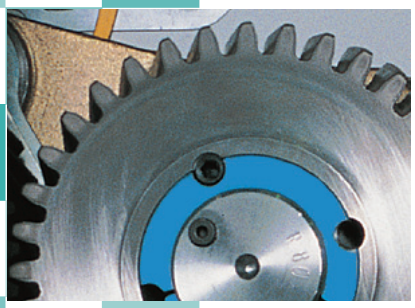
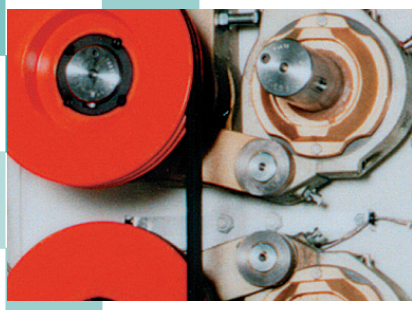
PROGRAM BOOK

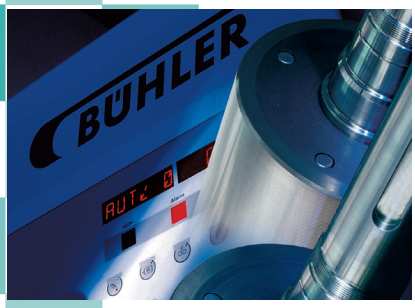
WORLD BREWING CONGRESS 2004

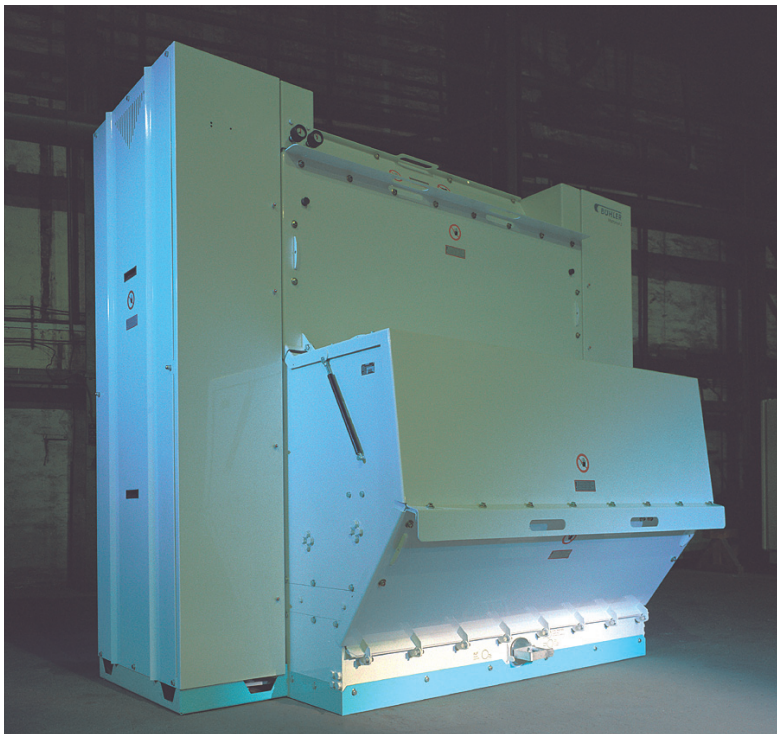
July 24 - 28 • Manchester Grand Hotel • San Diego, California U.S.A.

Discover
what makes
the difference









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BÜHLER
YOUR PERFORMANCE IN MIND

WELCOME FROM THE JOINT PLANNING COMMITTEE

Kathy Kinton

Rob Maruyama

Welcome to World Brewing Congress 2004 and beautiful San Diego, California! The Joint Planning Committee extends their greetings and are very pleased that you could attend.

The World Brewing Congress was first proposed in the fall of 1992. Eight years later the first World Brewing Congress was held in Orlando in 2000. Here we are four years later with another successful World Brewing Congress program once again attended by brewing professionals from all over the globe.

The Joint Planning Committee would like to acknowledge and thank the hosting organizations, American Society of Brewing Chemists and Master Brewers Association of the Americas, and the participant organizations, the Brewery Convention of Japan, the European Brewery Convention, and the Institute and Guild of Brewing, for their support during the planning of this important congress.

The committee would also like to acknowledge and thank the technical presenters and the exhibition participants for their time and contributions in making WBC 2004 a great success. Please recognize their contributions by participating fully in the sessions and by frequently visiting the exhibition hall, located in the Douglas Pavilion.

Again, we are excited you are here! For those of you returning to WBC, we thank you for your continued support. If this is your first WBC, we thank you for showing your support with your attendance. We encourage you to take advantage of all that WBC 2004 has to offer in the technical sessions, exhibition, and social program. This is a great opportunity to meet fellow brewing professionals, share information, and network with colleagues.

We've left some free time in the program so that you may enjoy all that San Diego has to offer. Enjoy your time in San Diego and at World Brewing Congress 2004!

Kathy Kinton

Rob Maruyama

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WORLD BREWING CONGRESS 2004 COMMITTEES

JOINT PLANNING COMMITTEE
Kathy Kinton
Rob Maruyama

TECHNICAL PROGRAM COMMITTEE
Dirk Bendiak, co-chair
Mike Sutton, co-chair
Yasutsuga Kawasaki
Seisuke Takaoka
Esko Pajunen
Graham Stewart

CO-HOSTED BY
American Society of Brewing Chemists
Master Brewers Association of the Americas

WITH ACTIVE PARTICIPATION BY
Brewery Convention of Japan
European Brewery Convention
Institute and Guild of Brewing

SPONSORS

WBC 2004 recognizes the following organizations for their generous donations.

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Briess Malt & Ingredients Company
Deschutes Brewery
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Frings America
Haffmans
Heineken USA
International Malting Company
JohnsonDiversey
Karl Strauss Brewing Company
Miller Brewing Company
Norit Processing Technology
Rockwell Automation
Sierra Nevada Brewing Company
Sudmo North America Inc.
The PQ Corporation
World Minerals Inc.
ZIEMANN Ludwigsburg GmbH

Known to us at press time.

ABOUT EACH ORGANIZATION

AMERICAN SOCIETY OF BREWING CHEMISTS

The American Society of Brewing Chemists (ASBC) was founded in 1934 and is currently represented on nearly every continent. Its mission statement is: "To ensure the highest quality, consistency and safety of malt-based beverages and their ingredients, ASBC will be a global authority for excellence in the field of brewing and related sciences and technology by: proactively identifying and rapidly responding to industry concerns; continuously improving and expanding methods of measurement; broadly and effectively communicating relevant information; and providing world class personal and professional development."

When founded, ASBC's main objective was to improve and bring uniformity to the brewing industry on a technical level. Today, ASBC's primary objectives are to resolve technical problems on an industry-wide basis, keep current on the technical needs of the brewing industry, and anticipate the industry's future concerns.

ASBC members are primarily employed by the brewing industry and allied industries throughout the world; some members work as consultants to the industry and others work in government and academia.

ASBC produces two publications, the Journal of the ASBC and the ASBC Newsletter. The Journal is a quarterly refereed journal that concentrates on original research findings, new applications, and symposium topics, as well as review articles. It also includes subcommittee reports presented at the annual meeting. Members receive a complimentary subscription.

The Newsletter focuses on administrative activities and changes, section activities, committee appointments, and technical news. It also includes the annual directory of ASBC members and their company affiliations. Members receive a complimentary subscription.

*In addition to these two publications, ASBC publishes brewing references, sells technical industry products such as screens, starch and gauges, and has a job placement service. ASBC also offers members several ways to grow professionally through the annual meeting, local section meetings, short courses and various and diverse technical committees. For the most comprehensive and up-to-date ASBC information visit ASBC*net *at www.asbcnet.org.*

Welcome to San Diego!

On behalf of the American Society of Brewing Chemists (ASBC), welcome to the World Brewing Congress 2004, in San Diego, California! ASBC is very proud to be joining the Master Brewers Association of the Americas, along with the Brewery Convention of Japan, the European Brewery Convention, and the Institute and Guild of Brewing to bring you this spectacular international event.

Our last World Brewing Congress held in 2000 in Orlando, Florida left many vivid memories. The 2000 congress had over 1100 participants from 42 countries. There were 120 world class papers and posters that brought a wealth of information on the latest technology and research, different methods of brewing, and the future of our industry. That future is now upon us and we are once again gathered to exchange new and innovative information and continue the great legacy of past world brewing congresses. WBC 2004 has over 200 presentations, 5 workshops, 130 exhibits and an abundance of networking opportunities to meet and reacquaint with colleagues. We have no doubt that this will be another superb congress.

We invite you to stop by our ASBC booth and learn more about our exciting organization and meet some of the great people that help shape our industry today. The goal of ASBC is to deliver knowledge and service to the industry by testing and recommending new methodologies for the evaluation of beer, raw ingredients, processing aids, and packaging materials. These methods ensure that the final product meets the highest quality standards and the consistency and safety expected by the consumer. In addition, ASBC is a leader in the communication of scientific information and applied technical knowledge and provides world-class personal and professional development.

We, in ASBC, are honored that we are one of the international hosts of this event. Enjoy the congress!

Suzanne Y. Thompson
President, American Society of Brewing Chemists

BREWERY CONVENTION OF JAPAN (BCOJ)

Since the early 1980s, Japanese beer specialists have made scientific contributions based on strong know-how. As a result, Japan gained international recognition for its research and development activities in brewing technology, and ASBC and EBC expressed an interest in establishing ties with the formal Japanese organization in the brewing area.

These relations developed to unify their beer analysis methods. As part of the general trend toward closer mutual communication, a committee, named "Board Meeting", was established within the Brewers Association of Japan (BAJ) in 1982. In an effort to maintain permanent relations with the relevant international organizations, the committee strengthened its international activities, and reorganized to form the Brewery Convention of Japan (BCOJ) in 1992.

The objectives of the BCOJ are: to unify analytical methods for the evaluation of materials and products used in beer brewing and other related industries; to advance both chemical and technical research through mutual communication among beer brewing industry specialists; and to work in cooperation with other foreign and domestic organizations with the same objectives.

BCOJ, established within BAJ, consists of 5 major Japanese beer companies: Asahi Breweries, Ltd.; Kirin Brewery Co. Ltd.; Orion Breweries, Ltd.; Sapporo Breweries, Ltd.; and Suntory Ltd. BCOJ comprises Secretariats, Analysis Committee and Program Committee. Regional beer producers are not represented by BAJ. The activities of each committee are: Analysis Committee—Planning and administration of research on analytical methods (domestic cooperative work), and activities with ASBC and EBC relating to international analytical methods; Program Committee—Planning and implementation of the Annual Conventions, and planning and implementation of the lectures and meetings.

BCOJ's publication include "Methods of Analysis of BCOJ" (1996), "Methods of Analysis of BCOJ (revised edition)" (1998), "BCOJ Microbiology Methods" (1999) , "The Ingredients of Brewing Products (Revised edition)" (1999),"BCOJ Sensory Evaluation Methods" (2002) and "Brewing and Packaging"(2002).

Greetings from the Brewery Convention of Japan

It is great honor for us that the Brewery Convention of Japan has been invited to participate in the World Brewing Congress 2004, the leading event of the world's brewing industry. And also, we are very grateful that we are provided with a number of opportunities to give presentations of our studies at WBC 2004.

We would like to gain new knowledge and information, and hope that all of us have mutual deeper understanding through the Congress. And we believe firmly that WBC 2004 will be a great congress to accelerate the development of brewing technologies in the world.

Yasutsugu Kawasaki
President, Brewery Convention of Japan

EUROPEAN BREWERY CONVENTION

The European Brewery Convention has become, since 1947, the preeminent expert organization in Europe for all brewing, governmental, and technical organizations acting cooperatively in pre-competitive areas of brewing and malting science and technology for the benefit of the brewing industry, consumers, and the community. The members of EBC are national brewing associations of 22 European countries, representing the national brewers. This means that practically all the European breweries—big and small—are EBC members through their national associations.

The objectives of EBC are

- *to promote the development of brewing and malting science and technology, the application of best practices of brewing and malting technology, and the transfer of knowledge from other industries into brewing and malting;*
- *to act as the European advisory expert body of science and technology in the brewing and malting industry;*
- *to identify new scientific and technical opportunities;*
- *to stimulate proactively and communicate developments in product safety, environmental issues, beer wholesomeness and health in support of moderate and responsible beer drinking; and*
- *to enable and enhance cooperative activity on all pre-competitive technical aspects of beer quality.*

To realize these objectives, EBC operates by maintaining and developing a database of European technical experts working on a voluntary basis; forming standing committees and groups (Analysis Committee, Barley and Malt Committee, Brewing Science Group, Technology and Engineering Forum), ad-hoc working groups, etc., each with their own terms of reference; organizing biennial international congresses; organizing specialized symposia on selected topics; publishing material resulting from the above activities; providing technical expertise to The Brewers of Europe, the trade confederation for the brewing industry in the European Union; and establishing working relationships with other appropriate organizations.

EBC is best known for its biennial congresses, but it is also known by brewing experts for its many other activities on pre-competitive areas in brewing and malting. The high level of these activities can be attributed to the active members of brewing companies, universities and research institutes who have given their invaluable contribution to the entire brewing industry through EBC.

Issues such as beer and safety, maintenance of quality, product and raw material integrity, as well as environmental care together with cooperation in pre-competitive research and development of technology, are important reasons for the valuable work of EBC.

Welcome to All Delegates of the World Brewing Congress 2004

On behalf of the European Brewery Convention I wish to extend a warm welcome to all delegates of the World Brewing Congress 2004.

For the second time, this Congress has been organized to bring the world brewing community together to face the future. EBC is proud to have been able to contribute to the scientific programme and we have done our best to suggest a number of interesting and challenging topics, such as *Raw Materials*: PCR & Barley Variety, Single Kernel NIR, Continuous Barley Improvements: The Role of the EBC Barley & Malt Committee; *Microbiology*: PCR-based Detection, Biofilms; *Yeast and Fermentation*: Yeast & Stress; Propagation; and *Environmental and Safety Issues*: IPPC & BAT.

Some papers are updates of the finest from the EBC Congress held in Dublin last year. We would like to extend our thanks to the authors and their companies for once more presenting their work here in San Diego during this important event.

We look forward to an interesting Opening Plenary Session "Creating our Future: An Executive View".

I am convinced that this congress will be of great value to all of us. Welcome to San Diego!

Jan Vesely
President, European Brewery Convention

INSTITUTE & GUILD OF BREWING

The Institute & Guild of Brewing (IGB) has an international membership which embraces the brewing, distilling, and allied industries. With a core focus of education and training, its Vision Statement is "To be recognized as the world's leading members organisation for the advancement of education and professional development in the science and technology of brewing, distilling, and related industries."

IGB qualifications are internationally recognized and much sought after. Examinations take place annually at a large number of centres around the world, and uptake has increased steadily in recent years as companies recognize their worth in career development terms. The basic level qualification, the General Certificate in Brewing & Packaging and its distilling counterpart, the General Certificate in Distilling, have been available for only a few years, and have fast become popular. The longer established Associate Members Examination (Diploma in Brewing/ Distilling from 2005) and Diploma Master Brewer (Masterbrewer from 2005) have, over time, become accepted international educational benchmarks across the industries. Training courses and packages to support all the IGB qualifications are available, and constantly under review in an attempt to meet customer requirements.

The IGB produces three publications. The "Journal" is a specialised publication, devoted to original scientific and technological articles, and with an international reputation. It is available quarterly to members on-line and in paper form as part of their annual subscription, and to non-members by subscription. "The Brewer International" is a monthly members magazine which contains technical and training articles, news and views, and general information which might be of use to members. "The IGB Company Directory" is published annually.

Additional to its education & training activity, the IGB organises regular conventions and seminars at an international level. In particular, and on alternate years, a major convention in the Southern Africa and Asia-Pacific regions, the next of which will be in Sun City, South Africa in 2005. Also in 2005, the IGB will hold the second World Distilled Spirits Convention, in Edinburgh, Scotland. The Institute maintains close contact with other significant organizations, such as MBAA, ASBC, and EBC, and has its own Internet Website: www.igb.org.uk.

Welcome from The Institute & Guild of Brewing

The Institute & Guild of Brewing is delighted to be part of the organisation of this World Brewing Congress, in partnership with its colleagues from the Master Brewers Association of the Americas, the American Society of Brewing Chemists, the Brewery Convention of Japan, and the European Brewery Convention. All our resources and experience have been combined to offer you a truly world-class event, and we are confident that you will find it of considerable value, as well as thoroughly enjoyable.

The organisers have worked hard to bring together a technical programme of the highest quality and you will also have the opportunity to review posters from the global brewing fraternity. Invited speakers are acknowledged international experts in their fields, and there is plenty of time for panel discussions. WBC 2004 commercial exhibits will provide you with all the up-to-date information you require from brewing industry suppliers from around the world. The venue speaks for itself, and you can avail yourself of every sort of social activity, meet old friends, and make new acquaintances.

Thank you for participating in this unique and important event. Our team looks forward to meeting you personally during your time in San Diego.

On behalf of the Institute & Guild of Brewing,

Bill Taylor,
President, Institute & Guild of Brewing

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MASTER BREWERS ASSOCIATION OF THE AMERICAS

The Master Brewers Association of the Americas was formed in 1887 with the purpose of promoting, advancing, and improving, the professional interest of brew and malt house production and technical personnel. Today, MBAA is a dynamic, global community working to advance the brewing, fermentation, and allied industries by: advocating the exchange of knowledge; creating, assembling, interpreting, and disseminating credible and beneficial information; developing world-class education offerings; and providing valuable personal and professional development opportunities.

