant in the Brewery and Food Industries Department of the UCL with Professor Sonia Collin. Since 2003, Laurence has worked as a Research Scientist in the Corporate Science and Technology Development Department of InBev (Belgium). She is author/co-author of various publications, posters and lectures.

P-40

Novel online sensor for measuring dissolved CO₂ using attenuated total reflectance (ATR) technology

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(1) Thermo Fisher Scientific Process Instruments, Minneapolis, MN

Traditional methods for measuring carbon dioxide both in the laboratory and online are based on Henry's Law and use pressure and temperature to calculate dissolved CO₂ concentration. These methods are not specific to carbon dioxide and measure all gases including oxygen and nitrogen. A novel sensor has been developed which measures only dissolved CO₂ and is suitable for online applications. Based on infrared spectroscopy, the sensor uses the attenuated total reflectance (ATR) sampling technique to continuously analyze the beverage in flow and no flow applications. The sensor is compact and is designed to fit directly into the process. The operation and design of the sensor are discussed. The performance of the ATR-based sensor will be compared with traditional temperature-pressure based devices. The ATR-based sensor provides improved measurement accuracy which is not dependent on beer type, density or alcohol content, is not affected by pressure surges, and can operate during CIP cycles.

Rick Cash currently is a Marketing Technology Manager for Thermo Fisher Scientific's Process Instrument Division. Rick has 20 years of experience in design and development of technically advanced instrumentation and measurement products at Thermo Fisher, CyberOptics, and Honeywell, Inc. He holds a BSEE from the University of Michigan and a MSEE from the University of Minnesota

P-41

A new method for color determination of laboratory mashed wort utilizing a NTU turbidity correction equation

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The accurate measurement of wort color has required the removal of haze prior to spectrophotometric readings at 430 nms. This study attempts to compare three methods of haze removal—diatomaceous earth filtration, 0.45-micron PTFE syringe filters, and 0.45-micron PVDF syringe filters and is specific to unpasturized laboratory mashed wort samples as prepared by

ASBC Malt-4, a method commonly used by malt analysis laboratories. 32 malt samples ranging from pale to caramel 60 were mashed in duplicate using two sets of mashing devices in two different laboratories. The three haze removal methods were applied prior to wort color determinations in both laboratories. The wort color data collected for each haze removal method and unfiltered wort NTU turbidity readings were then used to build a possible wort color NTU turbidity correction equation. The use of the NTU correction equation would allow for accurate wort color determinations without the routine use of time-consuming, costly filtration materials.

Adrienne Caruso received a B.S. in chemistry from Maryville University in St. Louis, MO, in 1999. Since graduation she has worked as an analytical chemist in the Brewing Technical Center at Anheuser-Busch. Besides serving on technical subcommittees, she served as the ASBC Local Section 2 chair in 2005–2006 and is currently a member of the National ASBC Program Committee.

P-42

Sampling of sulfurs in beer by membrane extraction and analysis using GCMS

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(1) Wasson-ECE Instrumentation, Fort Collins, CO

Sulfur in beer is typically accessed by headspace analysis. Wasson-ECE Instrumentation has developed a method for membrane extraction of sulfurs in beer. Development of this sampling methodology will allow brewers to sample beer during the brewing process with online instrumentation. During the sampling process the beer is pulled past a membrane. The sulfur components of interest pass through the membrane onto a sulfur-selective trapping media, allowing concentration of the sample up to 100 times the native concentration. Once concentrated the sulfur components are desorbed to the GCMS for analysis.

Shannon Coleman has a B.S. in Chemistry from the University of Colorado and a Masters Degree in Chemistry from Emory University. He has been involved with new product development at Wasson-ECE Instrumentation since 2003.

P-43

***qGPC6H*, a gene that increases starch content in barley grain**

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Maltsters and brewers require barley with low grain protein percentage. Fortunately, low grain protein percentage is associated with improved grain yield. A novel allele of *qGPC6H*, a gene on barley chromosome 6 that dramatically impacts grain protein percentage, was moved from a Nepali land race line into the Western North American germplasm pool in the 1970s. This allele reduces grain protein percentage by 1.5–2 percentage points. We mapped the approximate location of this gene (See et al., 2002) and have since fine-mapped the gene utilizing

a series of recombinant interval families. Utilizing this multi-generation, time-consuming but resource conserving approach, we identified genotypes containing double recombination events around *qGPC6H* that are now being utilized in our barley improvement program. We also report results from a single-location replicated yield trial consisting of Karl, the original donor of the low protein *qGPC6H* allele, 4 independent BC₄ lines in which the high grain protein allele was backcrossed into Karl, Lewis, an agronomically superior 2-rowed barley variety, and 4 independent BC₄ backcross line in which the low grain protein allele was backcrossed into Lewis.

Dr. Blake received his B.S. degree in genetics from U.C. Davis in 1976, his M.S. degree from South Dakota State University in 1979, and his Ph.D. degree (genetics) from Bob Nilan's barley genetics program at Washington State University in 1983. He joined the Montana State University faculty in 1984 and remains the MSU professor of barley breeder and genetics.

P-44

Glucans in barley (*Hordeum vulgare* L.) and malt: The influence of steeping time

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The high beta-glucan content in barley and malt can cause problems in maceration and filtration in brewing. The objective of this research was to establish the effect of two steeping times on beta-glucan content and malt quality parameters. Experimental lines and two varieties of barley (Esmeralda y Esperanza) were micromalted for 30 and 49 hours of steeping. Beta-glucan content was lower with 49 hours, and malt quality parameters were better (fine ground extract >76.5% DB and alpha-amylase content >45 UD), but the percentage of malt recovery was affected by long steeping times. There was a positive and significant correlation between beta-glucan content, filtration time, extract and viscosity.

Evangelina Sevilla P. received a degree in biological chemistry from Guadalajara University in Jalisco, México. She began employment with INIFAP in February 1980. She worked in micromalting of experimental lines and the quality management section at headquarters from 1993 to 2007. Since 1996, she has been Head of Research at the Barley Quality Laboratory for improvement of malt quality.

P-45

Characteristics of thiol oxidase in malt

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We believe that thiol oxidase oxidizes –SH groups in proteins in mashing, producing disulfide bridges that contribute to sluggish wort separation and also producing hydrogen perox-

ide, which jeopardizes flavor stability. The enzyme has been purified from malted barley. Thiol oxidase activity increased gradually during malting. The enzyme has a molecular weight of 35,600. The optimum pH was 8.0. Mercaptoethanol, di-thiothreitol, cysteine and glutathione have been evaluated as substrates. Enzyme activity was strongly inhibited by iodoacetamide and mercury. The enzyme was activated by manganese and copper. The properties of the enzyme in relation to brew-house events will be discussed.

Makoto Kanauchi graduated from Tokyo University of Agriculture in Tokyo, Japan, in March 1996. He received a Ph.D. in Bio-regulation Control from Tokyo University of Agriculture in March 1999. He worked in Prof. Charlie Bamforth's Laboratory in Food Science and Technology, University of California at Davis (November 1999 to May 2003). Subsequently, he was employed at the Institute of Food Science in Fuji Oil Corporation in Moriya, Ibaraki, Japan, as a Researcher (August 2003 to March 2005). Since April 2005, he has been an Assistant Professor at the Department of Food Management, Miyagi University. He has also been a Lecturer in enzymology and alcoholic beverages (mainly spirits and wine) at the Tokyo University of Agriculture since October 2005.

P-46

Plant brewing extract decrease in summer period and possible origins

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A decrease in plant brewing yield may be observed in summer. This problem is met when the latest malt of the previous harvest is brewed and is believed to be due to long storage of the grain. High temperatures encountered during this period could be responsible for this phenomenon. To define the origin of this decrease, malt quality parameters and brewing performance were measured on samples produced with heat-stressed grain: a barley sample harvested during a high temperature period, as well as barley samples stored under specific temperature and anoxia conditions. Malt was also produced with various steeping and germination temperatures, in order to mimic grain heating in case of temperature control failure. Malt quality data were collected for 6 years, showing the reproducibility of this phenomenon, with an average loss of 1 extract point in summer. This poster will show data about seasonal brewing yield decrease and general malt quality modifications. It will summarize the results of heat-stressed grain trials, showing that all three conditions tested may impair malt quality and have an impact on process and final product quality. Interestingly, the impact on process and product quality is not in all cases predictable based on the malt analyses.

Luc Didierjean obtained a Ph.D. in Plant Molecular Biology in 1992 from Université Louis Pasteur, Strasbourg. He completed post-doctoral work for Novartis and DuPont, working on plant resistance to biotic stress and herbicide detoxification. He joined Kronenbourg Brewery Research Centre in 1998 and is

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Osmolyte concentration in green and kilned malts as indicators of finished malt quality

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This research was conducted to test the hypothesis that osmolyte concentrations of green and/or kilned malts can be used as early indicators of finished malt quality. Barley seeds were steeped and germinated in a micromalter for six days during which time samples were collected every 24 h. Green malt samples were analyzed for malt osmolyte concentration (GMOC) and were kilned and analyzed for osmolyte concentration (OC), malt extract (ME), diastatic power (DP), alpha-amylase activity, soluble/total protein (S/T), and beta-glucan concentration. GMOC and OC increased most rapidly between days 1 and 3 or 1 and 4 of germination, respectively, and plateaued or declined thereafter. ME typically followed the same pattern as GMOC and OC although the rates of increase in ME slowed and/or plateaued sooner than did GMOC and OC values. This suggests that GMOC and OC continue to measure storage compound degradation longer than does ME. ME and OC were correlated on days 2–4 and day 6 ($r = 0.740\text{--}0.942$, $P < 0.0001$). Day 2 and 3 OC values correlated with ME values from all days ($r = 0.740\text{--}0.942$, $P < 0.0001$). ME and GMOC were correlated on all days of germination ($r = 0.878\text{--}0.943$, $P < 0.0001$). GMOC from day 1 were correlated with ME from days 1–5 ($r = 0.756\text{--}0.886$, $P = 0.0003$ to <0.0001) and GMOC from day 2 were correlated with ME from days 1–6 ($r = 0.769\text{--}0.910$, $P = 0.0002$ to <0.0001). OC from day 2 correlated with beta-glucan concentrations from days 2–6 ($r = -0.702$ to -0.830 , $P < 0.0001$). GMOC and beta-glucan concentrations were correlated on days 1–6 ($r = 0.788$ to -0.896 , $P \leq 0.0001$). No significant correlations were found between OC and DP or alpha-amylase on any day. GMOC were correlated with alpha-amylase and S/T for days 3–6 ($r = 0.733$ to 0.890 , $P = 0.002$ to <0.001). Collectively, these data suggest that both OC and GMOC values from early periods of germination can be used as indicators of finished ME and of selected other malt quality values from malts produced 1–4 days later.

Cynthia Henson is a research plant physiologist with the USDA-Agriculture Research Service and an Associate Professor of Agronomy at the University of Wisconsin-Madison. She received a Ph.D. in Agronomy from the University of Wisconsin-Madison and subsequently joined ARS. She currently serves as the Research Leader of the Cereal Crops Research Unit.

P-48**The ultrastructure of barley and proso millet during malting observed by scanning electron microscopy**

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Scanning electron microscopy (SEM) is a good tool to study the microstructure in grains, since high magnifications can be achieved. Samples of proso millet and barley were taken and observed by SEM at different stages of the malting process. In unmalted proso millet, starch granules are located in big ridged cells, surrounded by relatively thin cell walls. Angular starch granules in the streaky endosperm and rather spherical granules in the floury area have been observed. The size of the starch granules ranges from 1.3 to 13.5 μm . The mean diameters vary from approximately 4 to 5 μm which is similar to maize and rice starch granules. Many large granules show strong indentations in SEM pictures on their surfaces due to the dense packaging of the endosperm. Small spherical protein bodies are attached on starch granules. The protein bodies are concentrated in the peripheral cells of the endosperm, becoming more scattered and less frequent toward the inside. In barley, in the loosely packed endosperm the difference between small and big starch granules was more apparent than in the more compact endosperm. The small starch granules are approximately 2–4 μm , while the big granules ranged from 15 to 25 μm in size. During malting, the ultrastructure of both proso millet and barley is degraded. SEM proved that proso millet starch granules are attacked by pitting. The organization of the amorphous and crystalline regions (or domains) of the granule structure generating the concentric layers that contribute to the “growth rings” was visible by SEM when proso millet starch granules were severely broken down. In barley, small starch granules, show surface erosion and not pitting like big barley starch granules. Barley starch is mostly attacked near the equatorial groove. In barley, both big and small starch granules are degraded, which caused a loss of the closely packed arrangement. Barley endosperm seemed more disintegrated than that of proso millet. In barley, the breakdown of endosperm cell walls is more evident. The presence of cell wall pieces indicated that after 2 days germination cell walls were severely attacked. In conclusion, SEM can be used as a tool in industry to couple processing characteristics to structure of grains.

Beatus Schehl studied Food Technology at the University of Stuttgart-Hohenheim, Germany. Schehl's Dr-Thesis (PhD) focused on the application of genetically modified yeast strains in spirit production at the Department of Beverages and Fermentation Technology, Stuttgart-Hohenheim, Germany. Since 2005 Schehl has been working as a Post-Doc on glutenfree foods and beverages (mainly focused on beverages, e.g., glutenfree beer) at the Department of Food and Nutritional Sciences, University College Cork, Ireland.

P-49**Barley CAP: A multi-disciplinary research effort to apply genomics approaches to the genetics of malting barley quality**

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The overall goal of the Barley Coordinated Agricultural Project (CAP) is to access agronomic and economically important genes in barley, thus facilitating the development of superior barley cultivars. More specifically the Barley CAP was designed to address current technical barriers to widespread incorporation of high throughput marker assisted selection (MAS) in barley breeding. The project is a true multi-disciplinary effort, representing 30 scientists from 19 institutions with expertise ranging from genetics/genomics, breeding, pathology, databases, computer science, food science, malt quality, and statistics. Funding is provided by the USDA Cooperative State Research, Education, and Extension Service. Each of 10 breeding programs are submitting 96 contemporary barley lines (for each of the 4 project years) that have been screened for numerous agronomic, disease and malt quality traits. A 3,072 single nucleotide polymorphism (SNP) map is to be constructed, and SNP markers will be used to conduct genome-wide association mapping for traits of interest. Partnership between the Barley CAP and USDA Genotyping Centers will ensure that SNP markers that tag important traits will be quickly moved into a high-throughput format suitable for MAS in barley breeding programs. The very large population being utilized in this project increases statistical power and ensures that genes discovered are relevant to stakeholder needs. The current presentation provides an update on the first year's research progress.

Paul Schwarz is a Professor of Plant Sciences at North Dakota State University where he directs malting barley quality research and serves as the director of the Institute of Barley and Malt Sciences. He also serves as an adjunct Professor in the School of Biosystems Engineering and Food Science at Zhejiang University, Hangzhou. Dr Schwarz publishes and lectures extensively on barley, malt quality, and brewing. His recent research is primarily in the area of food safety and mycotoxins as related to malting and brewing. Dr Schwarz has worked at the Kurth Malting Corp., A. Egger Bierbrauerei, and was a visiting scientist at the Coors Brewing Co.