Our mission is to enrich the art and craft of brewing by:

- *encouraging technical and scientific inquiry to improve the brewing and associated industries;*
- *collecting and disseminating information of value to its members, the profession, and the brewing and associated industries;*
- *promoting training and education of production and technical personnel;*
- *affording opportunity to its members to associate and to exchange views; and*
- *promoting a spirit of cooperation and camaraderie among its members.*

Our vision is to be:

- *recognized as the global leader in the brewing profession, with vitality and global membership appeal;*
- *the provider of choice to our members and the industry for diversified educational and information offerings advancing the brewing profession;*
- *earning the pride and respect of our members and their companies as a dynamic organization, changing as our industry changes;*
- *growing and diversifying our organization with actively involved members at all levels; and*
- *collaborating with other brewing industry associations throughout the world to enhance our industry and profession.*

The Master Brewers Association of the Americas offers you the opportunity to interact with other industry professionals and to learn practical solutions, resourceful safeguards, and innovative technologies to strengthen your ability to succeed. For information on MBAA visit MBAA.com at www.mbaa.com.

Welcome to the World Brewing Congress 2004

On behalf of the Master Brewers Association of the Americas, I extend to you a warm welcome to World Brewing Congress 2004. MBAA is a proud co-sponsor of this world-class international educational event.

The exciting technical program covers a wide diversity of topics that you will find of value. Over 100 technical presentations and more than 100 posters were selected from an even larger number of volunteered contributions. This constitutes a major opportunity to learn from international experts in many new areas. For those who find too many papers of interest—you have the option to visit them all by purchasing the WBC 2004 CD-Rom where a majority of the PowerPoint presentations can be found.

We invite you to fully leverage this unique opportunity to network and exchange views with the international group of technical presenters and with your peers from around the world during this meeting. Also, be sure you take full advantage of the technical staff that has come to display products and services in the exhibition program.

We hope that you will enjoy both the scientific and social aspects of this very special technical meeting.

Sincerely,

Inge Russell
President, Master Brewers Association of the Americas

GENERAL INFORMATION

REGISTRATION

Elizabeth Foyer

WBC 2004 registration is located in the Elizabeth Foyer located on the second floor of the Hyatt. Registered attendees and exhibitors may pick up their credentials and an attendee pre-registration list at the WBC registration desk during the following hours:

Registration Hours

Saturday, July 24	Noon – 6:00 p.m.
Sunday, July 25	8:00 a.m. – 5:30 p.m.
Monday, July 26	7:30 a.m. – 2:30 p.m.
Tuesday, July 27	7:30 a.m. – 5:00 p.m.
Wednesday, July 28	7:30 a.m. – 1:30 p.m.

EXHIBITS

Douglas Pavilion

An international gathering of brewing industry representatives are available to discuss their latest products and services. Exhibiting company descriptions can be found on page 162.

A buffet lunch will be served daily from 11:30 a.m. to 2:00 p.m. and is open to registered attendees, exhibitors, speakers and students.

Exhibit Hours

Sunday, July 25	11:30 a.m. – 2:00 p.m.
Monday, July 26	11:30 a.m. – 2:00 p.m.
Tuesday, July 27	11:30 a.m. – 2:00 p.m.

POSTERS

Douglas Pavilion

Be sure to make time to view the posters and join the authors each day from 11:30 a.m. to 12:30 p.m. for discussions. Authors, titles, and poster numbers are listed on page 37.

Poster Viewing Hours

Sunday, July 25	11:30 a.m. – 2:00 p.m.
Monday, July 26	11:30 a.m. – 2:00 p.m.
Tuesday, July 27	11:30 a.m. – 2:00 p.m.

SPONSORS' SHOWCASE

Elizabeth Foyer

Stop by the Sponsors' Showcase area to learn more about the five associations hosting WBC 2004; American Society of Brewing Chemists, Master Brewers Association of the Americas, Brewery Convention of Japan, European Brewery Convention, and the Institute and Guild of Brewing. Information on membership, publications, resource materials, continuing education opportunities, clothing, services, and much more will be available for viewing and purchase.

Sponsors' Showcase Hours

Sunday, July 25	8:00 a.m. – 5:30 p.m.
Monday, July 26	7:30 a.m. – 2:30 p.m.
Tuesday, July 27	7:30 a.m. – 5:00 p.m.
Wednesday, July 28	7:30 a.m. – 1:30 p.m.

WBC SILENT AUCTION

Elizabeth Foyer

The ASBC and MBAA foundations are jointly hosting a silent auction benefiting their respective scholarship programs. Stop by the silent auction area located in the Elizabeth Foyer and bid on a wide array of items. Bids will be accepted Sunday from 8:00 a.m. – 5:30 p.m., Monday from 7:30 a.m. to 2:30 p.m., and Tuesday from 7:30 a.m. to 2:00 p.m. Make a difference in a student's life – bid high and bid often!

SPEAKER READY ROOM

Molly A

Speakers may test and/or review their presentations in the speaker ready room.

Speaker Ready Room Hours

Saturday, July 24	Noon – 6:00 p.m.
Sunday, July 25	7:00 a.m. – 6:00 p.m.
Monday, July 26	7:00 a.m. – 6:00 p.m.
Tuesday, July 27	7:00 a.m. – 6:00 p.m.
Wednesday, July 28	7:00 a.m. – 11:30 a.m.

MEDIA INFORMATION

Molly B

The Media Room, for members of the news media, is located on the second floor of the Hyatt in Molly B. Specific questions regarding the congress can be directed to personnel at the registration desk. Exhibitors are asked to bring their media kits to the press room during exhibitor registration from noon to 6:00 p.m. on Saturday.

Media Room Hours

Saturday, July 24	Noon – 6:00 p.m.
Sunday, July 25	8:00 a.m. – 5:30 p.m.
Monday, July 26	7:30 a.m. – 2:30 p.m.
Tuesday, July 27	7:30 a.m. – 5:00 p.m.
Wednesday, July 28	7:30 a.m. – 1:30 p.m.

SUPPLIER SESSIONS

Newly introduced, these sessions offer an in-depth look at products and services for the industry. The presentations are each 45 minutes in length and offer the latest information on products, applications, and solutions. For more details on these presentations, see page 174.

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HACH ULTRA ANALYTICS

SOCIAL PROGRAM

WELCOME RECEPTION
Poolside

The Welcome Reception, included in the registration fee for registered attendees, exhibitors, speakers/poster presenters, registered guests, and students, is a wonderful way to kick off World Brewing Congress 2004! Join your friends and colleagues for a festive evening of entertainment, hors d'oeuvre buffets, beverages, spectacular views of San Diego, and the sparkling waters of San Diego Bay. The fun begins Saturday, July 24, from 6:00 to 9:00 p.m.

BUFFET LUNCH AND HOSPITALITY
Douglas Pavilion

Join exhibitors and colleagues in the exhibition hall for topical conversation, a bountiful lunch buffet, and your favorite beverages Sunday through Tuesday. These lunch/hospitality times provide the perfect backdrop for combining business and pleasure. The lunch hospitality will be held from 11:30 a.m. to 2:00 p.m., Sunday through Tuesday.

HOSPITALITY/LUNCHEON/CLOSING PLENARY SESSION

11:30 a.m.	Hospitality	Elizabeth Foyer
12:15 p.m.	Luncheon	Elizabeth A/E
1:30 p.m.	Closing Plenary Session	Elizabeth A/E

The Next Big Thing is Really Small: How Nanotechnology Will Change the Future of Your Business. Join your brewing colleagues for hospitality, lunch and listen to the exciting closing plenary speaker Jack Uldrich, nanotechnology consultant and the author of the *The Next Big Thing is Really Small.* Jack will explain what nanotechnology is, will document the flurry of nanotechnology research that is taking place in the R&D labs of Fortune 500 companies, as well as introduce participants to the most promising nanotechnology start-ups.

GOLF TOURNAMENT
Riverwalk Golf Club

The WBC Golf Tournament will be held on Monday, July 26, at the Riverwalk Golf Club, located just a short drive from the Manchester Grand Hyatt. Steeped in the rich tradition of golf legends past, Riverwalk Golf Club offers a classic golfing experience like no other.

The bus(es) will depart promptly at 2:15 p.m. from the front drive of the Manchester Grand Hyatt. Shotgun start is scheduled at 3:00 p.m.

CONGRESS HOSPITALITY LOUNGE
Randle D/E and Randle Foyer

The Congress Hospitality Lounge is the perfect place to meet before or after a night out on the town! Join your colleagues for conversation and refreshments!

Congress Hospitality Lounge Hours

Sunday, July 25	5:00 – 11:00 p.m.
Tuesday, July 27	5:00 – 11:00 p.m.

GUEST HOSPITALITY
Ford

Join fellow registered guests in the comfortable Guest Hospitality Lounge for a continental breakfast each morning and refreshments each afternoon. The lounge is only open to registered guests.

WOMEN IN BREWING
America's Cup Terrace

Join your colleagues for refreshments and networking. The social is at the America's Cup Terrace from 5:30 – 6:30 p.m.

CLOSING RECEPTION AND BANQUET
Elizabeth Foyer and Ballroom

The closing reception and banquet are included in the registration fee for regular attendees, speaker/poster presenters, and registered guests. Business attire is recommended for this evening of fine dining and entertainment.

GUEST PROGRAM

SATURDAY, JULY 24

6:00 – 9:00 p.m.	Welcome Reception — Poolside

SUNDAY, JULY 25

10:00 – 11:30 a.m.	Welcome Brunch (for registered guests only) and Introduction to San Diego – Madeline A/C
11:45 a.m.	Depart for SeaWorld—Bus(es) depart promptly from the Hyatt front entrance. *SeaWorld tickets sponsored by Anheuser Busch*
2:30 p.m.	Bus(es) Return
3:30 p.m.	Bus(es) Return
3:30 – 5:00 p.m.	Guest Hospitality Lounge – Ford
5:00 – 11:00 p.m.	Congress Hospitality Lounge – Randle D/E and Randle Foyer

MONDAY, JULY 26

8:00 – 10:00 a.m.	Guest Continental Breakfast – Ford

TUESDAY, JULY 27

8:00 – 10:00 a.m.	Guest Continental Breakfast – Ford
3:30 – 4:00 p.m.	Guest Hospitality Lounge – Ford
5:00 – 11:00 p.m.	Congress Hospitality Lounge – Randle D/E and Randle Foyer

WEDNESDAY, JULY 28

8:00 – 10:00 a.m.	Guest Continental Breakfast – Ford
2:30 – 4:00 p.m.	Guest Hospitality Lounge – Edward B/C
7:00 – 11:00 p.m.	Closing Reception and Banquet – Elizabeth Foyer and Ballroom (business attire)

DRESS

The official dress of WBC 2004 is business casual. Business/cocktail attire is suggested for the Wednesday Closing Reception and Banquet.

In order to provide a safe and healthy environment for all attendees, WBC 2004 is a smoke-free meeting. Smoking is prohibited in all meeting rooms and banquet halls.

ABOUT SAN DIEGO

There are many reasons why San Diego is consistently rated one of the top vacation destinations in North America. The following is just a sampling of San Diego's offerings that you can enjoy during WBC 2004. Check with the Hyatt's concierge for museum information, current festivals/events, and public transportation.

Gaslamp Quarter—In the heart of downtown San Diego is the 16-1/2 block Gaslamp Quarter, a charming Victorian dining and entertainment district that captures the lively spirit of a bygone era.

San Diego Zoo—This 100-acre tropical garden zoo houses 4,000 animals of 800 species and is noted for its giant pandas currently on loan from China.

San Diego Zoo's Wild Animal Park—A 2,200-acre preserve where 3,000 wild animals roam free over vast expanses as they would in their native habitats of Africa and Asia.

SeaWorld San Diego—Located on Mission Bay, this 189-acre park features six major shows, fascinating attractions, and dozens of exhibits containing marine life from around the globe.

Balboa Park—In the heart of San Diego featuring 1,200 lush acres of 85 cultural attractions, including 15 museums, art galleries, Reuben H. Fleet Science Center, Old Globe theatre, Starlight Bowl, sports facilities, the San Diego Zoo, and the historic Spreckels Organ Pavilion.

San Diego Missions—San Diego's Spanish heritage is preserved in its 21 beautiful missions. Check with Hyatt concierge for listing and driving directions.

Shopping—Families can find major league "shop-portunities" when visiting neighboring Tijuana, Mexico. The kids will especially enjoy a trip to Horton Plaza.

Photos courtesy of the San Diego CVB. San Diego Skyline from Pt. Loma by James Blank; Giant Panda at the World Famous San Diego Zoo by the San Diego Zoo; SeaWorld San Diego by SeaWorld; Plaza De Panama, Balboa Park, by Brett Shoaf.

SCHEDULE OVERVIEW

SATURDAY, JULY 24

8:00 a.m. – 5:00 p.m.	Pre-Congress Course: Introduction to Design of Experiments – Mohsen A/B
Noon – 6:00 p.m.	Registration – Elizabeth Foyer
Noon – 6:00 p.m.	Speaker Ready Room – Molly A
Noon – 6:00 p.m.	Media Room – Molly B
1:00 – 5:00 p.m.	Pre-Congress Course: Flavor Workshop: Oxidation Flavors—The Science of Beer Aging – Madeline A/D
2:00 – 7:00 p.m.	Exhibits Set Up – Douglas Pavilion
2:00 – 7:00 p.m.	Poster Set Up – Douglas Pavilion
6:00 – 9:00 p.m.	Welcome Reception – Poolside

SUNDAY, JULY 25

6:45 – 7:45 a.m.	Presenters' Breakfast – Del Mar A/B (includes today's presenters)
7:00 a.m. – 6:00 p.m.	Speaker Ready Room – Molly A
8:00 a.m. – 5:30 p.m.	Registration & Silent Auction – Elizabeth Foyer
8:00 a.m. – 5:30 p.m.	Sponsors' Showcase – Elizabeth Foyer
8:00 a.m. – 5:30 p.m.	Media Room – Molly B
10:00 – 11:30 a.m.	Opening Plenary Session: Creating Our Future: An Executive View – Elizabeth A/E
10:00 – 11:30 a.m.	Guest Welcome Brunch (guest program) / Introduction to San Diego – Madeline A/C
11:30 a.m. – 2:00 p.m.	Exhibits, Hospitality, and Buffet Lunch – Douglas Pavilion
11:30 a.m. – 2:00 p.m.	Poster Session (see list on page 37). Authors present 11:30 a.m. – 12:30 p.m. – Douglas Pavilion
11:45 a.m.	Depart for SeaWorld (guest program) – Bus(es) depart promptly from the Hyatt front entrance
2:00 – 4:30 p.m.	Supplier Sessions – Gregory A/B (see page 174 for complete listing)
2:00 – 5:05 p.m.	TECHNICAL SESSION I: Malt. Scott Heisel, Moderator – Elizabeth A/C
2:00 – 5:05 p.m.	TECHNICAL SESSION II: Beer Analysis. Cindy-Lou Dull, Moderator – Elizabeth D/E
2:00 – 5:05 p.m.	TECHNICAL SESSION III: Filtration. Frederik Havel, Moderator – Elizabeth F/H
2:00 – 5:15 p.m.	WORKSHOP I: Maintenance: Is There a Better Practice? Moderator to be Announced – Randle A/B
2:30 p.m.	Bus(es) Return From SeaWorld (guest program)
3:20 – 3:50 p.m.	Refreshment Break – Elizabeth Foyer
3:30 p.m.	Bus(es) Return From SeaWorld (guest program)
3:30 – 5:00 p.m.	Guest Hospitality (guest program) – Ford
5:00 – 11:00 p.m.	Congress Hospitality Lounge – Randle D/E/Foyer

MONDAY, JULY 26

6:45 – 7:45 a.m.	Presenters' Breakfast (includes today's presenters and authors of posters P-1 through P-52) – Madeline A/D
7:00 a.m. – 6:00 p.m.	Speaker Ready Room – Molly A
7:30 a.m. – 2:30 p.m.	Registration & Silent Auction – Elizabeth Foyer
7:30 a.m. – 2:30 p.m.	Sponsors' Showcase – Elizabeth Foyer
7:30 a.m. – 2:30 p.m.	Media Room – Molly B
8:00 – 10:00 a.m.	Guest Continental Breakfast – Ford
8:00 – 11:25 a.m.	TECHNICAL SESSION IV: Hops. Dave Hysert, Moderator – Elizabeth A/C
8:00 – 11:25 a.m.	TECHNICAL SESSION V: Environmental/Engineering. Kathy Kinton, Moderator – Elizabeth D/E
8:00 – 11:25 a.m.	TECHNICAL SESSION VI: Malting. Xiang Yin, Moderator – Elizabeth F/H
8:00 – 11:00 a.m.	WORKSHOP II: Sharing the Knowledge: Brewers, Distillers, and Vintners. Steve Wright, Moderator – Randle A/B
8:30 – 10:30 a.m.	Supplier Sessions – Gregory A/B (see page 174 for complete listing)
9:15 – 9:45 a.m.	Refreshment Break – Elizabeth Foyer
11:30 a.m. – 2:00 p.m.	Exhibits, Hospitality, and Buffet Lunch – Douglas Pavilion
11:30 a.m. – 2:00 p.m.	Poster Session (see list on page 37). Authors present 11:30 a.m. – 12:30 p.m. – Douglas Pavilion
2:15 p.m.	Depart for Golf Tournament (ticketed event) – Bus(es) depart promptly from the Hyatt front entrance.
3:00 p.m.	Golf Tournament Shotgun Start