P-50**How can varieties and rain-fed production environments affect malting quality in spring barley?**

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Rain-fed barley production environments can be highly variable across a region and across years. Almost all malting barley production in Washington State is under rain-fed conditions. The industry has noticed that in some cases malt beta-glucan levels and other malting quality parameters have been unacceptable in barley raised in eastern Washington under rain-fed condi-

tions. We therefore, undertook a three-year (2003–2005) study to measure barley (BBG) and malt/wort (MBG) beta-glucan levels, as well as, other malting quality parameters in six spring barley varieties (2-row AC Metcalfe, Harrington, Farmington, Radiant and 6-row Legacy and Morex) at four variety test locations. The mean annual precipitation range at these four locations (2003–2005) was about 380–500 mm (15–20 in.), which represents the precipitation range for realistic malting barley production in eastern Washington. All nine parameters evaluated were affected by variety (V), location (L) and year (Y). No variety x environment (V x E) interactions were detected for malt extract percentage (ME), barley protein percentage (BP), soluble/wort protein percentage (SP), soluble/total protein ratio (S/T), and barley beta-glucan percentage. VxE interactions were detected for kernel weight (KW), VxL and VxY; for diastatic power (DP), VxL, VxY, and VxLxY; for alpha-amylase activity (AA), VxL and VxY; and for malt beta-glucan content, VxL, VxY, and VxLxY. Whereas, temperature means varied for the four test locations for the growing season (Apr.–Aug.; 15–18 C) and for the Jul.–Aug. grain filling period (20–23 C), they did not vary from year to year. Precipitation did vary from year to year for crop year (Sept.–Aug.) and for growing season (Apr.–Aug.). Crop year precipitation was highest in 2004 at all but one location and lowest in 2005 at all locations. Growing season precipitation was also highest in 2004 but lowest in 2003 at all locations. The year effect on the malting quality parameters was almost exclusively due to variation in precipitation. There were no clear common trends for variety performance for all parameters measured across locations or years. However, there were predictable trends for ME, KW, BP, SP, S/T, and DP, but not for AA, BBG, and MBG. No test location was clearly superior for producing highest malting quality across all parameters. Among the premium malting varieties in the study, AC Metcalfe had slightly higher overall quality compared to Harrington, but Legacy and Morex were essentially equal in quality. The lower quality Farmington and Radiant were clearly distinguished from the premium varieties. ME and MBG were most dramatically and negatively affected in 2005, the driest year. Overall, only rain-fed production conditions in the driest years would cause concern for malting quality acceptability.

Steve Ullrich is Professor of Crop Science in the Department of Crop and Soil Sciences at Washington State University at Pullman with research, teaching, advising, and administrative duties. He leads the WSU barley breeding program and does barley genetics research concentrating on quantitative genetic analysis of complex economically important traits, such as those that affect malting, feed, and food quality.

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Cellulosic ethanol from barley agricultural waste: Can the “other” ethanol expand the revenue potential for barley growers?

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Straw is an abundant byproduct of small grain production systems. Barley, wheat and oats produce nearly as much straw as grain; however, across the barley growing states and provinces the market for straw is generally far less than is available and therefore aged, decaying piles of baled straw are commonly seen along any of the rural highways in the grain producing regions of North America. The U.S. Department of Energy (DOE) proposes to utilize cellulosic biomass to displace 25 percent of the U.S. liquid fuel consumption with ethanol by 2020. It is feasible that systems to utilize this abundant agricultural “waste product” for fuel ethanol production will be developed in the near future. At Montana State University in Bozeman, we are evaluating commercial malting barley varieties and ~1,800 accessions of the Spring Barley World Core Collection (WCC) for forage and straw digestibility using the bovine rumen as a model system for bacterial digestion in parallel with commercially available enzymes. A 96-member pilot study demonstrated that we can easily measure differences in dry matter digestibility (DMD) in forage samples among lines from the WCC utilizing our *in rumen* bioassay. The differences are relatively large (<60 to >90 percent DMD) and are reproducible. Although forage samples are comprised of plants at flowering, and therefore still green, we suspect that dried straw remaining after grain harvest will also demonstrate this variability in DMD and will be evaluated after the 2007 harvest this summer. Just as the WCC varies greatly morphologically and agronomically, we assume that the collection also represents a wide diversity in genetic potential for forage and straw cellulose digestibility. This diversity is likely due to variability in the plant biomolecule “lignin” that provides stem strength, but has also been shown to affect enzymatic cellulose digestibility. A subset of the WCC has been evaluated for genotype diversity and analysis of the association of digestibility and key genes in the lignin biosynthetic pathway is underway. Results of genotype association analysis, *in rumen* digestibility of all WCC forage samples and plans to improve cellulose digestibility characteristics in malting barley varieties through traditional breeding will be presented. If the value of a barley crop can be enhanced via a second harvest of straw, the profit potential for barley producers should improve dramatically.

Victoria Carollo Blake received a B.S. in Biology at San Jose State University. Upon graduation she took a position at Aquanatics/Advanced Oxygen Systems in Alameda, CA, researching artificial oxygen carriers. One of her (failed) research endeavors was a bottle cap liner to scavenge the oxygen from the head space of beer. She then went to U.C. Davis and obtained her Ph.D. in Plant Biology via the Department of Viticulture and Enology with a few fall semesters working the “crush” in Napa Valley. In 1999 Victoria went to work for the USDA-ARS in Albany, CA, as a molecular biologist and barley curator for the GrainGenes database project. In early 2006, Victoria left California to marry Tom Blake and has joined his barley improvement project at Montana State University.

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Dielectric study of brewer's spent grain for frequencies between 2.5 and 3.5 giga hertz

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Brewer's spent grain (BSG) is an example of food waste produced by the brewing industry. The major components of BSG will be the walls of the husk-pericarp-seed coat, which are rich in cellulose and non-cellulosic polysaccharides and lignin and may contain some protein and lipid. The chemical composition of BSG varies according to barley variety, harvest time, malting and mashing conditions and the quality and type of adjuncts added in the brewing process. In general, BSG is considered a lignocellulosic material rich in protein and fiber, which account for around 20 and 70% of its composition respectively. Due to the large continuous supply from the growing brewing industry, relatively low cost and potential nutritional value, BSG can be considered as an attractive adjunct for human food. However, in spite of all the low cost and high nutritive value of BSG, its use is still limited, it has received little attention as a marketable commodity, and its disposal is often an environmental problem. Improper management and the lack of efficient instrumentation for rapid characterization of BSG have been identified as reasons why this co-product is wasted instead of being utilized. Knowledge of the dielectric properties of BSG at microwave frequencies is important in the description of their physical and chemical properties. Understanding the dielectric properties of BSG in a microwave field will enhance the adaptation of a microwave sensor as a rapid and non-invasive material characterization instrument. This paper describes the dielectric studies carried out on BSG. The dependence of dielectric properties of this material on other variables is discussed. Measurement technique used for determining the complex permittivity of BSG are reviewed and graphic data are presented to illustrate the dependence of complex permittivity of BSG on frequency, moisture content, fat content, density, particle size, and temperature. The dielectric properties are represented here by the relative complex permittivity $\epsilon = \epsilon' - j\epsilon''$, where the real part ϵ' , or dielectric constant, characterizes the ability of a material to store the electric field energy and the imaginary part ϵ'' , or dielectric loss factor, reflects the ability of a material to dissipate electric energy in the form of heat. The dielectric properties of BSG was measured at microwave frequencies in the range of 2.5–3.5 giga hertz. Dielectric measurements were carried out in waveguide 10 (WG10) using microwave transmission and reflection technique. Results of measurements are presented as a function of frequency, moisture content, fat content, density, particle size and temperature.

Sing Ng received a B.Eng. in Electrical and Telecommunication Engineering and is currently a Ph.D. student at Manchester Metropolitan University, Manchester. His research investigates the application of microwave technology for rapid food characterization. Currently he is focusing on the characterization of food waste produced by the food and beverage industries.

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Improving the flavor stability of beer by using a polymer

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Flavor stability is a complex topic and can not easily be related to a single process in brewing technology. The effect of ageing originates on the one hand from the loss of positive flavor and aroma compounds, on the other hand by the formation of ageing compounds. The development of the ageing taste is caused mainly by oxidation reactions. Slight concentrations of oxygen are already enough as they are inevitable even with optimum bottling. Antioxidative beer ingredients can delay the formation of the ageing aroma and thus counteract the oxidation reactions. The three most important influential factors are the formation of ageing components (e.g. Strecker-aldehydes), the protective attributes of antioxidative substances (SO₂, Phenols, etc.) and the masking effects of flavor compounds (Linalool, Esters, etc.). With regard to the reaction mechanism of beer staling, metal-catalyzed reactions (e. g. radical mechanism, heavy metals) influence the flavor stability negatively. For example heavy metals like iron and copper catalyze the Haber-Weiss and Fenton reaction causing the formation of radicals. Ageing components, antioxidative substances and flavor compounds can be objectively measured by various methods (e.g. GC, HPLC, and ESR) to evaluate flavor stability analytically. Each of these analyses correlate individually under the correct circumstances with the sensory evaluation of the beer. The application of filter aids provides an opportunity to remove negative prooxidative substances by filtration. The application of Divergan® HM polymer is a new approach to improve the quality of beer flavor and colloidal stability in the brewing process. Lehrstuhl für Technologie der Brauerei I, TUM-Weihenstephan/Germany measured the effect of Divergan® HM polymer on the flavor stability of beer by analytical and sensory evaluation. BASF Divergan® HM polymer is a novel filter aid which works by adsorbing the heavy metal particles in aqueous and aqueous alcoholic liquids. It is insoluble in water and all common solvents, biologically inert and easy to handle. In the presented investigations Divergan® HM was added in different concentrations to a kieselguhr filtration as a filter aid to check the effect on flavor stability. The filtration tests were done in a pilot plant scale (50 L) using a Pilsner Type beer brewed in industrial scale. The fresh and forced aged beers were analyzed for their concentration of heavy metals, ageing indicators, and in addition a sensory evaluation was done. The addition of Divergan® HM polymer resulted in a significant improvement in flavor stability.

Martina Gastl was born in 1974. She graduated as a brewer and maltster in Klosterbrauerei Andechs, Germany (1994–1996) and studied brewing science and beverage technology at TU München-Weihenstephan, Germany (1996–2002). From 2002 until 2006 she worked on here doctoral thesis in brewing technology at Lehrstuhl für Technologie der Brauerei I (TU München-Weihenstephan) on “Technological Influence on

Lipid Degradation in Terms of Improvement of Beer Flavour Stability.” Since 2002 Martina has been a scientific employee and since 2005 a scientific assistant and head of the GC/HPLC Laboratory at Lehrstuhl für Technologie der Brauerei I (TU München-Weihenstephan).

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The qualitative and temporal bitter differences of the reduced and non-reduced iso-alpha-acids in lager beer

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The reduced iso-alpha-acids, rho-iso-alpha-acids (rho), hexahydro-iso-alpha-acids (hexa) and tetrahydro-iso-alpha-acids (tetra) are important to brewers who are concerned with UV light degradation of iso-alpha-acids (iso). The peak bitter intensities of these compounds have been explored, and our research on the topic was presented at the ASBC meeting in 2006. However, the temporal aspects, including overall impact and duration, along with the qualitative aspects, like harsh and aspirin, have not been thoroughly investigated. In this study, we collected time-intensity data and qualitative descriptors for the four compounds using a trained panel. Seven concentrations of each compound were evaluated by time-intensity over a three-week period. Replications were blocked by panelist, week, and day. Data were analyzed by a change-point model for concentration dependant attributes, and principal components analysis was used on all temporal aspects to evaluate differences among the compounds ($\alpha = 0.05$). One concentration of each compound was also evaluated by a trained panel for qualitative differences. The free-choice profiling sensory protocol was used to determine qualitative separation among the compounds, and data were analyzed by generalized procrustes analysis. Rho was the most significantly different compound according to temporal aspects with less peak bitterness, persistence and a quicker dissipation than the other three compounds. Interestingly, panelists could most reliably measure changes in concentration when evaluating tetra and iso. Qualitative differences among these compounds may explain why tetra and iso were most dependably identified in the time-intensity study. According to the qualitative analysis, these two compounds were the most similar of the four analyzed and were more astringent and harsh than hexa and rho. However, tetra was significantly more medicinal than iso. Hexa and rho were vegetative with hexa being more medicinal than rho. The combined time-intensity and free choice profiling data for iso, tetra, hexa, and rho gives a more complete picture of the bitter differences among the four compounds, a feature that is essential for brewers using the reduced iso-alpha-acids to replace iso.

Annette Fritsch is pursuing a Ph.D. at Oregon State University. She received a B.S. in food science from The Ohio State University in 2001 and a M.S. from Oregon State in 2007. She was employed by Givaudan Flavors Corporation from 2001 until 2004 as a product developer. During her employment, she functioned as a manager, team leader, and customer contact. She has been a member of ASBC since October of 2004 and was awarded the Ecolab Scholarship in 2005 and the Brian William's Scholarship in 2006 by the ASBC Foundation.

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Large scale isolation of pure individual iso-alpha-acids from isomerized hop extract

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Individual iso-alpha-acids are required as standard compounds and needed when studying the parameters which affect the quality of beer, such as the contribution of these compounds to the final taste of beer, foam formation, and stability. Despite the obvious need for these compounds, they are not commercially available. This is due to the difficulty of separating these compounds with economically viable methods and their instability. Recently, we developed a simple and relatively cheap method to isolate pure alpha-acids and iso-alpha-acids using centrifugal partitioning chromatography and beta-cyclodextrin. The purity of the isolated compounds is above 95% by HPLC and NMR. Upon request small amounts of cis- or trans-iso-alpha-acids can be given for free for preliminary testing.

Alfi Khatib was born in Jambi, Indonesia, in 1971. From 1989 to 1994, he studied in the Department of Food Science and Human Nutrition, Faculty of Agricultural Technology, Bogor Agricultural University in Bogor, Indonesia. He worked as a researcher in Ajinomoto Calpis Beverage Indonesia Co. Ltd in Indonesia until December 1994. In January 1995 he joined the Department of Food Science and Human Nutrition, Faculty of Agricultural Technology, Bogor Agricultural University in Bogor, Indonesia, as a junior lecturer. He was awarded the TALIS scholarship from the Dutch government to follow a masters program in the Department of Pharmacognosy, Leiden University (1999–2000). In October 2003, he started his Ph.D. studies at the Division of Pharmacognosy, Section Metabolomics, Institute of Biology, Leiden University, with the grant from the Committee of the Phytochemical Society of Europe Joint Meeting 1999 Fund and a DELTA scholarship from the Dutch government. He finished his Ph.D. studies in October 2006. Recently he has been working as a post-doctoral researcher in the same division in The Netherlands.

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Impact of mashing-off temperature and alternative kettle hopping regimes on hop alpha acids isomerization and bitterness

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The key reaction of hops in brewing is the thermal isomerization of alpha acids into iso-alpha acids during wort boiling, iso-alpha acids being largely responsible for typical beer bitterness. However, low and variable alpha-acids isomerization and final utilization in the beer are common problems in the brewing industry. At the origin of this intricate issue are difficulties with the extraction of alpha acids from hops, the limited solubility of alpha acids in wort, incomplete isomerization during the boil,

and adsorption of alpha acids/iso-alpha acids on the trub. In this work, alternative ways of kettle hopping and mashing-off are investigated in relation to the isomerization kinetics, iso-alpha acids yield, and the bitterness profile. The isomerization of alpha acids was studied by HPLC determination of individual alpha acids and iso-alpha acids as function of wort boiling time (0–90 min). Worts (12°P) were prepared at 10-L scale by standard brewing procedures and mashing-off at 78°C or 95°C. Several kettle hopping regimes were tested, i.e. full addition of CO₂-extract or pellets at the onset of the boil, dosed addition of CO₂-extract or pellets in the first 40 min of boiling, and addition of CO₂-extract pre-dissolved in ethanol (either full addition at onset of boil or dosing with time). When mashing-off at 78°C, altering the hopping regime did not lead to large changes in isomerization yields (42–48%) but clear variations in the profiles of iso-alpha acids, i.e. in the relative proportions of isochumulones and trans-isomers, were noticed. High amounts of residual alpha acids were always detected, in particular in the hot trub fraction, even after 90 min of wort boiling. This points to hindrance of the isomerization by adsorption of alpha acids to the trub. Aiming at more protein coagulation prior to wort boiling, mashing-off was performed at 95°C. In subsequent wort boiling experiments, much less alpha acids were lost in the trub and much higher isomerization yields of up to 63% were found. In addition, mashing-off at 95°C resulted in favorable bitterness profiles, i.e. lower proportions of isochumulones and trans-isomers. Surprisingly, independent of the mashing-off temperature, dosed addition of pellets or CO₂-extract gave rise to isomerization yields similar to full hopping at the onset of boiling. This finding contradicts the view that for maximum bitterness, all alpha acids should be added at the onset of wort boiling and suggests opportunities for higher utilization of hop essential oils and polyphenols by applying dosed addition. In summary, our new findings point to the potential of alternative ways of kettle hopping and mashing-off at 95°C for more economic hopping, combined with enhanced bitterness quality and stability.