TUESDAY, JULY 27

6:45 – 7:45 a.m.	Presenters' Breakfast (includes today's presenters and authors of posters P-53 through P-104) – Madeline A/D
7:00 a.m. – 6:00 p.m.	Speaker Ready Room – Molly A
7:30 a.m. – 5:00 p.m.	Registration – Elizabeth Foyer
7:30 a.m. – 2:00 p.m.	Silent Auction – Elizabeth Foyer
7:30 a.m. – 5:00 p.m.	Sponsors' Showcase – Elizabeth Foyer
7:30 a.m. – 5:00 p.m.	Media Room – Molly B
8:00 – 10:00 a.m.	Guest Continental Breakfast – Ford
8:00 – 11:25 a.m.	TECHNICAL SESSION VII: Flavor. Sue Thompson, Moderator – Elizabeth A/C
8:00 – 11:25 a.m.	TECHNICAL SESSION VIII: Analysis. Jean-Pierre Dufour, Moderator – Elizabeth D/E
8:00 – 11:25 a.m.	TECHNICAL SESSION IX: Microbiology. Candace Wallin, Moderator – Elizabeth F/H
8:00 – 11:30 a.m.	WORKSHOP III: Malting Barley Variety Development and Evaluation Systems. Erin Armstrong, Moderator – Randle A/B
8:30 – 10:30 a.m.	Supplier Sessions – Maggie (see page 174 for complete listing)
9:15 – 9:45 a.m.	Refreshment Break – Elizabeth Foyer
11:30 a.m. – 2:00 p.m.	Exhibits, Hospitality, and Buffet Lunch – Douglas Pavilion
11:30 a.m. – 2:00 p.m.	Poster Session (see list on page 37). Authors present 11:30 a.m. – 12:30 p.m. – Douglas Pavilion
2:30 – 4:30 p.m.	Supplier Sessions – Maggie (see page 174 for complete listing)
2:00 – 5:05 p.m.	TECHNICAL SESSION X: Fermentation. Dave Ryder, Moderator – Elizabeth A/C
2:00 – 5:05 p.m.	TECHNICAL SESSION XI: Packaging. Christopher Nunes, Moderator – Elizabeth D/E
2:00 – 5:05 p.m.	TECHNICAL SESSION XII: Beer/Brewing. George Reisch, Moderator – Elizabeth F/H
2:00 – 5:15 p.m.	WORKSHOP IV: Managing the Supply Chain to Protect Integrity and Ensure Quality. Anne Bridges, Moderator – Randle A/B
2:30 – 4:00 p.m.	Guest Hospitality – Ford
3:20 – 3:50 p.m.	Refreshment Break – Elizabeth Foyer
5:00 – 11:00 p.m.	Congress Hospitality – Randle D/E / Foyer
5:30 – 6:30 p.m.	Women In Brewing Reception – America's Cup Terrace

WEDNESDAY, JULY 28

6:45 – 7:45 a.m.	Presenters' Breakfast (includes today's presenters) – Madeline A/D
7:00 a.m. – 11:30 p.m.	Speaker Ready Room – Molly A
7:30 a.m. – 1:30 p.m.	Registration – Elizabeth Foyer
7:30 a.m. – 1:30 p.m.	Sponsors' Showcase – Elizabeth Foyer
7:30 a.m. – 1:30 p.m.	Media Room – Molly B
8:00 – 10:00 a.m.	Guest Continental Breakfast – Ford
8:00 – 11:25 a.m.	TECHNICAL SESSION XIII: Yeast. Greg Casey, Moderator – Elizabeth A/C
8:00 – 11:25 a.m.	TECHNICAL SESSION XIV: Health and HACCP. Rob Maruyama, Moderator – Elizabeth D/E
8:00 – 11:25 a.m.	TECHNICAL SESSION XV: Malting/Mashing. Rob McCaig, Moderator – Elizabeth F/H
9:15 – 9:45 a.m.	Refreshment Break – Elizabeth Foyer
9:30 – 11:30 a.m.	WORKSHOP V: Brewing Education and Training. Inge Russell, Moderator – Edward A/C
11:30 a.m. – 1:30 p.m.	Hospitality / Luncheon – Elizabeth Foyer and Elizabeth A/E
1:30 – 3:15 p.m.	Closing Plenary Session: The Next Big Thing Is Really Small: How Nanotechnology Will Change the Future of Your Business – Elizabeth A/E
2:30 – 4:00 p.m.	Guest Hospitality – Edward B/C
7:00 – 7:30 p.m.	Closing Reception – Elizabeth Foyer/Terrace
7:30 p.m. – 11:00 p.m.	Closing Banquet (business attire) – Elizabeth Ballroom

PROGRAM

SATURDAY, JULY 24

8:00 a.m. – 5:00 p.m.	Pre-Congress Course: Introduction to Design of Experiments. Eric Samp, Ph.D., Technical Leader, Coors Brewing Company, Golden, Colorado, U.S.A. – Mohsen A/B This is a perfect introductory course for a wide range of brewing professionals to learn statistical experimental design and how to conduct efficient experiments with multiple test variables. The experimental design techniques covered will provide brewing professionals with methods to effectively evaluate the influence of these types of variables by constructing, executing, and analyzing factorial designs. Discover how to determine the statistical significance of effects, identify interactions, and interpret them. In addition, reducing experimental test sizes by fractionating full factorials will be covered, along with interpretation of design resolution and techniques to determine it. Other topics will include how to test for higher order effects, block for variables that cannot be easily randomized, determine path of steepest ascent/decent, conduct screening designs, and deal with multiple responses.
Noon – 1:00 p.m.	Introduction to Design of Experiments – Lunch – Del Mar A/B
Noon – 6:00 p.m.	Registration – Elizabeth Foyer
Noon – 6:00 p.m.	Speaker Ready Room – Molly A
Noon – 6:00 p.m.	Media Room – Molly B
1:00 – 5:00 p.m.	Pre-Congress Course: Flavor Workshop: Oxidation Flavors—The Science of Beer Aging – Madeline A/D Gain a better understanding of oxidation flavors and processes that affect these flavors at this half-day workshop led by globally-recognized experts. Bill Simpson, Cara Technologies/FlavorActiv, will describe the types of oxidative compounds and their associated flavors, and attendees will learn to identify and evaluate oxidation flavors during the tasting session. Olav Vind Larsen, Danbrew/ A.J.L., will then explore the implications of process design on oxidation. Charlie Bamforth, UC-Davis, will provide insight into the science behind oxidation. The workshop will deliver key information on a subject important to brewers.
2:00 – 7:00 p.m.	Exhibitors and Posters Set Up – Douglas Pavilion
6:00 – 9:00 p.m.	Welcome Reception – Poolside

SUNDAY, JULY 25

6:45 – 7:45 a.m.	Presenters' Breakfast (includes today's presenters) – Del Mar A/B
7:00 a.m. – 6:00 p.m.	Speaker Ready Room – Molly A
8:00 a.m. – 5:30 p.m.	Registration / Silent Auction / Sponsors' Showcase – Elizabeth Foyer
8:00 a.m. – 5:30 p.m.	Media Room – Molly B

WBC 2004 OPENING PLENARY SESSION: Creating Our Future: An Executive View – Elizabeth A/E

10:00 – 10:10 a.m.	WBC 2004 Welcome
10:10 – 10:30	Globalization. *J. F. van Boxmeer, Heineken*
10:10 - 10:50 a.m.	Environmental. *Yasutsugu Kawasaki, Suntory Limited*
10:50 - 11:10 a.m.	Beer and Health. *Terry Micek, Coors Brewing Company*
11:10 - 11:30 a.m.	Brewing Operations. *TBA, SAB/Miller*
11:30 a.m. – 2:00 p.m.	**Exhibits, Hospitality, and Buffet Lunch – Douglas Pavilion**
11:30 a.m. – 2:00 p.m.	**Poster Session (see list on page 37). Authors present 11:30 a.m. – 12:30 p.m. – Douglas Pavilion**

TECHNICAL SESSION I: Malt. Scott Heisel, Moderator – Elizabeth A/C

2:00 – 2:05 p.m.	Opening Remarks
2:05 – 2:30 p.m.	O-1. New Method for Malt Treatment by Subcritical Water. *Koichi Nakahara, Suntory Ltd., Osaka, Japan*
2:30 – 2:55 p.m.	O-2. Wort Amino Acid Composition of Different Barley Varieties and Effect on Nitrogen Assimilation. *Xiang Yin, Prairie Malt/Cargill Malt, Biggar, SK, Canada*
2:55 – 3:20 p.m.	O-3. Choice of Enzyme Solutions Should Determine the Choice of Raw Materials and Process—Not Vice Versa. *Sten Aastrup, Novozymes, Bagsvaerd, Denmark*
3:20 – 3:50 p.m.	Break
3:50 – 4:15 p.m.	O-4. NIR Spectroscopy for Single-Kernel Analysis—A Novel Tool for the Evaluation of Homogeneity in Barley and Malt. *Frank Rath, VLB Berlin, Berlin, Germany*
4:15 – 4:40 p.m.	O-5. Lipid Oxidation During Mashing and Its Impact on Beer Quality—Recent Progress. *Hisao Kuroda, Sapporo Breweries Ltd., Shizuoka, Japan*

4:40 – 5:05 p.m. O-6. The First PCR Marker for Breeding of High-Quality Winter Malting Barley—A Novel Selection Tool Against Beta-Amylase-Weak Genotypes. *Michael Voetz, VLB Berlin, Berlin, Germany*

TECHNICAL SESSION II: Beer Analysis. Cindy-Lou Dull, Moderator – Elizabeth D/E

2:00 – 2:05 p.m. Opening Remarks
2:05 – 2:30 p.m. O-7. A New Brewing Science Study in the 21st Century Fused with Brain Science—Measurement of Human Brain Activity Evoked by Stimulation of Beer Bitterness Using Magnetoencephalography. *Hirotaka Kaneda, Sapporo Breweries Ltd., Shizuoka, Japan*
2:30 – 2:55 p.m. O-8. Stable Isotope Dilution Assay of Methanethiol and Dimethyl Trisulfide in Beer Using Purge and Trap Method. *Sachio Iinuma, Kirin Brewery Co., Ltd., Yokohama, Japan*
2:55 – 3:20 p.m. O-9. Development of Multiresidue Analysis Method of Agrochemicals Using Liquid Chromatography/Tandem Mass Spectrometry. *Masayuki Omote, Asahi Breweries, Ltd., Ibaraki, Japan*
3:20 – 3:50 p.m. Break
3:50 – 4:15 p.m. O-10. Wort Turbidity—Comparison of Different Measuring Principles. *Arnd Rogner, Sigrist-Photometer AG, Ennetbuergen, Switzerland*
4:15 – 4:40 p.m. O-11. Toward Improved Fermentation Consistency Using Multivariate Statistics. *Behnam Taidi, Scottish Courage Ltd., Edinburgh, Scotland*
4:40 – 5:05 p.m. O-12. Multivariate Analysis of Routine Beer Analysis Methods. *Karl Siebert, Cornell University, Geneva, NY*

TECHNICAL SESSION III: Filtration. Frederik Havel, Moderator – Elizabeth F/H

2:00 – 2:05 p.m. Opening Remarks
2:05 – 2:30 p.m. O-13. Cost and Quality Comparison Between DE and Crossflow Filtration for Beer Clarification in Industrial Scale. *Hans Denniger, Westfalia Separator AG, Oelde, Germany*
2:30 – 2:55 p.m. O-14. The Filterability of Wort and Beer. *Stefan Kreisz, Institute for Brewing Technology, Freising, Germany*
2:55 – 3:20 p.m. O-15. Practical Experiences with Membrane Filtration for the Clarification of Beer on an Industrial Scale. *Reinoud Noordman, Heineken Technical Services, Zoeterwoude, Netherlands*
3:20 – 3:50 p.m. Break
3:50 – 4:15 p.m. O-16. Crossflow Filtration of Beer—A True Alternative to Diatomaceous Earth Filtration. *Alexander Modrok, Sartorius AG, Goettingen, Germany*
4:15 – 4:40 p.m. O-17. Beer Stabilization Technology, Clearly a Matter of Choice! *Mustafa Rehmanji, International Specialty Products, Wayne, NJ*
4:40 – 5:05 p.m. O-18. Precoat Filtration, Not a Dead End Street: Introduction of a New Generation of Candle Filters. *Thomas Weigand, Filtrox AG, Sankt Gallen, Switzerland*

WORKSHOP I: Maintenance: Is There a Better Practice? Dan Robert, Moderator – Randle A/B

2:00 – 5:15 p.m. This workshop will cover the foundational elements associated with developing a world-class maintenance organization. Representatives will provide practical examples of how asset management has had a positive impact on product quality, throughput improvements, inventory management, and safety from both Coors Brewing Company and Molson. Quality improvements include DOs, DMS, and customer complaints.

SUPPLIER SESSIONS

3:45 – 4:30 p.m. AMC Technologies/PreSens
5:00 – 11:00 p.m. Congress Hospitality Lounge – Randle D/E / Foyer

MONDAY, JULY 26

6:45 – 7:45 a.m. Presenters' Breakfast (includes today's presenters and authors of posters P-1 through P-52) – Madeline A/D
7:00 a.m. – 6:00 p.m. Speaker Ready Room – Molly A
7:30 a.m. – 2:30 p.m. Registration & Silent Auction – Elizabeth Foyer
7:30 a.m. – 2:30 p.m. Sponsors' Showcase – Elizabeth Foyer
7:30 a.m. – 2:30 p.m. Media Room – Molly B

TECHNICAL SESSION IV: Hops. Dave Hysert, Moderator – Elizabeth A/C

8:00 – 8:05 a.m. Opening Remarks
8:05 – 8:30 a.m. O-19. Organoleptic Profiling and Interactions of Hop Oil Fractions in Various Beer Types. *Ray Marriott, Botanix Ltd., Paddock Wood, Kent, U.K.*
8:30 – 8:55 a.m. O-20. Bitter Quality of Beer as Affected by Isocohumulone Levels. *Thomas Shellhammer, Oregon State University, Corvallis, OR*
8:55 – 9:15 a.m. O-21. Analysis of Hop Terpenes in Beer and Wort Using the SBSE Method with GC-MS. *Toru Kishimoto, Asahi Breweries, Ltd., Ibaraki, Japan*

9:15 – 9:45 a.m.	Break
9:45 – 10:10 a.m.	O-22. Utilization of Polyphenol Fraction from Hop Bract Part as Functional Food. *Motoyuki Tagashira, Asahi Breweries, Ltd., Ibaraki, Japan*
10:10 – 10:35 a.m.	O-23. A Proteome Approach for Detection and Characterization of Hop Inducible Proteins Involved in Hop Resistance of Beer-Spoiling Lactobacilli. *Jürgen Behr, Technische Universität München, Freising, Germany*
10:35 – 11:00 a.m.	O-24. Potential of Reutericyclin as a Tasteless Hop Analogue in Beer Preservation. *Rudi Vogel, Technische Universität München, Freising, Germany*
11:00 – 11:25 a.m.	O-25. A Rapid and Low-Cost Method for Quantification of Reduced Iso-Alpha-Acids in Brewing. *Mónica Gasparri, Cervecería Polar, C.A., Caracas, Venezuela*

TECHNICAL SESSION V: Environmental/Engineering. Kathy Kinton, Moderator – Elizabeth D/E

8:00 – 8:05 a.m.	Opening Remarks
8:05 – 8:30 a.m.	O-26. ECO-MATRIX: A New Economical Pipe System. *Kristina Boee, Tuchenhagen Brewery Systems, Buechen, Germany*
8:30 – 8:55 a.m.	O-27. Asahi's Approach to Reduction of Energy Basic Unit to Half. *Akitoshi Yoshizawa, Asahi Breweries, Ltd., Ibaraki, Japan*
8:55 – 9:15 a.m.	O-28. Membrane Separation Activated Sludge Processes: Method of Purifying Warm Water for Warmer. *Yasuhiro Sasaki, Asahi Breweries, Ltd., Nisinomiya City, Japan*
9:15 – 9:45 a.m.	Break
9:45 – 10:10 a.m.	O-29. Happy Fish Due to or In Spite of an Optimized Wastewater Treatment System? *Vera Groot Kormelinck, Paques BV, Balk, Netherlands*
10:10 – 10:35 a.m.	O-30. Best Available Techniques in the Brewing Industry. *Pjotr van Oeveren, Heineken International, Zoeterwoude, Netherlands*
10:35 – 11:00 a.m.	O-31. Greener Beverage Product Security and De-Casing Solutions. *Paul Ligon, WM IPS, Woodland, TX*
11:00 – 11:25 a.m.	O-32. Aware of Water. *Paul Bruijn, Heineken Technical Services, Zoeterwoude, Netherlands*

TECHNICAL SESSION VI: Malting. Xiang Yin, Moderator – Elizabeth F/H

8:00 – 8:05 a.m. Opening Remarks

8:05 – 8:30 a.m. O-33. Raw Barley as Adjunct—Optimal Application of Malt and Commercial Enzymes for Beer Production. *Declan Goode, University College Cork, Cork, Ireland*

8:30 – 8:55 a.m. O-34. A New Technique for Combined Milling and Mashing in the Brewhouse. *Richard Sharpe, Brewing Research International, Nutfield, Surrey, U.K.*

8:55 – 9:15 a.m. O-35. Physiochemical Changes in Barley/Malt During the Malting Process with Particular Emphasis on Beta-Glucan and Beta-Glucanases. *Eoin Lalor, Quest International Ireland Ltd., Carrigaline, Ireland*

9:15 – 9:45 a.m. Break

9:45 – 10:10 a.m. O-36. Malting Characteristics of Three Canadian Hulless Barley Varieties, CDC Freedom, CDC McGwire, and CDC Gainer. *Yueshu Li, Canadian Malting Barley Technical Centre, Winnipeg, MB, Canada*

10:10 – 10:35 a.m. O-37. Brewing with Canadian Hulless Barley Varieties, CDC Freedom, CDC McGwire, and CDC Gainer. *Robert McCaig, Canadian Malting Barley Technical Centre, Winnipeg, MB, Canada*

O-38. Withdrawn

11:00 – 11:25 a.m. O-39. Investigation into Conditions During Early Stage of Kilning to Improve Beer Flavor Stability. *Tsutomu Ueda, Asahi Breweries, Ltd., Ibaraki, Japan*

WORKSHOP II: Sharing the Knowledge: Brewers, Distillers, and Vintners. Steve Wright, Moderator – Randle A/B

8:00 – 11:00 a.m. Brewers, distillers, and vintners share the challenges of working with natural processes and materials. Technical developments can reveal information of value to all groups. Topics to be discussed include advances in instrumental and sensory correlation, future research directions such as novel yeast strains, and identification and characterization of lactic acid bacteria.