Barbara Jaskula was born in 1979 in Wroclaw, Poland. She obtained a Ms.C. degree in biotechnology (2003) from Wroclaw University of Technology, Poland, and is currently working on a Ph.D. on hop alpha acids summarization in the Laboratory of Enzyme and Brewing Technology, KaHo Sint Lieven, Ghent, Belgium.

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Determination of the varietal pedigree of commercial hop using microsatellite DNA markers

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The varietal pedigrees of 17 commercial hop samples were determined using 11 microsatellite DNA markers. Some samples with different variety names were found to be identical in their genotypes at 11 microsatellite DNA marker loci, while some samples with the same variety names were found to be different in their genotypes. This indicated that the flavor and quality of beer may have been influenced by unknown sources of raw hop materials available on market. Seventeen samples were combined into 11 groups that could be distinguished using as

few as 4 microsatellite DNA markers, indicating that microsatellite DNA markers are highly effective in determining variety pedigrees of raw hop materials available on the market. If hop varieties were fingerprinted using microsatellite DNA markers, then the variety pedigree of any hop materials can be compared using their DNA fingerprint with the standards. In such a way, the identity of raw hop materials can be controlled, and the quality of beer can be improved.

Yan Lin (B.Sc.Bio., M.Sc.Aagri., Ph.D.) is the Brewing Raw Materials (BRM) Manager for Tsingtao Brewery Co. Ltd. Yan Lin completed a B.Sc.Bio. at the Normal University of Liaoning in 1990, M.Sc. in Biochemistry at Shenyang Agricultural University in 1994, and Ph.D. in Molecular Biology at China Ocean University in 2006 in the area of malting barley and hop variety identification by DNA markers. She spent 12 years at Tsingtao Brewery Co. Ltd. and has been involved in BRM Analysis, Modern Instruments Analysis, BRM suppliers management, BRM new varieties evaluation and development, and malting and brewing quality research at the Center of Research and Development. Yan Lin has extensive experience with BRM quality assurance systems, laboratory operations, and research and development.

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Rye malt as an ingredient for beer

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Rye is unique among cereals for its high content of dietary fiber (more than 15% of dry matter). About half of this amount consists of arabinoxylans (AX). AX play an important part in the characteristic of rye malt as it limits the access of enzymes to the starch kernels. Furthermore, the water-extractable AX cause very high wort viscosity and therefore filtering problems. Therefore, rye malts are usually not used as raw material in breweries. Some rye beers are commercially available; however, the market is small. The object of this study was to re-evaluate the properties of rye malt as an ingredient for beer with special emphasis on AX. Response surface methodology (RSM) was used to model the degradation of AX as well as changes in parameters important for brewing. Rye was malted in a Joe White micro malting plant. Rye was steeped at 15°C to a water content of 45% and germinated for 2 to 6 days at 10 to 20°C. Kilning conditions were 45°C for 5h and 50°C for 15h. The malts were analyzed for extract content, fermentability and viscosity using the Congress mashing system. Total NITROGEN (TN), soluble nitrogen (SN) and free amino nitrogen (FAN) were also determined. Activities of alpha- and beta-amylase, beta-glucanase, xylanase and protease in the malts were measured. Degradation of AX was followed by analysis of the contents of total and soluble AX as well as the degree of polymerization. The analytical results revealed that extract content of rye worts increases slightly with longer germination temperature. Fermentability is slightly lower than in comparable barley worts. The amylolytic activities were found to be

highest after germinating the grains for 5 days. Wort's viscosity is strongly influenced by both variables with low temperatures and long germination temperatures leading to lower viscosities. The results of analyses of the AX and the relevant degrading enzymes support the connection between AX and wort viscosity. TN and SN were hardly affected by variations in time and temperature, FAN increased with longer germination time, and the levels easily were sufficient for yeast growth. This study shows the possibility to significantly reduce the viscosity of rye worts by using an optimal malting regime for breakdown of AX. Although viscosity is still high, there is a potential for rye as a brewing material as all other relevant parameters are favorable. Rye malts also could be an interesting ingredient for the production of functional beverages due to their high content of dietary fiber.

Florian Huebner studied Food Technology at the University of Stuttgart Hohenheim and has been working on a Ph.D. thesis since 2006 in the Department of Food & Nutritional Sciences, University College Cork.

P-59

Evaluation of malting barley quality with a fuzzy logic model

YUESHU LI (1), Robert McCaig (1)

(1) Canadian Malting Barley Technical Centre, Winnipeg, Canada

Evaluating barley is a difficult task since there are so many factors involved in the evaluation process which could affect the evaluation. For instance, the achieved quality for a particular barley variety in a particular crop year results from the interactions between barley's genetic potential and growing (environmental) conditions; its malting performance is the result of interactions between barley's malting quality potential and applied malting conditions, and the brewing performance of the resultant malt is the result of interactions between the brewing quality potential of the malt and applied brewing conditions. A fuzzy logic mathematical model was developed at CMBTC for evaluating the overall quality of malting barley samples. This model takes a rational, systematic approach and generates a comprehensive evaluation based on a few quality parameters currently collected in the barley trade, malting process and brewing process.

Yueshu Li is the Director of Malting Technology at the Canadian Malting Barley Technical Centre (CMBTC), Winnipeg, Canada. He joined the Canadian Malting Barley Technical Centre in 2000. As Director of Malting Technology he is presently responsible for carrying out and coordinating research projects and providing technical support to Canadian barley users, as well as monitoring the quality of the barley varieties currently on the market and promoting newly released barley varieties. Prior to joining the CMBTC he was Senior Technical Consultant for Malting Barley in the Market Development Department of the Canadian Wheat Board. Yueshu has held several senior research and management positions in the malting industry in both North America and China, including Prairie Malt Limited, Schreier Malting, and CUC Nanjing Malt Limited, PRC. Yueshu completed his undergraduate work and

holds a Ph.D. in plant physiology and ecology from the University of Saskatchewan, Canada. Yueshu is a member of ASBC, MBAA and AACC International.

P-60

Improving the cost efficiency of quality assurance screening for microbial safety and quality of malting barley

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Australia generally has a dry climate for barley harvest that results in dry barley for storage. However, screening for quality assurance purposes is still required, because in the unlikely event of barley infection by *Fusarium*, *Aspergillus* and other fungal species, harmful mycotoxins could accumulate. However, quality control protocols require that malting barley is free of mycotoxins such as deoxynivalenol (DON) and ochratoxin A (OA). Immunoaffinity columns (IACs) are widely used for isolating mycotoxins from barley, malt and feed followed by quantification with either HPLC or fluorometry. The procedures are easy to use, rapid, accurate and toxin specific. However, the cost of these IACs are relatively high, and manufacturers do generally not recommend their reuse. However, repeated use of OA columns has been reported as feasible. A more cost-efficient method of screening large numbers of samples for OA and DON in barley and malt will result in improved consumer safety for malt and barley products. The DONtest and Ochratoxin IACs were obtained from Vicam for cleanup followed by HPLC or fluorometry for DON and OA quantification, respectively. None of the Australian malt and barley samples surveyed were found to contain detectable levels of either of DON or OA. These results were consistent with a 3-year quality assurance survey by Joe White Maltings. Consequently, reuse of the IACs was evaluated using sample spiking. Upon 1st use the mean recovery of 1µg/g DON was 60.0%. Even after 11 uses of DON IACs the recovery was 55.0% at this level of spiking, which was not significantly different than the result from the 1st use of the columns. At 5µg/g spiking level of DON recovery on 1st use was 69.7% and decreased significantly on the 3rd use of these columns. For 5ng/g OA a non-significant drop in recovery was observed from the 1st use (90.1%) of the columns up to their 6th use (95.9%). Whereas a significant drop in the recovery of 85ng/g OA was recorded in the 4th use of the columns (46.1%) compared to its recovery in the 1st use (53.9%). The results from this study support the limited reuse of the DON and OA IACs. The number of reuses is markedly higher if the concentration of mycotoxins is low compared to high, especially for extreme concentrations (5µg/g for DON and 85ng/g for OA) used in this study. By this screening protocol, if a mycotoxin positive sample is detected, the sample can then be retested with a new column if the level of mycotoxin exceeds 5µg/g of DON or 50µg/g OA. Thus the repeated use of these columns assists in reducing the cost of mycotoxin analysis without compromising quality, especially when the occurrence of these mycotoxins is rare such as with Australian malt and barley. This research is part of a larger investigation to characterize the microflora of Australian malting barley.

Mandeep Kaur graduated with a B.Sc. in Agriculture (Honours) in 1997 and a M.Sc. in Agronomy in 1999, both from Punjab Agricultural University, India, before taking a position as Assistant Agronomist in Punjab Agricultural University. In 2005 she commenced her Ph.D. project at the University of Tasmania on "Assuring the Microbial Safety and Quality of Australian Malt and Barley," which is funded by an ARC linkage grant with industry support from Joe White Maltings Pty. Ltd.

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Controlled mixed culture refermentation of spontaneous fermented lambic beer: A reliable process to facilitate the production of "old gueuze"

KOEN GOIRIS (2), Marjan De Ridder (2), Gert De Rouck (2), Luc De Cooman (2), Hubert Verachtert (1), Guido Aerts (2) (1) K.U.Leuven, Laboratory of Industrial Microbiology and Biochemistry, Heverlee-Leuven, Belgium; (2) KaHo Sint-Lieven, Laboratory of Enzyme, Fermentation and Brewing Technology, Gent, Belgium

In the wide range of Belgian specialty beers, old gueuze is really outstanding. Gueuze, a blend of spontaneous fermented lambic of different ages, has a typical flavor derived from many fruity esters and a high lactic acid content. However, the refermentation process is time-consuming and full of risks (e.g. too much or too little CO₂, ropiness or off-flavors). Also production of lambic itself is hardly reproducible due to complex yeast-bacteria interactions, characteristic for spontaneous fermentation. To prevent the disappearance of old gueuze as a very special traditional beer, it is of major importance that a laboriously produced lambic derived from spontaneous fermentation can be refermented in the bottle without too many risks. In this study, several industrial-scale lambic beers were inoculated with 10 different cocktails of organisms comprising *Saccharomyces* spp., *Brettanomyces* spp., *Lactobacillus* spp., and *Pediococcus* spp. Pure strain cultures as well as organisms isolated from lambic beer were used after single propagation in optimized media. Growth conditions were optimized for propagation of the individual organisms. Lambic beers were filtered using plate-sheet filters of 0.45 µm before adding different sugar syrups and inoculation to test the final attenuation for each cocktail of microorganisms. After bottling and refermentation at 25°C, the beers were stored at 15°C for over 16 months. In another set of experiments lambic beers were inoculated with the best cocktails of the first trial. During refermentation and further maturation, extract and alcohol content were measured, the evolution in microbial population was determined using selective media and CO₂ content was measured in the bottle. Flavor profiling was based on sensory evaluation and HS-SPME-CGC-MS. A top fermented beer was also refermented using the mixed cultures and analyzed to assess further implementation for "bioflavoring" of new specialty beers. Refermentation with strains isolated from lambic beers were lengthy (12 months) to achieve satisfactory flavor. Use of a cocktail with *B. lambicus* and *S. bayanus* resulted in fast CO₂ production and based on analytical data and sensory evaluation, after 2 weeks the flavor profile was already comparable with the traditional product. The flavor even became superior after 12 months of maturation. Repeated use of this cocktail in a second series of new lambic beers confirmed the results. Refermentation of a

top fermented beer with this mixed culture resulted in a beer with a very special but pleasant flavor. The results show that the flavor profile of old gueuze can be achieved by controlled mixed refermentation minimizing the risks for formation of off-flavors, without changing the specific flavor of traditionally produced old gueuze.

Koen Goiris was born in 1976. Koen obtained an academic degree in Industrial Engineering-Biochemistry at KaHo St.-Lieven, Ghent, Belgium (2000). Appointments: From 2000 to the present Koen has been an Assistant Scientist in Malting and Brewing Science at the Laboratory of Enzyme and Brewing Technology of KaHo St.-Lieven. Koen's research topics include high tech hopping—advanced bittering, novel hop aroma technology and hop polyphenols; beer flavor and flavor stability; and mixed fermentation.

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PCR based approach for monitoring the hygienic status of well water for brewing purposes

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The application of common indicator systems to monitor the hygienic/pathogenic status of spring water for brewing purposes is often found to be unsatisfactory. For this reason a PCR based analysis procedure was developed which, by means of a novel evaluation system, optimized the quality of information by (I) a differentiation of the conventional parameters coliform germs in typical fecal coliform and primary environment coliform through the direct identification of the genus (e.g. *Escherichia*, *Kluyvera* or *Pantoea*) and (II) through the direct identification of pathogenic micro-organisms (e.g. *Campylobacter*, *Listeria* or *Legionella* spp.). This procedure provides an extended differentiation which is necessary for unspecific and unsure findings (e.g. by a positive result for coliforms without detection of *E. coli* or by colony counts exceeding the limit without detection of indicator organisms). The chosen bacterial strains were obtained from the German Collection of Microorganisms and Cell Cultures (DSMZ). The strains were cultivated in liquid medium—composition and conditions as suggested by the supplier—and from these the bacterial DNA was extracted with high purity. On the basis of these DNA templates, various oligonucleotide primers were tested with the aim of finding specific PCR markers for the selective identification of the relevant bacterial strains. For the examination of contaminated water samples, large amounts (up to 20 L) were filtered and the filter-bound bacteria then lysed out enzymatically/chemically in small volumes (6 mL). The DNA was finally purified and concentrated using affinity columns and analyzed by PCR. The specificity, sensitivity and selectivity of the PCR analysis procedure could be demonstrated in extensive trials. It is of especial relevance that, for the first time, when testing water we were able to differentiate between the 12 most important coliform bacteria in fecal and environmental coliform germs. The inclusion of a procedure to filter large quantities of water at the sampling stage and thus dispensing with a time-consuming propagation step to concentrate the sample makes it possible to (I) have the results within a few hours and (II) obtain an

exact quantification with the help of LightCycler (LC) PCR. The detection limit is in the range of 10 germs/L. For monitoring the hygienic/pathogenic status of well water for brewing purposes a distinct improvement over the customary indicator system was achieved using real time PCR. The newly developed method is characterized by increased specificity, reduced time required and a remarkably low determination limit.

Michael Voetz, born in 1964, received a diploma in biology from the University of Cologne in 1991. He earned a Ph.D. in plant molecular biology from the University of Cologne/Max-Planck-Institute for Breeding Research in 1995. From 1995 to 2000, he was a scientific collaborator at the Research Department of the Weissheimer Malzfabrik in Andernach, working in the field of barley biotechnology. Since 2000, he has been head of the biotechnology/PCR laboratory at the Research Institute for Raw-Materials within VLB in Berlin. Since 2005 he has been a lab manager in this institute.