- Technical Developments in the Scotch Whisky Industry—What Can the Brewing and Distilling Industries Learn from One Another? *Graham Stewart, Heriot-Watt University, Edinburgh, Scotland*
- Occurrence of Lactic Acid Bacteria in Distilleries and Breweries and Their Development During Mashing. *Elise Cachat, Heriot-Watt University, Edinburgh, U.K.*
- A Study on Characteristic Flavor Compounds in Malt Whisky by the Addition of Brewer's Yeast. *Akira Wanikawa, Asahi Breweries, Ltd., Ibaraki, Japan*
- Analytical Technology in the Wine Industry—A Review of Analytical Tools Currently Available to the Winemaker and Their Potential Applications for Brewers and Distillers. *Gordon Burns, ETS Laboratories, Saint Helena, CA*
- Picking Out the Tuba Player from the Orchestra—Comments on the Similarities and Differences Between Beer and Wine Flavor. *Phil Chou, Modesto, CA*
- Speaker Panel

SUPPLIER SESSIONS

8:30 – 9:15 a.m. EaglePicher Filtration & Minerals – Gregory B
Filtration Media. *Kimberly Walsh, EaglePicher Filtration & Minerals*

8:30 – 9:15 a.m. PBM Inc. – Gregory A
Brewery Sampling Valves. *Jim Pericles, Jerry Foley; PBM Inc.*

9:45 – 10:30 a.m. Procon Technologies – Gregory A
In-Line Beer Analysis with Novel Analysis Technologies. *Willem de Jong (Rhosonics)*

9:45 – 10:30 a.m. Tyco Flow Control / Hygienic Process Equipment – Gregory B
Patented Mixproof Valve Technology. *Paul Lopez, Tyco Flow Control*

11:30 a.m. – 2:00 p.m. Exhibits, Hospitality and Buffet Lunch – Douglas Pavilion

11:30 a.m. – 2:00 p.m. Poster Session (see list on page 37) Authors present 11:30 a.m. – 12:30 p.m. – Douglas Pavilion

TUESDAY, JULY 27

6:45 – 7:45 a.m. Presenters' Breakfast (includes today's presenters of posters P-53 through P-104) – Madeline A/D

7:00 a.m. – 6:00 p.m. Speaker Ready Room – Molly A

7:30 a.m. – 5:00 p.m. Registration – Elizabeth Foyer

7:30 a.m. – 2:00 p.m. Silent Auction – Elizabeth Foyer

7:30 a.m. – 5:00 p.m. Sponsors' Showcase – Elizabeth Foyer

7:30 a.m. – 5:00 p.m. Media Room – Molly B

TECHNICAL SESSION VII: Flavor. Sue Thompson, Moderator – Elizabeth A/C

8:00 – 8:05 a.m. Opening Remarks

8:05 – 8:30 a.m. O-40. A Survey About Different Fractions of Hydroxy Fatty Acids During Malting and Brewing and Their Importance for Beer Flavor Stability. *Stefan Meyna, University of Technology, Berlin, Germany*

8:30 – 8:55 a.m. O-41. Relationship Between the Flavor Compounds Formation and the Gene Expression Profiles of Brewing Yeast. *Atsushi Fujita, Suntory Ltd., Osaka, Japan*

O-42. Withdrawn.

9:15 – 9:45 a.m. Break

9:45 – 10:10 a.m. O-43. Improvement of Beer Flavor Stability by Reducing Deterioration Precursors in Malt. *Takako Inui, Suntory Ltd., Osaka, Japan*

10:10 – 10:35 a.m. O-44. Sensory Techniques for Understanding Consumer Preference. *Debbie Parker, Brewing Research International, Nutfield, Surrey, U.K.*

10:35 – 11:00 a.m. O-45. Unraveling Beer Flavor Through the Use of Gas Chromatography-Olfactometry. *David Maradyn, Interbrew, London, ON, Canada*

11:00 – 11:25 a.m. O-46. Actual Aspects of the Analytical Prediction of Flavor Stability. *Oliver Franz, Technische Universität München, Freising, Germany*

TECHNICAL SESSION VIII: Analysis. Jean-Pierre Dufour, Moderator – Elizabeth D/E

8:00 – 8:05 a.m. Opening Remarks

8:05 – 8:30 a.m. O-47. The Enrichment of Foam-Positive Substances by the Use of Ultrafiltration. *Deniz Bilge, University of Technology, Berlin, Germany*

8:30 – 8:55 a.m. O-48. The Relative Significance of Physics and Chemistry for Beer Foam Excellence. *Charles Bamforth, University of California, Davis, CA*

8:55 – 9:15 a.m. O-49. Comparison of Methods for Assessing Protein in Beer. *Karl Siebert, Cornell University, Geneva, NY*

9:15 – 9:45 a.m. Break

9:45 – 10:10 a.m. O-50. Beer Foam Stability—The Role of Specific Polypeptides. *Graham Stewart, Heriot-Watt University, Edinburgh, Scotland*

10:10 – 10:35 a.m. O-51. Comprehensive Quality Assurance of Asahi Breweries, Ltd. *Hisanori Okita, Asahi Breweries, Ltd., Ibaraki, Japan*

10:35 – 11:00 a.m. O-52. Application of GC/MS Method Using SPE Columns for Quantitative Determination of Diacetyl and 2,3-Pentanedione During Beer Fermentation. *Jelena Pejin, Faculty of Technology, Novi Sad, Serbia and Montenegro*

11:00 – 11:25 a.m. O-53. Beverage Appearance and Flavor Protection from Carbon Dioxide Quality Excursions. *Chris Duffell, domnick hunter ltd., Newcastle, Tyne & Wear, U.K.*

TECHNICAL SESSION IX: Microbiology. Candace Wallin, Moderator – Elizabeth F/H

8:00 – 8:05 a.m. Opening Remarks

8:05 – 8:30 a.m. O-54. Microbial Attachment and Biofilm Formation in Brewery Bottling Plants. *Erna Storgårds, VTT Biotechnology, Espoo, Finland*

8:30 – 8:55 a.m. O-55. Molecular Methods for Detection and Identification of Microbial Contaminants in Brewing Quality Control. *Auli Haikara, VTT Biotechnology, Espoo, Finland*

8:55 – 9:15 a.m. O-56. Microsieves and Fluorochromes—A New Application to Detect Beer-Spoiling Microorganisms. *Karl-Josef Hutter, Eichbaum Brauereien AG, Graben-Neudorf, Germany*

9:15 – 9:45 a.m. Break

9:45 – 10:10 a.m. O-57. Microbiological Quality Control in Breweries Based on Real-Time PCR—Implementation Experiences and Future Potential for Brewery Application. *Andreas Brandl, Technische Universität München, Freising, Germany*

10:10 – 10:35 a.m. O-58. A New Improved PCR Method for the Detection and Identification of Live Spoilage Organisms. *Karin Pawlowsky, Brewing Research International, Nutfield, Surrey, U.K.*

10:35 – 11:00 a.m. O-59. Detection and Identification of Beer-Spoilage Bacteria Using Real-Time PCR. *Matthias Kiehne, BIOTECON Diagnostics GmbH, Potsdam, Germany*

11:00 – 11:25 a.m. O-60. Evaluation Study of the Actual Frequency of Different Beer-Spoiling Bacteria with the VIT Analysis. *Jiri Snaidr, vermicon AG, Munich, Germany*

WORKSHOP III: Malting Barley Variety Development and Evaluation Systems. Erin Armstrong, Moderator – Randle A/B

8:00 – 11:30 a.m. Effective development and evaluation of malting barley varieties is key to the production of high-quality malt and beer. Presenters will review the various systems in place in Canada, the United States, Australia, and Europe. Questions on specific systems, as well as comparisons with those in other parts of the world, will be discussed.

- Purification and Characterization of a Malt Polysaccharide Inducing Premature Yeast Flocculation. *Hideki Koizumi, Kirin Brewery Co., Ltd., Yokohama, Japan*
- Breeding Program USA. *Mike Davis, American Malting Barley Association, Milwaukee, WI*

- Continuous Barley Improvements: Role of EBC Barley and Malt Committee. *Wendell Iverson, Heineken, Zoerterwoude, Netherlands*
- Breeding Program Canada. *Erin Armstrong, Brewing & Malting Barley Research Institute, Winnipeg, MB, Canada*
- Newly Developed Method for Estimating the Premature Yeast Flocculation Potential of Malt Samples. *Makiko Jibiki, Asahi Breweries, Ltd., Ibaraki, Japan*

SUPPLIER SESSIONS

8:30 – 9:15 a.m.	Novozymes – Maggie Viscoflow™. *Noel M. Bautista, Novozymes*
9:45 – 10:30 a.m.	Rockwell Automation – Maggie Tracking and Tracing Solutions: Preserving Your Brand Value. *Paul Nowicki, Rockwell Automation*
11:30 a.m. – 2:00 p.m.	**Exhibits, Hospitality, and Buffet Lunch – Douglas Pavilion**
11:30 a.m. – 2:00 p.m.	**Poster Session (see list on page 37). Authors present 11:30 a.m. – 12:30 p.m. – Douglas Pavilion**

TECHNICAL SESSION X: Fermentation. Dave Ryder, Moderator – Elizabeth A/C

2:00 – 2:05 p.m.	Opening Remarks
2:05 – 2:30 p.m.	O-61. New Results with an Immobilized Yeast System: Secondary Fermentation with IMMOPORE. *Gerrit Blümelhuber, Technische Universität München, Freising, Germany*
2:30 – 2:55 p.m.	O-62. Solid State Fermentation (SSF)—Alternative Fermentation Creating Greater Added Value for Grains. *Mark Lyons, Alltech Inc., Nicholasville, KY*
2:55 – 3:20 p.m.	O-63. Primary Beer Fermentation by PVA-Immobilized Brewing Yeast in a Gas-Lift Bioreactor. *Viktor Nedovic, University of Belgrade, Belgrade-Zemun, Serbia and Montenegro*
3:20 – 3:50 p.m.	Break
3:50 – 4:15 p.m.	O-64. Detection of Beer-Spoilage Microorganisms Using the Loop-Mediated Isothermal Amplification (LAMP) Method. *Youichi Tsuchiya, Sapporo Breweries Ltd., Shizuoka, Japan*
4:15 – 4:40 p.m.	O-65. Genetic Characterization of Hop-Sensitive Variants Obtained from Beer-Spoilage Lactic Acid Bacteria. *Koji Suzuki, Asahi Breweries, Ltd., Ibaraki, Japan*
4:40 – 5:05 p.m.	O-66. Hygiene Monitoring in the Food Industry—A New Approach for Control of the Microbiological Situation. *Frank Nitzsche, Koenig Brauerei GmbH, Duisburg, Germany*

TECHNICAL SESSION XI: Packaging. Christopher Nunes, Moderator – Elizabeth D/E

2:00 – 2:05 p.m. Opening Remarks
O-67. Withdrawn

2:05 – 2:30 p.m. O-68. Development of a Hybrid Canning Line with High Productivity in a New Kyushu-Kumamoto Plant. *Koichi Hotta, Suntory Ltd., Kumamoto, Japan*

2:30 – 2:55 p.m. O-69. Plastic Beer Bottles: Where Are We Today? *Nina Goodrich, Amcor, Mississauga, ON, Canada*

2:55 – 3:20 p.m. O-70. Shortening the Changeover Time of a Can Line into Less than 10 Minutes. *Takahiro Yoneda, Asahi Breweries, Ltd., Ibaraki, Japan*

3:20 – 3:50 p.m. Break

3:50 – 4:15 p.m. O-71. Development and Introduction of High-Performance Full-Bottle Inspector. *Hirohiko Inoue, Asahi Breweries, Ltd., Tokyo, Japan*

4:15 – 4:40 p.m. O-72. Impact the Bottom Line: A Business Case for Reliability-Driven Maintenance. *Paul Lanthier, Ivara Corporation, Burlington, ON, Canada*

TECHNICAL SESSION XII: Beer/Brewing. George Reisch, Moderator – Elizabeth F/H

2:00 – 2:05 p.m. Opening Remarks

2:05 – 2:30 p.m. O-73. Two Different Brewing Processes Disclosed from Two Ancient Egyptian Mural Paintings. *Hideto Ishida, Kirin Brewery Co., Ltd., Tokyo, Japan*

2:30 – 2:55 p.m. O-74. Miller Valley Brewery as a Development Tool in the 21st Century. *Jeanne Marais, Miller Brewing Co., Milwaukee, WI*

2:55 – 3:20 p.m. O-75. Design, Planning, and First Practical Experience—The New Grolsch Brewhouse in Enschede, The Netherlands. *Thomas Buehler, The Huppmann Group, Kitzingen, Germany*

3:20 – 3:50 p.m. Break

3:50 – 4:15 p.m. O-76. Wort Aeration—A Critical Approach. *Christoph Tenge, Technische Universität München, Freising, Germany*

4:15 – 4:40 p.m. O-77. Observations on a Lauter Tun with a New Design. *Heinz Miedaner, Staatliche Brautechnische Prüf- und Versuchsanstal, Freising, Germany*

4:40 – 5:05 p.m. O-78. Today's Small Brewer: An Industry Partner. *Daniel Bradford, Brewers' Association of America, Durham, NC*

WORKSHOP IV: Managing the Supply Chain to Protect Integrity and Ensure Quality. Anne Bridges, Moderator – Randle A/B

2:00 – 5:15 p.m. Managing the supply chain to protect integrity and provide a quality product is challenging in the global marketplace. To be successful requires active participation by all stake-holders. This is of particular interest and concern in managing agbiotech traits or GMOs in products between markets with differing regulatory and labeling regulations. Similar supply chain management strategies apply to value-added traits. Changes in global agriculture and potential changes to the European regulations suggest it is timely to review the options. Validated analysis methods for detection of GMO traits in food are essential but they are only part of the program. Equally important tools include the ability to identify the source of the food or ingredient, to provide appropriate test samples, and to determine the proficiency of the laboratory performing the analysis.

- A New Concept for Traceability and Quality Assurance Within the Production Chain of Brewing Barley and Malt in Germany. *Frank Nitzsche, Koenig Brauerei GmbH, Duisburg, Germany*
- GMOs: What are They, How Do I Detect Them, and Why Should I Care? *Kimberly M. Magin, Monsanto Co., St. Louis, MO*
- Food and Beverage Supply Chain—Identity Preservation, Safety, and Consumer Preferences. *Anne R. Bridges, Minneapolis, MN*
- Testing for Adventitious Presence in Seed: An Industry Perspective. *David Grothaus, Pioneer, A Dupont Company, Johnston, IA*
- Getting a Jump on GMOs: PCR Testing and Its Role in Managing GMOs in Your Supply Chain. *Carl Adams, Minneapolis, MN*
- Analytical Method Validation—Analysis for Products of Modern Biotechnology. *Randal Giroux, Cargill Inc., Wayzata, MN*
- Discussion Forum

SUPPLIER SESSIONS

3:45 – 4:30 p.m. domnick hunter inc., Gas Purification Division – Maggie
CO_2 Purification Device for Draft Beer Dispense. *Gary Robson, domnick hunter inc.,*

2:00 – 6:00 p.m. Exhibit and Poster Take Down – Douglas Pavilion

5:30 – 6:30 p.m. Women In Brewing Reception – America's Cup Terrace

5:00 – 11:00 p.m. Congress Hospitality Lounge – Randle D/E / Foyer

WEDNESDAY, JULY 28

6:45 – 7:45 a.m.	Presenters' Breakfast (includes today's presenters) – Madeline A/D
7:00 a.m. – 11:30 p.m.	Speaker Ready Room – Molly A
7:30 a.m. – 1:30 p.m.	Registration – Elizabeth Foyer
7:30 a.m. – 1:30 p.m.	Sponsors' Showcase – Elizabeth Foyer
7:30 a.m. – 1:30 p.m.	Media Room – Molly B

TECHNICAL SESSION XIII: Yeast. Greg Casey, Moderator – Elizabeth A/C

8:00 – 8:05 a.m.	Opening Remarks
8:05 – 8:30 a.m.	O-79. The Fuel Alcohol Industry: She's Younger, She's Bigger, but Is She Wiser? *W. M. (Mike) Ingledew, University of Saskatchewan Saskatoon, SK, Canada*
8:30 – 8:55 a.m.	O-80. Aroma-Active Ester Formation in Brewer's Yeast: What, How, Where, Why, and How to Control It? *Kevin Verstrepen, MIT Whitehead Institute for Biomedical Research, Cambridge, MA*
8:55 – 9:15 a.m.	O-81. Quality Improvement in Continuous Main Fermentation with Immobilized Yeast. *Andreas Ludwig, University of Technology, Berlin, Germany*
9:15 – 9:45 a.m.	Break
9:45 – 10:10 a.m.	O-82. The New Method for Drying Lager Yeasts. *Takaaki Izumi, Suntory Ltd., Osaka, Japan*
10:10 – 10:35 a.m.	O-83. Control of the Yeast Propagation Process—How to Optimize Oxygen Supply and Minimize Stress. *Olau Nielsen, Alfa Laval Scandi Brew, Soborg, Denmark*
10:35 – 11:00 a.m.	O-84. Different Physiological Marker to Monitor Yeast Propagation and Fermentation by Flow Cytometry. *Karl-Josef Hutter, Eichbaum Brauereien AG, Graben-Neudorf, Germany*
11:00 – 11:25 a.m.	O-85. Stress and the Regulation of Brewing Yeast Flocculation. *Katherine Smart, Oxford Brookes University, Oxford, Oxfordshire, U.K.*