P-63

Multiplex PCR for putative *Lactobacillus* and *Pediococcus* beer-spoilage genes and ability of gene presence to predict spoilage

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The most problematic beer-spoilage bacteria belong to the Gram-positive genera *Lactobacillus* and *Pediococcus*. Current methods of detecting and identifying bacteria found in beer are time-consuming and do not differentiate between bacteria capable of spoiling beer and benign bacteria. Several putative spoilage-associated genes have been suggested, including *hitA*, *horA*, *horC*, and *ORF5*. We have designed a multiplex PCR to these four putative spoilage-associated genes (and to the 16S rRNA gene as an internal control) and screened 83 *Lactobacillus* and 50 *Pediococcus* isolates. Results were statistically compared with the ability of isolates to grow in beer. This study shows that the presence of *horA* and, to a much lesser degree, *horC* predicts an organism's ability to grow in beer. This study also found that the genetic basis for the ability to grow in beer is less defined for *Pediococcus* compared to *Lactobacillus* isolates. While it is evident that there are other (as yet unknown) bacterial mechanisms involved in the ability to grow in beer, statistical modeling predicts that our detection method for *horA* alone is at least 85% accurate in predicting the beer-spoilage potential of *Lactobacillus* and *Pediococcus* isolates. This multiplex PCR will allow brewery quality control laboratories to substantially reduce the time required for detecting the presence of a bacterium in beer, while concurrently identifying if that bacterium is highly likely to cause spoilage.

Monique Haakensen received a honours B.Sc. degree in Microbiology and Immunology from the University of Saskatchewan in 2000. In 2006, she completed the Certification Program in Bioinformatics hosted by the Canadian Genetic Diseases Network. Monique is currently at the University of Saskatchewan doing her Ph.D. in Health Sciences with a focus on the various aspects of hop-resistance in lactic acid bacteria.

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Permeation of volatile organic compounds (VOC's) through plastic bottles and closures

LEIF A. GARBE (1), Alexander Würtz (1), Martin Orzinski (2) (1) TU Berlin/VLB Molecular Analysis, Berlin, Germany; (2) VLB Berlin, FMV, Berlin, Germany

Volatile organic compounds (VOC) play an important role as flavors and off-flavor substances in the beverage industry. Nowadays, plastic bottles and closures are used frequently as packaging materials. The possibility of VOC permeation through these packing materials, e.g. PET, is their major disadvantage. Therefore, multilayer, internal coatings and blends were developed; however, little is known about the permeation of VOC through plastic bottles and contamination of beverages. The determination of VOC permeation was established by a gas chromatography-mass spectrometry (GC-MS) analysis with an isotope dilution assay. A newly designed and constructed stainless-steel containment for bottles in an environment that is enriched with a defined concentration of VOC (citronellol, toluene and hexanol-1) was used. The chemical concentrations inside the plastic bottles were analyzed by GC-MS with an isotope dilution assay. The concentration of VOC in the container atmosphere was also determined quantitatively. It could be shown that the plastic bottle barrier systems (monolayer, multilayer, blends and internal coatings) do not show sufficient protection against permeation of VOC from the containment atmosphere into the analyzed liquid (bottles). The multilayer system shows the highest toluene permeation through the bottle wall compared with the monolayer and the coated bottles. A toluene content of 2 µg/L could be detected in the test liquid of the multilayer bottles after storage of two weeks in 10 µg/L (air) toluene in the atmosphere. In addition monolayer and coated bottles show no sufficient barrier against toluene. Further, the permeation of citronellol and hexanol-1 through monolayer, multilayer and coated bottles was analyzed, and the compounds were also quantified by GC-MS with isotope dilution assays.

Leif-Alexander Garbe graduated from the Technische Universität Berlin (TUB), Germany, with a diploma in chemistry in 1996. Afterward he worked at the Research and Teaching Institute for Brewing in Berlin (VLB). From 1997 to 2002 he was working on his Ph.D. thesis, entitled "Metabolic Pathways of Mono- and Dihydroxyfatty Acids in Yeast" (written in German) and received his Ph.D. (Dr. rer. nat.) in April 2002. During this time he was also working as a scientific assistant in the Department of Biotechnology, reporting to Prof. R. Tressl (TUB, chemical and technical analysis). His work included the supervision of undergraduate and graduate students in biotechnology and brewery. In 2002 he established a new research group at the TUB focusing on Microbial-, Enzymatic- and Chemical Formation and Cleavage Reactions of C-C, C-N and C-O bonds. In cooperation with the VLB he is performing new techniques to analyze trace compounds and impurities, especially in malt, wort and beer, by GC-MS, LC-MS and isotope dilution assays.

P-65

A new alternative to increase the flavor stability of the beer

Nicolas Declercq (2), Olivier Duthoit (3), MARC MAUDOUX (4), Sonia Colin (5), Philippe Cario (1)

(1) AEB Group, S. Polo (Bs) Italy; (2) AEB Iberica, Castellbisbal, Spain; (3) Spindal, Gretz-Armainvilliers, France; (4) Catholic University of Louvain La Neuve, Laboratory of Brewing Sciences & Technology, Louvain LN, Belgium; (5) Catholic University of Louvain La Neuve, Louvain LN, Belgium

In order to optimize the organoleptic characteristics of the beer by inhibiting LOX activities, melanoides, polyphenols and other oxydative functions active in the wort, an innovative treatment in the brewhouse based on natural antioxidants has been studied on an industrial scale. The study regroups the analysis of several lager and specialty beers. The protection of beer has been ensured for many years through the treatment with colloids and the use of traditional antioxidants from maturation till the bottling line, in order to comply with the market which requires 9 to 15 months stability. The use of antioxidants in the brewhouse is possible through a well-defined methodology, the effect on lipoxygenase and the consumption of certain heavy metals that do not affect the other activities of the raw materials, as well as the wort before fermentation. The best equilibrium to optimize the action on the wort has been a complex of potassium metabisulfite, tannic acid and ascorbic acid: while some components disappear during the boiling process, some other molecules are consumed themselves or are linked with existing chains in the wort composition. The ITT and RSV method allows us to measure the real impact of the wort and the finished beer, as well as classical analysis such as color ($^{\circ}$ EBC), total sulfites before the wort treatment and before fermentation (ppm), heavy metals (Fe^{2+} , Cu^{2+} , etc.), protein and polyphenol content (ppm). The fermentation metabolism has also been verified. A panel of degustators has analyzed the organoleptic evolution for several beers coming from Northern Europe and Mediterranean countries. The impact on color and turbidity has been clearly identified, as well as the improvement in the freshness and organoleptic stability after 3, 6 and 9 months. Such an alternative would be highly recommended as a preventive action to increase the quality and standardization of beer ageing.

Marc Maudoux received a Diploma of Brewing Engineer. Since 1985 he has been responsible for the Laboratory of Brewing Sciences and Technologies, University of Louvain La Neuve, Belgium. He has been acting for the University as a consultant for many European breweries and has given brewing courses at the University of Louvain la Neuve for 8 years.

P-66

Studies of particle sizes in beer treated with a proline-specific protease which prevents chill-haze in beers

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(1) DSM, The Netherlands

The effectiveness of a proline-specific endo-protease, called Brewers Clarex, in the prevention of chill haze in beer was presented to the 30th EBC in 2005 and at ASBC in 2005 & 2006. Besides an improved understanding of the application

benefits of Brewers Clarex compared to other beer stabilizers, new mechanistic understanding of the haze development in Brewers Clarex-treated beers may even call for a discussion on the predictiveness of current standard forcing tests when Brewers Clarex is applied. It may also lead to a re-evaluation of the perception of visible haze when reading Brewers Clarex-treated beers at a 90 degree angle. Several series of 20-hL pilot-scale studies were conducted at the Institut Francais des boissons de la Brasserie et de la Malterie (iFBM) in Nancy, France. Besides extensive beer analysis, the colloidal stability of these beers was investigated in detail, both during normal and accelerated ageing. Besides visual assessment, the haze development of Brewers Clarex, PVPP and Silica hydrogel (SHG) treated beers were studied at set time intervals, at different temperatures, and at both 25 and 90 degree scatter angles, which are sensitive toward large and small particulate matter, respectively. Additionally, the development of the particle size distribution (PSD) of the haze was assessed with photon correlation spectroscopy (PCS) for pilot and full-scale beers, stabilized with Brewers Clarex, PVPP and SHG. PCS was conducted at different temperatures, in order to assess the development of both permanent and chill-haze. The PSD study with PCS revealed that the Brewers Clarex-treated beers had a much smaller average particle size compared with PVPP- and SHG-stabilized beers, supposedly resulting from the hydrolysis of haze active proteins, reducing their ability to form large networks with polyphenols. Studies also show that the rate of particle size increase (i.e. the colloidal stability) during accelerated ageing was lower for Brewers Clarex-treated beers in comparison with conventional beer stabilization. Recent real-time shelf-life data confirm the observations from the forcing tests. As a consequence of the small particle size and their relatively slow growth over time, the standard beer haze measurements at 90 degrees is less indicative of colloidal stability of the beer when Brewers Clarex is used. In some cases even hydrolysis was so efficient that the 90 degree haze readings were much above 2 EBC, but the beers were visually extremely clear. The finding of such invisible hazes which are very stable (i.e. grow only very slowly) calls for a review of the standard forcing tests when Brewers Clarex is applied.