TECHNICAL SESSION XIV: Health and HACCP. Rob Maruyama, Moderator – Elizabeth D/E

8:00 – 8:05 a.m.	Opening Remarks
	O-86. Withdrawn
8:05 – 8:30 a.m.	O-87. Beer and Folates. *Caroline Walker, Brewing Research International, Nutfield, Surrey, U.K.*
8:30 – 8:55 a.m.	O-88. About Beer and Celiac Disease. *Michael Lewis, University of California, Davis, CA*
8:55 – 9:15 a.m.	O-89. HACCP Accreditation at Labatt-Interbrew North America—Corporate and Brewery Perspectives. *Jessica Hudale, Latrobe Brewing Company, LLC (Labatt-Interbrew), Latrobe, PA, and Terrance Dowhanick, Labatt-Interbrew North America, London, ON, Canada*
9:15 – 9:45 a.m.	Break
9:45 – 10:10 a.m.	O-90. Effective Strategies in Implementing HACCP in San Miguel Breweries. *Arnulfo Senires, San Miguel Corp., Mandaluyong City, Philippines*
10:10 – 10:35 a.m.	O-91. Taking Complexity and Cost Out of the Brewing Industry Supply Chain. *Chris Wallace, Scottish Courage Ltd., South Gyle, Edinburgh, Scotland*
10:35 – 11:00 a.m.	O-92. Popular Diets and the Nature of Beer Carbohydrates. *Nathaniel Davis, Anheuser-Busch, Inc., St. Louis, MO*
11:00 – 11:25 a.m.	O-93. Pilot-Scale Investigations into the Production of Filtered Beers Rich in Xanthohumol. *Martin Biendl, Hopsteiner – Hallertauer, Mainburg, Germany*

TECHNICAL SESSION XV: Malting/Mashing. Rob McCaig, Moderator – Elizabeth F/H

8:00 – 8:05 a.m.	Opening Remarks
8:05 – 8:30 a.m.	O-94. Parameters Influencing the Mash Filterability in the Brewing Process. *Robert Braekeleirs, MEURA s.a., Péruwelz, Belgium*
8:30 – 8:55 a.m.	O-95. Advantages of Fine Wet Milling with a Rotor/Stator System (RSS) and Lautering with Thin-Bed Chamber Mash Filter (TCM). *Hans-Jörg Menger, ZIEMANN Ludwigsburg GmbH, Ludwigsburg, Germany*
8:55 – 9:15 a.m.	O-96. Formation Pathways of Trioxilins During Mashing. *Leif-Alexander Garbe, Technische Universität, Berlin, Germany*
9:15 – 9:45 a.m.	Break
9:45 – 10:10 a.m.	O-97. Rheological Studies Simulating the Brewery Mashing Process. *Declan Goode, University College Cork, Cork, Ireland*
10:10 – 10:35 a.m.	O-98. The Impact of the Level and Thermostability of Diastatic Power Enzymes on the Hydrolysis of Malt and/or Rice Starch During Wort Production by a Small-Scale Simulated Mashing Procedure. *Evan Evans, University of Tasmania, Hobart, TAS, Australia*
10:35 – 11:00 a.m.	O-99. Degradation of Beta-Glucan Gel in Model Systems and Unfiltered Beer Due to High Hydrostatic Pressure Treatment. *Steffen Fischer, Technische Universität München, Freising, Germany*
11:00 – 11:25 a.m.	O-100. Application of Lactic Acid Bacteria in Malting and Brewing. *Helge Ulmer, University College Cork, Cork, Ireland*

WORKSHOP V: Brewing Education and Training. Inge Russell, Moderator – Edward A/C

9:30 – 11:30 a.m. Whether you are new to the industry and interested in obtaining a globally recognized qualification or are interested in upgrading your current knowledge base via courses or learning about opportunities for your staff members—this is the seminar to attend. Brewing and distilling education offerings will be addressed. This workshop brings together a number of the top brewing professors/lecturers in the world to discuss what education options are available for brewers and distillers. Each will give a short presentation detailing opportunities, options, length of course, costs, etc. For example, you will hear about studying on location at brewing schools in Germany, Scotland, or California; studying from home using the Institute and Guild of Brewing (IGB) home study modules to prepare for exams to obtain the qualifications of AME (Associate Membership Exam) and DMB (Diploma Master Brewer); or studying as an extension student linked to Heriot-Watt University to obtain a M.Sc./Postgraduate Diploma in brewing and distilling. You will learn about short courses offered by MBAA and by ASBC and about other relevant offerings from related scientific organizations. This workshop is an opportunity to compare educational options and to ask questions of the panel members to determine which venue/offering best meets the needs of you or your organization.

Introduction: *Inge Russell, Russell & Associates, London, ON, Canada*

Presenters: *Graham Stewart, International Centre for Brewing and Distilling, Heriot-Watt University, Edinburgh, Scotland, U.K.*
David Taylor, The Institute and Guild of Brewing, London, U.K.
Karl Wackerbauer, Research Institute of Brewing and Malting of VLB/TUB, Berlin (TUB)
Charles Bamforth, University of California, Davis, CA
Ray Klimovitz, MBAA Technical Director, Chippewa Falls, WI

Q & A with Audience

11:30 a.m. – 1:30 p.m. Hospitality and Lunch – Elizabeth Foyer and Elizabeth A/E

WBC 2004 CLOSING PLENARY SESSION: The Next Big Thing Is Really Small: How Nanotechnology Will Change the Future of Your Business – Elizabeth A/E

1:30 – 3:15 p.m. Jack Uldrich, nanotechnology consultant and author of *The Next Big Thing is Really Small*

By 2013, it is estimated that nanotechnology will account for $1 trillion in new products and services. It is further estimated that the United States will need 2 million new workers trained in the field. In his presentation, Jack Uldrich, will explain what nanotechnology is and why President Bush, in December of 2003, signed into law a $3.7 billion bill to establish the National Nanotechnology Initiative - the largest federally funded science program since the United States decided to put a man on the moon. Uldrich will document the flurry of nanotechnology research that is taking place in the R&D labs of Fortune 500 companies, as well as introduce participants to the most promising nanotechnology start-ups. He will then describe how the field has captured the imagination of the venture capital community and reveal which companies (and technologies) will reach the commercial marketplace in the next few years. Uldrich will conclude by explaining how nanotechnology will affect virtually every business and describe the concrete steps that people can begin taking today in order to prepare for the sweeping change that nanotechnology will enable tomorrow.

7:00 p.m. Closing Reception – Elizabeth Foyer/Terrace

7:30 – 11:00 p.m. Closing Banquet (business attire) – Elizabeth Ballroom

Make a difference in a student's life—participate in the joint ASBC and MBAA Foundations' Silent Auction. Proceeds from the auction will benefit the ASBC and MBAA scholarship programs.

Sunday	8:00 a.m. – 5:30 p.m.
Monday	7:30 a.m. – 2:30 p.m.
Tuesday	7:30 a.m. – 2:00 p.m.

ASBC Foundation

MBA FOUNDATION

POSTER SESSION

Douglas Pavilion

Posters are on display from 11:30 a.m. to 2:00 p.m. Sunday through Tuesday, July 25–27.

Moderators: Gil Sanchez, Milwaukee, WI, and John Engel, Miller Brewing Company, Milwaukee, WI

P-1 Differential Spectroscopy and Beer Oxidation. *Jan Savel, Budejovicky Budvar, N.C., Ceske Budejovice, Czech Republic*

P-2 Potential Ways of Methionine Degradation and Their Impact on Beer Flavor. *Olivier Duthoit, Université Catholique de Louvain, Louvain-la-Neuve, Belgium*

P-3 Development of a Biosensor for Monitoring Diacetyl During Beer Fermentation and Maturation. *John Sheppard, McGill University, Ste-Anne de Bellevue, QC, Canada*

P-4 In situ Optical Rotation Measurement for On-Line Monitoring of Brewery Fermentations. *Jorge Huerta, Oregon State University, Corvallis, OR*

P-5 Comparison of Methods for Assessing Colloidal Stability of Beer. *Karl Siebert, Cornell University, Geneva, NY*

P-6 Measurement of Nonenal Potential by Solid-Phase Microextraction (SPME). *Carsten Zufall, Cervecería Polar, C.A., Caracas, DF, Venezuela*

P-7 Development of a Headspace Gas Chromatography Method for the Analysis of Vicinal Diketones and Flavor-Active Analytes in Fresh Beer Samples. *Jennifer Helber, Boulevard Brewing Co., Kansas City, MO*

P-8 Single-Run Ion Chromatographic Analysis for a Complete Monitoring of Brewery-Related Ions Without Manual Sample Pretreatment. *Frank Nitzsche, Koenig Brauerei GmbH, Duisburg, Germany*

P-9 New Analysis Methods—Detection and Measurement of Carbon Dioxide in Beer Samples with NIR. *Frank Nitzsche, Koenig Brauerei GmbH, Duisburg, Germany*

P-10 New Method for the Determination of Beer Gushing Directly from Barley. *Josef Havel, Department of Analytical Chemistry, Masaryk University, Faculty of Science, Brno, Czech Republic*

P-11 5,5-Dithiobis-(2-Nitrobenzoic Acid) as an Alternative to Para-Rosaniline in the Colorometric Determination of Total SO_2 in Beer. *Alicia Carruthers, Interbrew, London, ON, Canada*

P-12 Electron Paramagnetic Resonance (EPR) Studies Comparing Wort Boiling Temperatures and Various Levels of SO_2 in Packaged Beer. *Robert Foster, Coors Brewing Co., Golden, CO*

P-13 Use of LC-APCI-MS/MS to Detect *trans*-Resveratrol, a Determinant Nutrition Key for Health, in Hop Pellets. *Sonia Collin, Unité de Brasserie et des Industries Alimentaires, Louvain-la-Neuve, Belgium*

P-14 The Business Case for the Smart Brewhouse. *Rene Beck, Emerson Process Management, Golden, CO*

P-15 New Investigations on Thin-Layer Evaporators for Wort Boiling. *Jens Voigt, Technische Universität München, Freising, Germany*

P-16 New Findings on Wort Boiling with Internal Calandrias. *Matthias Weinzierl, Anton Steinecker Maschinenfabrik GmbH, Freising, Germany*

P-17 Matching the Benefits of Automation with Brewery Growth. *Rene Beck, Emerson Process Management, Golden, CO*

P-18 New Formulas for Sharper Calculation. *Henning Nielsen, Scandinavian School of Brewing, Hellerup, Denmark*

P-19 Purification, Identification, and Properties of Diacetyl Reductase Enzymes in Ale and Lager Brewing Yeasts. *Barry van Bergen, McGill University, Ste-Anne-de-Bellevue, QC, Canada*

P-20 Brewing Performance of Lipoxygenase-1-Less Barley. *Naohiko Hirota, Bioresources Research and Development Labs, Gunma, Japan*

P-21 The Partial Substitution of Hot Filler Sanitation by a Cold Chemical Sanitizer. *George Agius, JohnsonDiversey Inc., Oakville, ON, Canada*

P-22 Optimal Asset Utilization in the 21st Century Brewery. *Bruce Schmidt, Ecolab Inc., Mendota Heights, MN*

P-23 Tank Farm CIP Optimization as an Example of Engineering Process Management in the Brewery. *Peter Koestler, The Gambrinus Co., San Antonio, TX*

P-24 The Safe Use of Chlorine Dioxide, Benefits to the Brewer. *Donald Hobro, Halox Technologies, Bridgeport, CT*

P-25 Enhancing the 'Craft' in Craft Brewing with Automation. *Al Marzi, Harpoon Brewing, Boston, MA*

P-26 Detergency and Efficacy in Draft Dispense System Cleaning. *Jaime Jurado, The Gambrinus Co., San Antonio, TX*

P-27 An Empirical Study of Hydrogen and Methane Two-Stage Production Directly from Brewery Effluent by Anaerobic Fermentation. *Yutaka Mitani, Sapporo Breweries Ltd., Shizuoka, Japan*

P-28 Efficient Energy Consumption System in New Suntory Kyushu-Kumamoto Plant. *Yoshinori Nishiwaki, Suntory Ltd., Kumamoto, Japan*

P-29 The Effect of Fermentation Temperature on the Production of Hydrogen Sulfide. *Young-Ran Kim, Kyung Hee University, Yongin-Si, South Korea*

P-30 Prevention of Protein-Polyphenol Haze in Beer Using a Proline-Specific Protease. *Michel Lopez, DSM Food Specialties, Seclin, France*

P-31 The Dangers of SASPL in Chillproofing Evaluation. *Kenneth Berg, The PQ Corporation, Conshohocken, PA*

P-32 Beer Filtration: Membrane Morphology and Fluid Dynamics. *John Brantley, Pall Corporation, Cortland, NY*

P-33 Membrane Filtration and Diafiltration of Mash for Wort Production. *Jan Schneider, VLB Berlin, Berlin, Germany*

continued

P-34 Cristobalite-Free Kieselguhr for Beer Filtration. *Dominik Antoni, Technische Universität München, Freising, Germany*

P-35 Adsorption of Beer Components During Membrane Microfiltration of Beer. *Peter Riddell, domnick hunter ltd., Birtley, County Durham, U.K.*

P-36 Wet-Mechanical Recycling of Filter Aid in Breweries. *Andreas Tramm, ATM GmbH, Vlotho, Germany*

P-37 CSS Combined Beer Stabilization. *Axel Jany, A. Handtmann Armaturenfabrik, Biberach, Germany*

P-38 Ethyl Pyruvate—A New Indicator of Flavor Stability of Beer and Its Controlling Factors. *Chikako Shimizu, Sapporo Breweries Ltd., Yaizu, Shizuoka, Japan*

P-39 Application of a New Electronic Nose with Fingerprint Mass Spectrometer to Brewing. *Hidetoshi Kojima, Sapporo Breweries Ltd., Yaizu, Shizuoka, Japan*

P-40 The Impact of Lipid Binding Proteins on the Flavor Stability of Beer. *Daniel Cooper, Brewing Research International, Nutfield, Surrey, U.K.*

P-41 Flavor Matching Using a Statistical Experimental Design. *Behnam Taidi, Scottish Courage Ltd., Edinburgh, Midlothian, Scotland*

P-42 Colloidal Stability and Flavan-3-ols. *Marc Kusche, Lehrstuhl für Technologie der Brauerei II/TUM, Freising, Germany*

P-43 Improving Flavor Panel Performance Using Structured Training and Validation. *Olav Vind Larsen, Alfred Jorgensen Laboratory/Danbrew PCD, Frederiksberg, Denmark*

P-44 Flavor Quality Control. *Lawrence Nielsen, Microanalytics, Round Rock, TX*

P-45 Investigation into Conditions in Steeping and Germination to Improve Beer Flavor Stability. *Katsuya Sasaki, Asahi Breweries, Ltd., Ibaraki, Japan*

P-46 How to Effectively Identify Flavor Compounds in Beer. *Lawrence Nielsen, Microanalytics, Round Rock, TX*

P-47 Developing HACCP Programs in Grain-Based Brewing and Food Ingredient Production Facilities. *Brad Rush, Briess Malt & Ingredients Co., Chilton, WI*

P-48 HACCP Activities Within the Slovenian Hop Industry. *Majda Virant, Slovenian Institute for Hop Research and Brewing, Zalec, Slovenia*

P-49 Differences in the UV Spectra of the Hop-Derived *cis*- and *trans*-Iso-Alpha-Acids. *Paul Hughes, Heineken Technical Services, Zoeterwoude, Netherlands*

P-50 Isomerization Kinetics of Hop Bitter Acids During Wort Boiling. *Mark Malowicki, Oregon State University, Corvallis, OR*

P-51 Analysis of Iso-Alpha-Acids and Reduced Iso-Alpha-Acids in Beer by Direct Injection and LC-UV/LC-MS. *Denis De Keukeleire, Ghent University, Ghent, Belgium*

P-52 Screening of Hop Varieties for Genes Involved in the Formation of Bioactive Prenylated Chalcones. *Arne Heyerick, Ghent University, Ghent, Belgium*

P-53 DNA Typing of Hop Using Sequence-Tagged Microsatellite Site Markers. *Daisuke Kanai, Asahi Breweries, Ltd., Ibaraki, Japan*

P-54 The Influence of Naturally Occurring Hop Acids on the BU Analyses of Dry-Hopped Beers. *Robert Smith, S.S. Steiner, Inc., Yakima, WA*

P-55 The Comprehensive Analysis of Hop Oil Using Two-Dimensional Gas Chromatography Combined with Time-of-Flight Mass Spectrometry. *Jean-Pierre Dufour, University of Otago, Dunedin, New Zealand*

P-56 Evaluation of the Effects of Iso-Alpha-Acids on Seals and Sealing Materials. *Timothy Duzick, Greene, Tweed, Kulpsville, PA*

P-57 Freeze Drying for Germination Maintenance of Barley Germ Plasm. *Eugenio De la Mora Miquel, Extractos y Maltas, S.A., Mexico City, DF, Mexico*

P-58 Reduction of Deoxynivalenol in Contaminated Barley by Malting and Physicochemical Treatment. *Won Jong Lee, Kangnung National University, Kangnung, Korea*

P-59 A New Method for Assessing Water Distribution in Steeped Barley. *Daniel Cooper, Brewing Research International, Nutfield, Surrey, U.K.*

P-60 Trends in Production and Supply of Canadian Malting Barley Varieties. *Michael Brophy, Canadian Wheat Board, Winnipeg, MB, Canada*

P-61 Molecular Characterization of Allelic Variants of Beta-Amylase. *Nora Lapitan, Colorado State University, Fort Collins, CO*

P-62 Enzymes: The Difference Between Malt and Feed Barley. *Glen Fox, Southern Cross University, Glenvale, QLD, Australia*

P-63 Improved Assay for Barley Seed and Green Malt Proteases. *Mark Schmitt, USDA-ARS, Madison, WI*

P-64 Effect of Fermentable Sugars and Amino Acids on Fermentability of Malts Made from Four Barley Varieties. *Dennis Langrell, Canadian Grain Commission, Winnipeg, MB, Canada*

P-65 Quality of Buckwheat Malts Germinated at Different Temperatures. *Hilde Wijngaard, National University of Ireland, Cork, Ireland*

P-66 Mathematical Models for Predicting the Effect of Electron-Beam Radiation on the Safety and Quality of *Fusarium*-Infected Malting Barley. *Balasubrahmanyam Kottapalli, North Dakota State University, Fargo, ND*

P-67 Single Malt Kernel Homogeneity Analysis and Processability of Malt. *Frank Nitzsche, Koenig Brauerei GmbH, Duisburg, Germany*

P-68 Optimal Malt Quality and Lautering Problems—Identification of Enzyme Activities to Optimize Processability of Malt. *Frank Nitzsche, Koenig Brauerei GmbH, Duisburg, Germany*

P-69 Improvement of the Microbiological Analysis by Use of Real-Time PCR. *Gudrun Vogeser, PIKA Weihenstephan GmbH, Freising, Germany*

P-70 Detection of *Fusarium* spp. Using the Loop-Mediated Isothermal Amplification (LAMP) Method. *Yasukazu Nakakita, Sapporo Breweries Ltd., Shizuoka, Japan*

P-71 Insect Contamination Hazard in a Brewery. *Gianluca Donadini, Università Cattolica del Sacro Cuore, Istituto di Entomologia e Patologia Vegetale, Piacenza, Italy*

P-72 Rapid and Automated Inspection System of Beer-Spoilage Bacteria. *Takaomi Yasuhara, Asahi Breweries, Ltd., Ibaraki, Japan*

P-73 High-Pressure Inactivation of Beer-Spoiling Lactobacilli. *Rudi Vogel, Technische Universität München, Freising, Germany*

P-74 Monitoring and Controlling Microbiological Contamination in the Beer Filling Area. *Joe Dirksen, Ecolab Inc., Shoreview, MN*

P-75 Enhancing the Performance of Bottlewash Solutions. *George Agius, JohnsonDiversey Inc., Oakville, ON, Canada*

P-76 New Conclusions in Measurements of Permeation Through Plastic Bottles and Closures. *Martin Orzinski, Research and Teaching Institute for Brewing, Berlin, Germany*

P-77 Feasibility Study of DLC-Coated PET Bottle for Beer. *Masaki Nakaya, Kirin Brewery Co., Ltd., Yokohama, Japan*

P-78 New Approach to the Optimization of Filling and Packaging Lines by Efficient IT Applications. *Tobias Voigt, Technische Universität München, Freising, Germany*

P-79 Cost-Performance Analysis on Plastic Packaging Solutions for Beer. *Aida Aranda, BP Chemicals, Naperville, IL*

P-80 Strategic Training System for Brewery Workers. *Hideya Sakamoto, Suntory Ltd., Tokyo, Japan*

P-81 The Optimization of Water Consumption in Beer Brewery by Applying the Water Pinch Technology. *Tetsuji Yano, Suntory Ltd., Tokyo, Japan*

P-82 On-Line Biomass Monitoring with Scanning Radio-Frequency Impedance Spectroscopy. *John Carvell, Aber Instruments Ltd., Aberystwyth, Ceredigion, U.K.*

P-83 Dry Beer Yeast—New Aspects of Rehydration, Storage, and Shelf Life. *Tobias Fischborn, Lallemand Inc., Montreal, QC, Canada*

P-84 Investigation into Genes that are Related to the Insufficient Growth of *Saccharomyces cerevisiae* at Low Temperatures. *Hiromi Yamagishi, Asahi Breweries, Ltd., Ibaraki, Japan*

P-85 Temporal Production of Platelet-Activating Factor by Yeast (*Saccharomyces cerevisiae* and *Saccharomyces uvarum*) at Different Temperatures. *William Roudebush, Reproductive Biology Associates, Atlanta, GA*

P-86 Anaerobiosis Stress Response in Brewing Yeast Strains. *Stephen Lawrence, Oxford Brookes University, Oxford, Oxfordshire, U.K.*

P-87 Yeast Handling and Cold Shock Stress. *Jessica Leclaire, Oxford Brookes University, Oxford, Oxfordshire, U.K.*

P-88 Genome-Wide Analysis of Gene Expression for Hydrogen Sulfide Production in the Bottom-Fermenting Yeast *Saccharomyces pastorianus*. *Toshiko Minato, Kirin Brewery Co., Ltd., Yokohama, Japan*

P-89 Measuring Oxidative Stress in Yeast Cells—A New Approach to Look into Yeast Cells. *Frank Nitzsche, Koenig Brauerei GmbH, Duisburg, Germany*

P-90 Key Enzyme Activities and the Physiological State of Brewing Yeast During Propagation and Fermentation. *Urs Wellhoener, Technische Universität München, Freising, Bayern, Germany*

P-91 Filtration Characteristics of Fermented Wort Mediated by Yeast Strain Selection. *Philip Douglas, Adelaide University, Glen Osmond, SA, Australia*

P-92 Improving the Prediction and Monitoring of Brewing Yeast Performance Using Flow Cytometry. *Michaela Miedl, Heriot-Watt University, Edinburgh, Scotland*

P-93 The Novel Yeast Propagation Method for the Appropriate Fermentation of Beer. *Takeshi Kurashige, Asahi Breweries, Ltd., Osaka, Japan*

P-94 Yeast Quality and Quantity Management System. *Shigehiro Yoshizaki, Kirin Brewery Co., Ltd., Yokohama, Japan*

P-95 Uptake and Utilization of Zinc by Brewing Yeasts. *Graeme Walker, University of Abertay Dundee, Dundee, Tayside, Scotland*

P-96 Measurement of Yeast Vitality—A Comparison of Methods. *Frithjof Thiele, Lehrstuhl für Technologie der Brauerei I/TUM, Freising, Germany*

P-97 Modelling of Yeast Growth and Physiology. *Tomas Kurz, University of Technology, Berlin, Germany*

P-98 Effect of the Storage of Surplus Yeast on the Quality of Recoverable Yeast Beer. *Mark Schneeberger, Lehrstuhl für Technologie der Brauerei I/TUM, Freising, Germany*

P-99 Cross Flow Microfiltration of Yeast—Detection of Proteinase A Activity in Recovered Beer and Estimation of Enzyme Inactivation Conditions. *Diedrich Harms, Koenig Brauerei GmbH, Duisburg, Germany*

P-100 Polar Lipids of *Saccharomyces cerevisiae*. *Wolfgang Tosch, University of Manchester, Manchester, U.K.*

P-101 An Examination of the Relationship Between Yeast and Beer Style. *Christopher White, White Labs Inc., San Diego, CA*

P-102 Subcellular Localization of the Acetate Ester Synthase Atf1. *Kevin Verstrepen, MIT Whitehead Institute for Biomedical Research, Cambridge, MA*

P-103 Waste Yeast, an Energy Commodity. *Floris Delee, New Belgium Brewing Co. Inc., Ft. Collins, CO*

P-104 CO_2 Brewery Self Sufficiency and Best in Quality. *Jos Sloesen, Haffmans B.V., Venlo, Netherlands*

WORKSHOPS

WORKSHOP I: Maintenance: Is There a Better Practice?

This workshop will cover the foundational elements associated with developing a world-class maintenance organization. Representatives will provide practical examples of how asset management has had a positive impact on product quality, throughput improvements, inventory management, and safety from both Coors Brewing Company and Molson. Quality improvements include DOs, DMS, and customer complaints.

Moderator: Dan Robert

WORKSHOP II: Sharing the Knowledge: Brewers, Distillers, and Vintners

Brewers, distillers, and vintners share the challenges of working with natural processes and materials. Technical developments can reveal information of value to all groups. Topics to be discussed include advances in instrumental and sensory correlation, future research directions such as novel yeast strains, and identification and characterization of lactic acid bacteria.

Moderator: Steve A. Wright

Steven A. Wright is a native of Southern Ontario and attended the University of Guelph, earning B.Sc. and M.Sc. degrees in applied microbiology. Steve entered the distilled spirits industry in 1980 in fulfillment of his master's degree program, and he has kept his career in fine spirits since that time. Over his years in the industry, Steve has had experience in distillery fermentation research, operations troubleshooting, analytical methods development, HACCP auditing, and new product development. Steve has 22 years of service with Hiram Walker and Allied Domecq Spirits & Wine, and he is currently liquid development director with Allied Domecq's Global Marketing Group. In this role, Steve is responsible for the development of new, spirits-based products in support of Allied Domecq's core global brands. Steve is a past president of the Distillers Grains Technology Council and is a long-standing member of the ASBC. He enjoys speaking at technical and industry meetings and workshops and sharing his insights into the science and the heritage of whiskies and other distilled beverages.

Technical Developments in the Scotch Whisky Industry—What Can the Brewing and Distilling Industries Learn from One Another?

Graham Stewart

Graham Stewart received B.Sc. degrees in microbiology and biochemistry from the University of Wales and Ph.D. and D.Sc. degrees from the University of Bath. He was a lecturer in biochemistry at Portsmouth University from 1967 to 1969. He began employment with the Labatt Brewing Company in 1969, based in London, Ontario, Canada. He held a number of scientific/technical positions with Labatt's, and from 1986 to 1994, held the post of technical director. From 1994 to the present, he has been professor and director of the International Centre for Brewing and Distilling at Heriot-Watt University in Edinburgh, Scotland. He is a member of the Master Brewers Association of the Americas, the American Society of Brewing Chemists, the Institute of Brewing Studies, and the Institute and Guild of Brewing and, in 1999 and 2000, was this Institute's president.

Occurrence of Lactic Acid Bacteria in Distilleries and Breweries and Their Development During Mashing

Elise Cachat

Elise Cachat obtained her M.Sc. degree in organic chemistry from Heriot Watt University before joining the International Centre for Brewing & Distilling as a Ph.D. student at the same university. She is now in the final year of her studies and gratefully acknowledges the financial support of Suntory Ltd.

A Study on Characteristic Flavor Compounds in Malt Whisky by the Addition of Brewer's Yeast

Akira Wanikawa

Akira Wanikawa received a B.S. degree in agricultural chemistry from Hokkaido University in Japan. He joined The Nikka Whisky Distilling in April 1987 in a cider plant, Hirosaki plant. He was transferred to the R&D institute in 1992 and began to study flavors in malt whisky. He was then transferred to the brewing R & D laboratory of Asahi Brewery, a same group company, in April 2001. He earned a Ph.D. degree in agriculture chemistry from Hokkaido University in 2002 with work on sweet and fatty flavor compounds in malt whisky and their pathway. His current work is research on several flavor compounds of fermentation.

Analytical Technology in the Wine Industry—A Review of Analytical Tools Currently Available to the Winemaker and Their Potential Applications for Brewers and Distillers

Gordon Burns

Gordon Burns is the owner and technical director of ETS Laboratories in Saint Helena, CA. ETS has served the wine industry since 1977. Gordon is a member of the American Society for Enology & Viticulture, the Association of Official Analytical Chemists, the American Society of Brewing Chemists, and others. He is a past president of the Pacific Southwest Section of the AOAC, and he serves on the Wine Institute and American Society of Enology and Viticulture Technical Projects Committees.

Picking Out the Tuba Player from the Orchestra—Comments on the Similarities and Differences Between Beer and Wine Flavor

Phil Chou

After a childhood spent in Southern California, Phil Chou earned chemistry degrees from the University of Utah (B.S. in 1984), the University of Wyoming (M.S. in 1986), and the University of Minnesota (Ph.D. in 1992). He furthered his education through postdoctoral appointments at the University of Pittsburgh and Purdue University. Subsequently, he began his professional career in 1996 with a position at Great Lakes Corporation, developing new polymer additives. Phil's interest in brewing brought him to Miller Brewing Company in 2000, where he was hired as a chemist in the R&D Group. His primary focus was in the field of hop chemistry. After 3 years with Miller, Phil moved to his current job in the Grape and Wine Chemistry Group at the E&J Gallo Winery in Modesto, CA. An important area of his work centers on applying chemical principles to the improvement of wine-making processes and product quality.

WORKSHOP III: Malting Barley Variety Development and Evaluation Systems

Effective development and evaluation of malting barley varieties is key to the production of high-quality malt and beer. Presenters will review the various systems in place in Canada, the United States, Australia, and Europe. Questions on specific

systems, as well as comparisons with those in other parts of the world, will be discussed.

Moderator: Erin Armstrong

Bio unavailable.

Purification and Characterization of a Malt Polysaccharide Inducing Premature Yeast Flocculation

Hideki Koizumi

Hideki Koizumi received a master of science degree in biochemistry from Kyoto University, Japan. He began employment with Kirin Brewery in April 1999 as a researcher in the Central Laboratories for Key Technology.

Breeding Program USA

Mike Davis

Dr. Mike Davis is president of the American Malting Barley Association, Inc. (AMBA), a nonprofit trade association comprised of major U.S. brewing and malting companies. The primary purpose of the AMBA is to encourage and support an adequate supply of high-quality malting barley for the malting and brewing industry and to increase our understanding of malting barley. Dr. Davis received a B.S. degree in biology from the University of Connecticut, an M.S. degree in agronomy from Purdue University, and a Ph.D. degree in agronomy with a minor in biochemistry at the University of Nebraska. He is chair of the AMBA Technical Committee; executive secretary of the National Barley Improvement Committee; member of the U.S. Wheat & Barley Scab Initiative Executive and Steering Committees; and executive secretary of the North American Barley Genome Mapping Project.

Continuous Barley Improvements: Role of EBC Barley and Malt Committee

Wendell Iverson

Wendell Iverson has a B.Sc. degree in molecular biology from the Massachusetts Institute of Technology, a Ph.D. degree in fermentation technology from the University of Melbourne, and an M.Sc. degree in technology management and an M.B.A. degree from Washington University in St. Louis. He has worked at the Swiss Federal Institute of Technology in Zurich, Switzerland, Anheuser-Busch in St. Louis, MO, U.S.A., and Washington University in St. Louis. Since 1995, he has worked for Heineken, where he is currently manager, R&D strategy.

Breeding Program Canada

Erin Armstrong

Bio unavailable.

Newly Developed Method for Estimating the Premature Yeast Flocculation Potential of Malt Samples

Makiko Jibiki

Makiko Jibiki is a microbiologist at the Brewing Research & Development Laboratory, Asahi Breweries, Ltd. in Ibaraki, Japan. She received her M.S. degree in agriculture from Chiba University in 1990 and joined Asahi Breweries, Ltd. She has been engaged both in quality assurance and fundamental research in yeast physiology and its function in brewing.

WORKSHOP IV: Managing the Supply Chain to Protect Integrity and Ensure Quality

Managing the supply chain to protect integrity and provide a quality product is challenging in the global marketplace. To be successful requires active participation by all stake-holders. This is of particular interest and concern in managing agbiotech traits or GMOs in products between markets with differing regulatory and labeling regulations. Similar supply chain management strategies apply to value-added traits. Changes in global agriculture and potential changes to the European regulations suggest it is timely to review the options. Validated analysis methods for detection of GMO traits in food are essential but they are only part of the program. Equally important tools include the ability to identify the source of the food or ingredient, to provide appropriate test samples, and to determine the proficiency of the laboratory performing the analysis.

Moderator: Anne R. Bridges

Dr. Anne Bridges received her academic training in Australia and Canada. She is chair of the American Association of Cereal Chemists (AACC) Technical Committee for Biotechnology Methods. In this role, she has helped organize several international collaborative studies and symposia directed to the discussion of the availability of testing methods, appropriateness, and challenges of testing for biotechnology events in food throughout the food supply chain. The committee provides methods for the AACC Approved Methods *and participates in international standards activities relating to testing methods. Dr. Bridges has participated in many international conferences and discussions regarding the importance of validated testing of ag biotech traits. Recent activities have included participation in ISO discussions on standards elaborated by CEN; participation in the Working Group on Biotechnology and the CCMAS discussions at Codex; and participation in ILSI training programs in Brazil, Argentina, India, and Columbia. Dr. Bridges has also led programs in the United States for government scientists at the FDA and EPA, and most recently, for the Sino US-Agricultural Biotechnology Safety Assessment Study Tour Workshop. Dr. Bridges was with the Quality and Regulatory Organization at General Mills Inc. and was a member of Medallion Laboratories, a Division of General Mills, that provides testing services, including biotechnology testing to the food industry.*

A New Concept for Traceability and Quality Assurance Within the Production Chain of Brewing Barley and Malt in Germany

Frank Nitzsche

Dr. Frank Nitzsche (born in 1960) studied to become a brewer and maltster at Veltins Brauerei, Germany, between 1981 and 1983. He received a master's degree in brewing science from TU Muenchen-Weihenstephan in 1988. His Ph.D. work was done with Prof. Dr. Narziss until 1991. Since then he has been working for Koenig Brauerei as head of the R&D department at Koenig Brauerei until 1994, as head of QA until 1997, and nowadays, he is responsible for production and QA. In 1999, he founded Easyproof Laborbedarf GmbH, which works mainly on fast microbiological detection methods.

continued

GMOs: What are They, How Do I Detect Them, and Why Should I Care?