Harry Craig graduated in Applied Microbiology from the University of Strathclyde, Glasgow, before joining Allied Breweries as a trainee Brewer. After one year, Craig was sent to the University of Birmingham, England, where he gained an M.Sc. degree in Brewing Science under the late Professor J. S. Hough. After a number of production positions, he became the Brewing Manager in a large brewery. He joined a small biotechnology company in 1985 and thereafter Gist-brocades (now DSM) in 1993. He currently works as Technical Manager for Beer Enzymes and travels extensively. He has a wide knowledge of all types of brewing in many parts of the world. He is a member of the IBD, ASBC and MBAA.

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Mash application of glucoamylase and the effect on attenuation and wort separation

NEVILLE M. FISH (1), Neil Roberts (1), Wolfgang Tosch (1), Anne Whitehead (1), Andreas Gahr (2), Hans-Joerg Menger (3) (1) Danisco, Stockport, UK; (2) Research Brewery, Hopfenveredlung St. Johann GmbH & Co. KG, St. Johann, Germany; (3) Technology Department, Ziemann Ludwigsburg GmbH, Ludwigsburg, Germany

Limitations in malt limit dextrinase (responsible for the hydrolysis of alpha(1,6) bonds in amylopectin) means that worts may contain significant amounts of limit dextrans. Consequently, the maximum fermentability in normal beers is typically <70% RDF (Real Degree of Fermentation). Exogenous enzymes can be used in the mash to give worts with different carbohydrate profiles and beers with increased attenuation. Glucoamylase is a saccharifying enzyme that can hydrolyze both alpha(1,4) bonds and alpha(1,6) bonds in starch. The enzyme gives the largest increase in fermentability, with values of up to 85% RDF, when it is added to the mash. A reported consequence of using glucoamylase in the mash is the negative impact on wort separation—particularly lautering. We have characterized the effect of mash application of glucoamylases in terms of extract, wort sugar composition and fermentability and have examined the negative effects on wort separation. All malt mashings were carried out on a laboratory scale at Danisco and on a pilot scale at Hopfenveredlung St. Johann GmbH and Ziemann Ludwigsburg GmbH. Standard methods were used to analyze malt, extract, fermentability, spent grain starch and wort separation performance. Carbohydrate and alcohol concentrations were measured by HPLC. The mash application of glucoamylases has the effect of increasing RDF from, typically, 65 to 85% RDF, depending on enzyme dose rate (up to 10 liters of enzyme per tonne of grist). These increases in fermentability were due to the hydrolysis of limit dextrans, and starch oligosaccharides in general, giving worts that are high in glucose concentration. The corresponding beers were characterized by high alcohol yields and low residual carbohydrate. A further benefit was an increase in extract yield of up to 4% which was accompanied by a corresponding decrease in the spent grain starch content. Lautering was negatively affected by glucoamylase in that the pressure drop across the lauter tun increased to an extent that lautering time was extended and wort haze was increased. However, the effect on lautering was dependant on mash conditions and different glucoamylase enzymes. The effects noted in mash filtration were different; in this case milling and mashing in was carried out using the ZIEMANN DISPAX system. Wort separation problems are indicative of a negative effect of conditions and enzyme on the spent grains as the filtration medium.

Neville Fish received a B.Sc. in Biochemistry from St. Andrews University and a Ph.D. in Biochemical Engineering from the University of London. For the last 15 years he has worked in Rhodia, Genencor and Danisco on the development and application of enzymes for industrial processes with a special emphasis on food and beverage enzymes. He is currently responsible for beverage enzyme applications in Danisco.

P-68

The use of a lab-scale reference fermentation method to evaluate the impact of yeast-related variables on fermentation profiles

SIMON A. AHLGREN (1)

(1) Quality Assurance, New Belgium Brewing, Fort Collins, CO

Minimizing the variance in fermentation is a common goal among brewers. More consistent fermentations cause less variation in tank residence times and could potentially create more consistent tasting products. One of the key factors that affects fermentation is the treatment and condition of the yeast used to ferment the wort. With the purpose of determining the effect of yeast-related variables on fermentation, a lab-scale method was devised and used to compare input variables to output variables. The following yeast-related parameters were assessed: pitch-rates; wort oxygen concentrations; zinc concentrations; storage times and conditions; as well as viability and vitality assessments. These input variables were then compared to attenuation rates; pH drops; and alcohol generation through fermentation. The results of this study depict the impact of yeast-related variables on fermentation profiles.

Simon Ahlgren graduated with a B.S. degree in Biology with a Microbiology minor from Colorado State University and works as a Quality Assurance Analyst at New Belgium Brewing Company. Simon has been a proud member of the ASBC since February 2003.

P-69

Synthesis and metabolism of allylic hydroxy fatty acid in *Saccharomyces cerevisiae*

LEIF A. GARBE (1), Gunnar G. Köhler (1), Roland Tressl (1)

(1) TU Berlin/VLB Molecular Analysis, Berlin, Germany

In secondary metabolism of fatty acids enzymatically activated oxygen functions as direct oxidants. The resulting components are often precursors for strong aroma active molecules. On the one hand these products are important aroma constituents in the flavor industry, and on the other hand they are responsible for off-flavors in foods, especially beer. The mechanism of the metabolism of oxygenated fatty acids in yeasts is still to be elucidated. In former work the formation of an allylic hydroxy fatty acid in the metabolism of epoxy- and dihydroxy fatty acids was postulated. This work shows how the potentially toxic intermediate 4-hydroxy-dec-2-enoic acid is further degraded during metabolism of the yeast *Saccharomyces cerevisiae* and proposes biochemical strategies for detoxification of reactive agents in yeast metabolism. On the basis of isotopic-labeled and enantiomeric pure substrates the fate of the 4-hydroxy-dec-2-enoic acid could be investigated in incubation experiments. The deployed high concentrations of the toxic substrate could lead, due to the fact that β -oxidation is not possible, to an initial carbon chain elongation followed by reduction of the allylic double bond. Furthermore the generated 4-hydroxy decanoic acid can form the cyclic ester γ -decalacton, mainly responsible for peach aroma. The racemic and isotopic-labeled substrate could be synthesized by means of the so called SPAC-Reaction (sulfoxide piperidine and carbonyl). The stereospecific

substrates were submitted by Dr. Paul Evans, Department of Chemistry, Trinity College Ireland. Incubation experiments were analyzed after extraction by GC/MS.

Leif-Alexander Garbe graduated from the Technische Universität Berlin (TUB), Germany, with a diploma in chemistry in 1996. Afterward he worked at the Research and Teaching Institute for Brewing in Berlin (VLB). From 1997 to 2002 he was working on his Ph.D. thesis, entitled "Metabolic Pathways of Mono- and Dihydroxyfatty Acids in Yeast" (written in German) and received his Ph.D. (Dr. rer. nat.) in April 2002. During this time he was also working as a scientific assistant in the Department of Biotechnology, reporting to Prof. R. Tressl (TUB, chemical and technical analysis). His work included the supervision of undergraduate and graduate students in biotechnology and brewery. In 2002 he established a new research group at the TUB focusing on Microbial-, Enzymatic- and Chemical Formation and Cleavage Reactions of C-C, C-N and C-O bonds. In cooperation with the VLB he is performing new techniques to analyze trace compounds and impurities, especially in malt, wort and beer, by GC-MS, LC-MS and isotope dilution assays.

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- Quality assurance
- Plant engineering and packaging
- Sales and marketing
- Training and education

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