Kimberly M. Magin

Kim Magin joined Monsanto in 1993. She currently is director for oilseed industry affairs focusing on the development of new and existing programs to promote domestic demand for U.S. soybeans and to create value-added products; working to maintain and expand the global freedom to operate for Roundup Ready soy and canola, and to market acceptance and education. Prior to joining industry affairs, she specialized in the development and strategy for detection methods, method validation, and harmonization. She is a member of several method validation and testing standardization committees, including the Committee for European Norms, American Association of Cereal Chemists, Oil Chemist Society, and Association of Analytical Chemists, which are addressing method validation, standardization, and harmonization. She is the chair of the U.S. technical advisory committee to the ISO.

Food and Beverage Supply Chain—Identity Preservation, Safety, and Consumer Preferences

Anne R. Bridges

Dr. Anne Bridges received her academic training in Australia and Canada. She is chair of the American Association of Cereal Chemists (AACC) Technical Committee for Biotechnology Methods. In this role, she has helped organize several international collaborative studies and symposia directed to the discussion of the availability of testing methods, appropriateness, and challenges of testing for biotechnology events in food throughout the food supply chain. The committee provides methods for the AACC Approved Methods *and participates in international standards activities relating to testing methods. Dr. Bridges has participated in many international conferences and discussions regarding the importance of validated testing of ag biotech traits. Recent activities have included participation in ISO discussions on standards elaborated by CEN; participation in the Working Group on Biotechnology and the CCMAS discussions at Codex; and participation in ILSI training programs in Brazil, Argentina, India, and Columbia. Dr. Bridges has also led programs in the United States for government scientists at the FDA and EPA, and most recently, for the Sino US-Agricultural Biotechnology Safety Assessment Study Tour Workshop. Dr. Bridges was with the Quality and Regulatory Organization at General Mills Inc. and was a member of Medallion Laboratories, a Division of General Mills, that provides testing services, including biotechnology testing to the food industry.*

Testing for Adventitious Presence in Seed: An Industry Perspective

Dave Grothaus

Dave Grothaus received M.S. and Ph.D. degrees from the Ohio State University in microbiology and immunology, respectively. His postdoc work was at the University of Missouri (Columbia) in molecular biology from 1984 to 1992. Dave worked at DNA Plant Technology Corporation in New Jersey as director of research for the start-up plant biotechnology company and developed immunodiagnostic kits for plant diseases, pesticides, and environmental contaminants. From 1992 to the present, Dave has worked at Pioneer Hi Bred International in Johnston, IA, as research coordinator for Transgene Analysis, Discovery Research, Pioneer, A Dupont Company. He is responsible for the development, validation, and application of methods for the detection and quantification of transgenic proteins in plant tissue and seed.

Getting a Jump on GMOs: PCR Testing and Its Role in Managing GMOs in Your Supply Chain

Carl A. Adams

Dr. Carl A. Adams received his B.A. degree in chemistry from Hamline University (St. Paul, MN) and his Ph.D. degree in agricultural chemistry from the University of California, Berkeley. After postdoctoral work in the area of plant gene expression at Texas A&M University, he worked for EniMont America in Princeton, NJ. He subsequently spent several years at 3M inventing rapid methods of microbial detection, after which he transferred to General Mills, where he managed Medallion Labs' Biotech Testing Lab. He is the author and coauthor of several research papers and patents.

Analytical Method Validation—Analysis for Products of Modern Biotechnology

Randal Giroux

Dr. Randal Giroux currently serves as the scientific lead for Cargill's Corporate Biotechnology Council. He is recognized both nationally and internationally as an expert in agricultural biotechnology and the application of test methods for GM detection in the grain handling industry. Dr. Giroux is active professionally in agricultural biotechnology and works with a number organizations, including the American Association of Cereal Chemists, the International Life Science Institute (ILSI), and the Analytical Environmental Immunochemical Consortium (AEIC), as a member of the Technical Advisory Group for U.S. participation within the ISO TC 34 WG7 "Detection methods for genetically modified organisms and derived products", and most recently was selected to serve as a member of the USDA Secretary's Advisory Committee on Biotechnology and 21st Century Agriculture. Prior to joining Cargill, Inc., Dr. Giroux was the program manager of the Plant Molecular Biology Program in the Grain Research Laboratory of the Canadian Grain Commission focused on DNA-based varietal identification methods and the development of testing methods for genetically modified plants. Dr. Giroux possesses a unique skill set in agricultural biotechnology that allows him to understand biotechnology at a highly technical level and also address its potential impacts and opportunities in the agricultural-based industries.

WORKSHOP V: Brewing Education and Training

Whether you are new to the industry and interested in obtaining a globally recognized qualification or are interested in upgrading your current knowledge base via courses or learning about opportunities for your staff members—this is the seminar to attend. Brewing and distilling education offerings will be addressed. This workshop brings together a number of the top brewing professors/lecturers in the world to discuss what education options are available for brewers and distillers. Each will give a short presentation detailing opportunities, options, length of course, costs, etc. For example, you will hear about studying on location at brewing schools in Germany, Scotland, or California; studying from home using the Institute and Guild of Brewing (IGB) home study modules to prepare for exams to obtain the qualifications of AME (Associate Membership Exam) and DMB (Diploma Master Brewer); or studying as an extension student linked to Heriot-Watt University to obtain a M.Sc./Postgraduate Diploma in brewing and distilling. You will learn about short courses offered by MBAA and by ASBC and about other relevant offerings from related scientific organizations. This workshop is an opportunity to compare educational options and to ask questions of the panel members to determine which venue/offering best meets the needs of you or your organization.

Moderator: Inge Russell

Inge Russell received her B.Sc. degree from the University of Western Ontario and her Ph.D. and D.Sc. degrees in yeast biochemistry from the University of Strathclyde, Scotland. Over the past 31 years, she held various roles at Labatt/Interbrew, including research scientist, managing R&D, spearheading the innovation process within the breweries for plant employees, and working in marketing innovation. She is a fellow of a number of scientific societies and has published extensively in the field of yeast biotechnology. She is editor of the Journal of the Institute of Brewing *and coeditor of the journal* Critical Reviews in Biotechnology. *She is director of the Alltech Ph.D. program and an adjunct professor in the Department of Chemical and Biochemical Engineering at the University of Western Ontario and is a visiting professor at the International Centre for Brewing and Distilling, Heriot Watt University, Edinburgh, Scotland. Inge is currently president of the MBAA.*

Graham Stewart

Graham Stewart received B.Sc. degrees in microbiology and biochemistry from the University of Wales and Ph.D. and D.Sc. degrees from the University of Bath. He was a lecturer in biochemistry at Portsmouth University from 1967 to 1969. He began employment with the Labatt Brewing Company in 1969, based in London, Ontario, Canada. He held a number of scientific/technical positions with Labatt's, and from 1986 to 1994, held the post of technical director. From 1994 to the present, he has been professor and director of the International Centre for Brewing and Distilling at Heriot-Watt University in Edinburgh, Scotland. He is a member of the Master Brewer's Association of the Americas, the American Society of Brewing Chemists, the Institute of Brewing Studies, and the Institute and Guild of Brewing and, in 1999 and 2000, was this Institute's president.

David G. Taylor

David G. Taylor, Ph.D., B.Sc., F.I.Brew., has been recently appointed as The Institute and Guild of Brewing education and training consultant and will also become chair of the IGB Board of Examiners later this year. He has many years' experience in production, quality assurance, and product development in the U.K. brewing scene and has practical experience in brewing under license for a number of international brewing companies, involving many world-renowned brands. He was elected a fellow of the Institute of Brewing in 1995 and has been an international member of the Master Brewers Association of the Americas since 1991. He has been a regular contributor to the IGB's training programs and has been an examiner for the Institute's industry qualifications for several years. He also maintains an active interest in the industry's research and development activities. David is well-known on the international brewing conference and symposium circuit and has published and lectured worldwide on a wide range of brewing technology topics.

Karl Wackerbauer

Karl Wackerbauer is professor and Chair of Brewing Science at the University of Technology Berlin (TUB), managing director of the brewing school of the VLB and the International Brewmaster Course E2, and head of the Research Institute of Brewing and Malting of VLB/TUB. Qualifications and former occupations include qualified brewer in different breweries and malthouses (1951–1954), Diploma Brewmaster at TUM Weihenstephan (1956), Diploma Engineer at TUB Berlin (1959), and quality control manager and later brewmaster in a German brewery (1959–1962). He joined the VLB in 1962 and has held various positions (consultant to the brewing and affiliated industry, teacher, scientific director, etc.). He taught at the VLB Brewing School until 1970 in chemical technical analysis and from 1970 until today in brewing and malting technology as well as for the students from the university side. He received his Ph.D. degree in 1967, was an assistant professor at TUB in 1970, postdoctoral lecturing qualification in 1975, a scientific director of the Institute of Fermentation and Biotechnology (IfGB) from 1988 to 1999, and since 1977, is a full professor of the Chair of Brewing Science. His main interests include the technology of brewing beer, producing malt, quality assurance, and cost of products. He is a member of the Brewing Science Group of the EBC, executive member within the Technical Scientific Committee (TWA) of VLB, a member of the Beer Convention International (BCI), and on the advisory council of the German Heart Institute Berlin (DHZB).

Charlie Bamforth

Charlie Bamforth became the first Anheuser-Busch Endowed Professor of Malting and Brewing Sciences at the University of California, Davis in February 1999. He has more than 25 years of experience in the brewing industry, previously holding senior positions with Brewing Research International and Bass. Charlie was the founding chair of the European Brewery Convention Foam Sub-Group. A fellow of the Institute of Brewing and fellow of the Institute of Biology, he is editor-in-chief of the Journal of the ASBC *and a member of the editoral boards of the MBAA's* Technical Quarterly, *the* Biotechnology Letters, *and the* Journal of the Science of Food and Agriculture. *His book,* Standards of Brewing, *was published in 2003, together with the second edition of* Beer: Tap into the Art and Science of Brewing. *His latest book,* Beer: Health and Nutrition, *will be released in 2004. He has also published books on biotechnology and soccer goalkeepers.*

Ray Klimovitz

Ray Klimovitz has been in the brewing industry for more than 40 years, having worked for Canadian Breweries Ltd. (Carling Brewing Company, U.S.A.), the Jos. Schlitz Brewing Company, and the Stroh Brewery Company. Ray was director, brewing and special product development at Stroh's in 1999 when Stroh's ceased operations. Since October 1999, Ray has been involved in brewing and soft drink consulting as president of Klimovitz Brewing Consultants, Inc. He is currently project consultant for Sartorius, AG (Goettingen, Germany); VP product development for IZZE Beverage Company, Boulder, CO; and U.S. brewmaster for the Sleeman Brewing Company, Guelph, Ontario. Ray is technical director for the Master Brewers Association of the Americas and his office and residence are in Chippewa Falls, WI.

ABSTRACTS

TECHNICAL SESSION I: Malt

Moderator: Scott Heisel

Scott Heisel received a B.S. degree in biochemistry and a B.S. degree in agronomy from the University of Wisconsin–Madison in 1982. In 1986, he received his M.S. degree in agronomy. Scott worked for several years at the USDA/ARS Barley and Malt Laboratory and has published several papers on characterizing various enzymes of germinated barley and the use of biochemical techniques to identify barley varieties. He joined the American Malting Barley Association, Inc. (AMBA), Milwaukee, WI, in April of 1987 and currently is the vice president and technical director. Scott is an active member of the American Society of Brewing Chemists, serving as chair of Local Section 4, chair of technical subcommittees, and national treasurer (2001–2003). As a member of MBAA, Scott has participated as a guest lecturer for the Malting and Brewing Short Course and spoke at several national meetings. He also is a member of the National Barley Improvement Association.

O-1

New Method for Malt Treatment by Subcritical Water

KOICHI NAKAHARA, Norihiko Kageyama, Koji Nagao, Takako Inui, and Nobuyuki Fukui
Process Development Department, Engineering & Process Development Division, Suntory Ltd., Yamazaki, Shimamoto-cho, Mishima-gun, Osaka, Japan

Papers have been published in the field of extraction, purification, and decomposition using supercritical fluid technology. In industry, methods of supercritical CO_2 have been already applied to several food production processes, e.g., removal of caffeine from coffee. Meanwhile, in the brewing industry, this method has been applied to the extraction process of alpha-acid and essential oils from hops. However, supercritical water technology has never been introduced to the brewing or malting industry.We have been developing industrial applications of supercritical- and subcritical water for malt treatment. The malt tissue was hydrolyzed by water molecules and hydrogen ions at the near-critical temperature of water. By this method, several kinds of flavor and aromatic compounds were generated in a few minutes. The hydrothermal method resulted in an advantageous treatment to obtain the enhanced cooked flavors from the malt. This treatment gives a great advantage for the development of a new type beer.

Koichi Nakahara received a doctor's degree in agriculture from Kyushu University in Japan. Koichi graduated from Kyushu University in 1986 and graduated from graduate school of Kyushu University in 1988, majoring in applied microbiology. Since then, Koichi has been employed by Suntory Ltd. as a researcher. He has worked in the bioorganic chemistry laboratory and in the research area for natural products, Institute for Fundamental Research. Currently, Koichi is a chief chemist and general manager in the Process Development Department. Koichi works in the field of applied supercritical water technology.

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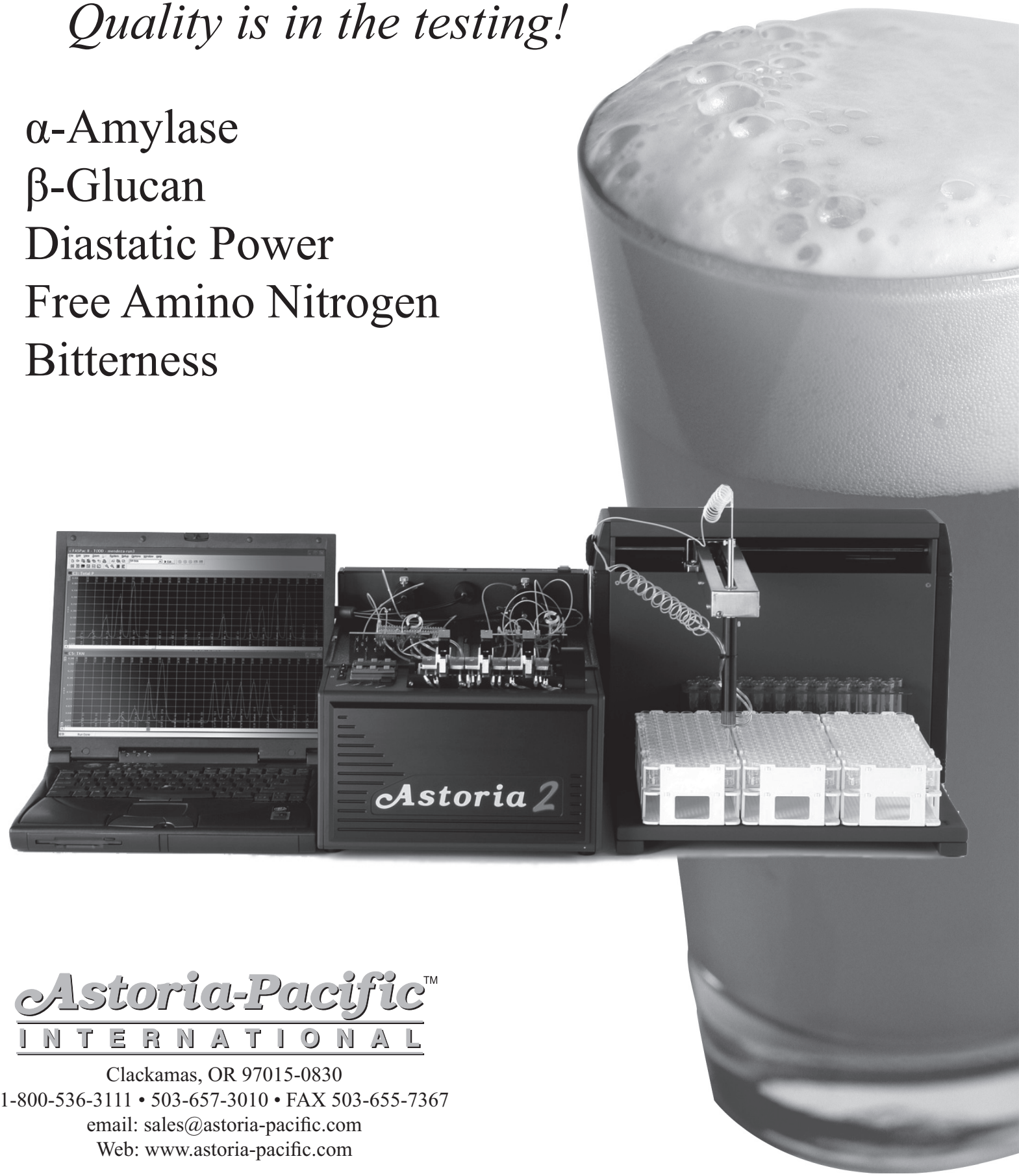

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O-2

Wort Amino Acid Composition of Different Barley Varieties and Effect on Nitrogen Assimilation

XIANG S. YIN, Gustavo H. Strasser, and William J. Ladish
Cargill Malt

The free amino acid composition of laboratory worts prepared from malt samples covering more than 20 varieties of malting barley from North America, South America, and Europe were studied. The patterns of the amino acid classes were examined across varieties. Significant differences were observed in the relative content of the Group D amino acid, proline, between the two-rowed and the six-rowed varieties. Ratio of other groups of amino acids was, therefore, affected accordingly. Results indicated that, within one variety, the percentage of each class of amino acids did not vary significantly due to malting process that was reflected by degree of modification and Kolback Index. At the same levels of soluble protein, the assimilable nitrogen level can vary by up to 10% depending on variety. The pattern of consumption of assimilable nitrogen during fermentation is also demonstrated using malt from different sources. Potential effects of the amino acid composition on yeast performance and beer quality were investigated.

Xiang S. Yin is the technical manager for Cargill Malt, Americas, based at Prairie Malt Limited, Canada. He obtained his first degree in engineering in fermentation technology at Wuxi, China, and received his Ph.D. degree in 1986 from the Department of Brewing & Biological Sciences, Heriot-Watt University, Edinburgh. He carried out his postdoctoral research at the University of Edinburgh and then at the Grain Research Laboratory in Winnipeg. As the recipient of the 1990 Centenary Research Award of the Institute of Brewing, Xiang worked at the Brewing Research International, England, on beer flavor in the same year. He was an associate professor at the Wuxi Institute of Light Industry in China for 3 years before joining Prairie Malt as director of technical services in 1991. Xiang is the author or coauthor of more than 30 scientific and technical papers for international conventions and publications.

O-3

Choice of Enzyme Solutions Should Determine the Choice of Raw Materials and Process—Not Vice Versa

STEN AASTRUP, Noel Bautista, Elmar Janser, and Kurt Doerreich
Novozymes

Beer production has always been dependent on enzyme activity and their limitations. The current presentation summarizes how the enzyme content and enzyme activity of malt has determined the brewing regimes and the choice of raw materials. It is discussed to what extent malt analyses and malt specifications can secure raw material supply of uniform quality and, thus, a predictable and controllable brewing process.It is shown how scientists, barley breeders, maltsters, and enzyme producers have complied with the wishes from the brewers. 1) To extend their flexibility in choice of raw materials. 2) To increase extractability. 3) To secure rapid and trouble-free brewing. 4) To make special products. The main tools being 1) selection of new barley varieties with more accessible endosperm and much higher enzymes potential; 2) use of external enzymes with new or improved abilities compared with malt enzymes; 3) use of starter cultures for malting, resulting in increased enzyme activity in the malt; 4) introduction of new enzymes or enzymes with improved abilities in barley varieties using gene technology. Currently, the use of external enzymes gives the brewer the highest flexibility in the choice of raw materials, processes, and final products. Many breweries, however, do not benefit totally from the possibilities given by the much broader action frame of these enzymes. Many brewers just add the enzymes and keep the existing process conditions. This presentation outlines how choice of raw materials, raw material specifications, and processes can be significantly changed in favor of better processing and better beer quality (e.g., improved flavor stability) by choosing the right combinations of enzymes. The final part of the presentation will concentrate on future solutions. These shall be based on the increased desire for flexibility to meet the requirements from the customers for a higher diversity of products with constant, recognizable quality and high flavor stability. Here, the brewmasters have to "play on the whole piano". From classical "tunes" to completely new beer types. This means that the brewer will start with designing the beer and the beer quality and then simply ask for the raw materials and the enzymes that can do the job. The brewer shall be able to concentrate on the most important aspect—beer quality—and let the enzymes take care of productivity and economy. This will put an increased pressure on the enzyme producers (maltsters and producers of external enzymes) to make more specific solution the specific requirements.

Sten Aastrup received his M.S. degree in biology from the University of Copenhagen in 1979. Since then, he has worked in the brewing industry for 10 years as a scientist and senior scientist at the Carlsberg Research Center; 5 years as head of the Carlsberg Malt House; and 9 years as senior consultant at Alfred Joergensen Laboratory. In 2004, Sten began employment with Novozymes as technical service manager.

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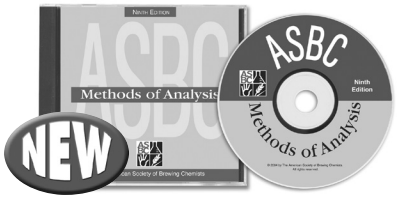

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O-4

NIR Spectroscopy for Single-Kernel Analysis—A Novel Tool for the Evaluation of Homogeneity in Barley and Malt

FRANK RATH (1) and Frank Nitzsche (2)
(1) VLB Berlin, Germany; (2) König Brauerei, Germany

An essential precondition for the rational and economic production of top quality malt and beer is the consistent high quality of the raw materials used. Inhomogeneous barley and malt can be a key cause of technological and qualitative problems, which make the industrial processing more difficult and more expensive, as well as reducing the quality of the final product. Paying more attention to the homogeneity of the barley and malt when evaluating their quality is thus an essential precondition for a more precise prediction of their performance in the malting and brewing processes and can lead to a further noticeable improvement in the quality of the raw materials. An innovative method to measure the homogeneity of barley and malt samples is presented that utilizes the special advantages of near-infrared technology based on a diode-array spectrophotometer for the rapid analysis of a very large number of single kernels. For the homogeneity analysis, a special measuring device was developed that uses glass-fiber optics to allow the intake and evaluation of spectral data from up to 10 different points per kernel. Several detectors are arranged in a staggered formation in order to minimize such interfering factors as the kernel shape, size, and orientation. The single kernels are fed in a continuous stream by an automatic mechanism. Unmodified and partially modified regions of the malt endosperm were identified and quantified on the basis of their NIR spectral data. The spectral information was evaluated with the help of analytical reference data obtained from homogeneity analysis using the calcofluor staining of the endosperm (Carlsberg Method). With the help of multivariate statistical algorithms, calibration methods to measure the homogeneity of the malt modification were calculated and validated. The model allows the homogeneity of endosperm modification of an unknown sample to be predicted purely on the basis of its spectral data. Further calibration models were developed for other important grain constituents—protein, moisture, and beta-glucan. The homogeneity analysis with NIR technology is a nondestructive method requiring no sample preparation and allowing a high analysis rate. It thus fulfills the necessary conditions to be able to analyze large samples as a basis for a high statistical security and good result reproducibility. The NIR-based single-kernel analysis thus overcomes the disadvantages and weaknesses of conventional homogeneity methods that limited their wider application. In the future, calibration models should be developed for other interesting kernel constituents and for other grain crops.

Dr. Frank Rath was born in 1957. Frank studied agricultural science at the Rheinische Friedrich-Wilhelms-University of Bonn (1980–1986) and received a Ph.D. degree in 1993. Frank has been a scientific collaborator at the Research Department/Plant Production and Physiology, Weissheimer Malzfabrik, Andernach (1986); a scientific collaborator at the Research Institute of Raw-Materials within the Research and Teaching Institute of Brewing in Berlin (VLB) (1986–1990); head of the Research Department/ Plant Production and Physiology, Weissheimer Malzfabrik, Andernach (1990–1998); and head of the Research Institute of Raw-Materials within the Research and Teaching Institute of Brewing in Berlin (VLB) (1999–present).

O-5

Lipid Oxidation During Mashing and Its Impact on Beer Quality—Recent Progress

HISAO KURODA (1), Naohiko Hirota (2), Hirotaka Kaneda (1), Naoyuki Kobayashi (1), Kazuyoshi Takeda (3), Kazutoshi Ito (2), and Masachika Takashio (1)
(1) Frontier Laboratories of Value Creation, Sapporo Breweries Ltd.; (2) Bioresources Research and Development Laboratories, Sapporo Breweries Ltd.; (3) Barley Germplasm Center, Research Institute for Bioresources, Okayama University

One of the most important issues in modern brewing is how to produce flavor- and foam-stable beer. We found that trihydroxyoctadecenoic acid (THOD), one of the products made by lipid oxidation during mashing, deteriorates both beer foam and the smoothness of beer. Lipid oxidation during mashing also results in the production of *trans*-2-nonenal (T2N) or its precursors, which are thought to be the major contributors to the stale flavor that arises during the storage of beer. We have focused on biochemical analyses of the enzymes involved in lipid oxidation during mashing and attempted to clarify how THOD and T2N are produced during mashing. We have already shown that linoleic acid hydroperoxide, the oxidative product of linoleic acid derived from malt, is produced by malt lipoxygenase; however, the pathways leading to THOD or T2N were unknown. The aim of the present study was to clarify these pathways. First, using recombinant protein technology, we proved that THOD was produced from the sequential oxidation of linoleic acid by malt lipoxygenase-1 and peroxygenase. Second, we discovered the presence of 9-fatty acid hydroperoxide lyase in malt and showed that it enzymatically cleaved 9-hydroperoxide of linoleic acid into T2N during mashing. Interestingly, both peroxygenase and 9-fatty acid hydroperoxide lyase showed higher heat stability than did lipoxygenase, so that the activities of these enzymes would survive after the inactivation of lipoxygenase and produce THOD and T2N during mashing. This indicates the importance of not only lipoxygenase but also peroxygenase and 9-fatty acid hydroperoxide lyase regarding the mashing methods, the processing methods of malt production, and the selection of types of malts or barley cultivars. In addition, because THOD and T2N are produced by this enzyme cascade during mashing, we predicted that if we efficiently block the first reaction, which produces 9-linoleic acid hydroperoxide by lipoxygenase-1, this would result in the reduction of THOD and T2N in beer, thus enabling the production of foam- and flavor-stable beer. Excitingly, the theory was recently proved by the result of brewing trials using the LOX-less barley line, which completely lacks authentic lipoxygenase-1 protein.

Hisao Kuroda received an M.Sc. degree from the Department of Biology of the Graduate School of Nagoya University in 1989. He then joined the Plant Bioengineering Research Laboratories, Sapporo Breweries Ltd. as a research scientist and worked on the biotechnology of malting barley. From 1998 to 2002, he worked on the malt enzymes related to lipid oxidation as a lead biochemist at Brewing Research Laboratories, Sapporo Breweries Ltd. Currently, Hisao studies the barley enzymes involved in lipid metabolism through a genomics and proteomics approach at Advanced Technology, Frontier Laboratories of Value Creation, Sapporo Breweries Ltd.

O-6

The First PCR Marker for Breeding of High-Quality Winter Malting Barley—A Novel Selection Tool Against Beta-Amylase-Weak Genotypes

MICHAEL VOETZ and Frank Rath
VLB Berlin, Germany

The amylolytic enzyme beta-amylase plays a key role in the production of fermentable sugars during the mashing process. In contrast to spring barley, different genotype-dependent thermostabilities of the enzyme could not be observed in winter barley. Nevertheless, extensive analyses of winter barley genotypes (cultivars and breeders' lines) showed that the level of beta-amylase activity varies by up to a factor of 3 to 4 when assaying genotypes grown under similar environmental conditions. After comparative enzyme analyses of numerous genotypes harvested at different locations, we have clear evidence that the highest achievable level of beta-amylase activity is a heritable trait in winter barley. To elucidate the molecular basis of this phenomenon, we first examined whether differential activation of the enzyme is responsible for the dramatic differences in beta-amylase activity. The beta-amylase is synthesized during grain development and needs to be converted into an active form during germination. The enzymatic reduction of disulfide bonds between the enzyme and other grain proteins and an endoproteolytic removal of C-terminal peptides are discussed as 'activating processes'. Since we could ascertain the same ranking of genotypes with respect to beta-amylase activity in barley and malt, the C-terminal processing of the protein could be excluded as a decisive reaction. We obtained similar results when omitting the reducing agent in the enzyme assay, thus proving that the differences in beta-amylase activity cannot be due to differences in enzyme activation. To find out if differential gene expression of the beta-amylase gene is crucial to the activity levels of the enzyme, we characterized the promoter sequences from beta-amylase genes isolated from genotypes with extreme high and low enzyme activity, respectively. The exchange of a single nucleotide within an I-Box-like promoter element could be detected in the low-activity genotypes. Based on this polymorphism, we designed selective PCR primers. Subsequent PCR analyses and enzyme assays of more than 100 varieties and breeders' lines revealed that, without exception, the winter barley genotypes with low beta-amylase activity carry the mutation in the promoter sequence indicated by a positive PCR result. The data presented are the basis for a novel and highly focused marker-assisted selection aimed at high DP values by deletion of beta-amylase-weak genotypes. It is now possible, for the first time, to select in early breeding generations without micromalting, thus achieving a substantial shortening of time spent on the breeding of optimized winter barley varieties.

Michael Voetz, born in 1964, received a diploma in biology from the University of Cologne in 1991. He earned a Ph.D. degree in plant molecular biology from the University of Cologne/Max-Planck-Institute for Breeding Research in 1995. From 1995 to 2000, he was 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.

TECHNICAL SESSION II: Beer Analysis

Moderator: Cindy-Lou Dull

Cindy-Lou Dull received a B.S. degree in dairy science from the University of Vermont and earned an M.S. degree in food science from Cornell University. She began her career in the development of rapid methods for the food and forensics industries before finding her niche in the brewing industry. In 1992, she joined corporate research and development at Anheuser-Busch, Inc., St. Louis, MO, as a microbiologist with her efforts directed toward aseptic brewing issues and rapid methods evaluation. A member of the Technical Center since 1994, she has worked in various capacities, most recently as a scientist in the Analytical Services group and as liaison to corporate brewing customers. She has enjoyed being an active member of ASBC since 1994, having participated in several subcommittees, chairing the subcommittee for CLEN Medium for the Detection of Wild Yeast, and serving on the Technical Committee, currently as chair. Cindy-Lou is well known by her friends and colleagues for her daily dose of inspirational quotes via e-mail, "Food for Positive Thought".

O-7

A New Brewing Science Study in the 21st Century Fused with Brain Science—Measurement of Human Brain Activity Evoked by Stimulation of Beer Bitterness Using Magnetoencephalography

HIROTAKA KANEDA (1,2), Naomi Goto (2), Tatsu Kobayakawa (2), Masachika Takashio (1), and Sachiko Saito (2) (1) Sapporo Breweries Ltd.; (2) National Institute of Advanced Industrial Science and Technology

One of the ultimate questions for brewing scientists may be where and how human beings identify the beer tastes and odors and evaluate their pleasantness. Bitterness is an important factor for beer pleasantness, although it is generally an unpleasant factor for foods and beverages. It is quite interesting for brewing scientists as to how the brain functions to make human beings feel pleasure when tasting beer. To answer this question, the fusion of brewing science studies with brain science and psychological studies will be indispensable and will provide new values in the creation of marketing strategy. We tried to noninvasively detect the human brain activity evoked by beer bitterness using magnetoencephalography (MEG). The measurement principle of the MEG is as follows. When information is being processed (neural activities occur), small currents flow in the brain, producing small magnetic fields. The MEG measures the magnetic field outside the scalp with a superconducting quantum interference device magnetometer. An equivalent current dipole (ECD) can be mathematically calculated from the distribution of the magnetic fields on the scalp. The taste delivery system has been developed. Deionized water and beer were presented to the tongue through a Teflon tube in the system by compressed air. The duration of each stimulus was 600 ms in one trial (total trials: 40) and the interstimulus interval was about 30 s, during which the tongue was continuously rinsed with deionized water. The MEG measured the changes in the magnetic fields on the scalp based on the brain activation in the recognition of the beer tastes. Although the magnetic fields did not significantly change during the stimulation by water and beer, the increase in the magnetic fields was observed for the stimulus of the beer with the addition of isohumulones, indicating the specific brain activation for isohumulones. The ECDs for the stimulation with beer enriched with isohumulones, placed on a subject's three-dimensional magnetic resonance imaging, were located at the transition between the parietal operculum and the insular cortex (area G) with a latency at 326.7 6 115.5 ms. It has been reported that area G is the primary gustatory area in the human brain. The results indicated that the brain activity stimulated by beer bitterness could be detected. Our studies will be the first step in the fusion of brewing science with brain science, leading to the clarification of the evaluation mechanisms for the pleasantness of beer tastes and to supporting the sensory evaluation studies of beer tastes.

Hirotaka Kaneda is a general manager of advanced technology at Frontier Laboratories of Value Creation of Sapporo Breweries Ltd. He graduated from Kyushu University in 1984 with a M.S. degree in food hygienic chemistry and then joined Sapporo Breweries Ltd. He has investigated beer stability and received a Ph.D. degree in food science from Nagoya University in 1994. He has studied the human brain function during gustation and olfaction as a guest researcher at the National Institute of Bioscience and Human Technology from 1996 to 2001. He received the Eric Kneen Memorial Award from the ASBC in 1995 and the Technical Award from the Agricultural Chemical Society of Japan in 2000. He is currently a member of the editorial board for the American Society of Brewing Chemists (2001–present).

O-8

Stable Isotope Dilution Assay of Methanethiol and Dimethyl Trisulfide in Beer Using a Purge and Trap Method

SACHIO IINUMA, Emiko Koremura, Tetsuji Yasui, Shuso Sakuma, and Motoo Ohkochi
Kirin Brewery Co., Ltd.

Sulfur compounds generally exhibit intense aroma properties due to their low olfactive thresholds. Methanethiol and its polysulfide, dimethyl trisulfide (DMTS), most often occurred at levels above their olfactive threshold in aged beer with nauseous sulfur-linked smells. As methanethiol is very oxidizable and chemically reactive, measurements of such compounds in their low threshold levels were considered very difficult. So stable isotope dilution assays (SIDA) of both methanethiol and DMTS in beer using purge and trap sample concentration techniques were developed. These sulfur compounds were measured by purging them onto Tenax adsorbent and then injecting the volatiles onto a GC column using thermal desorption and cryogenic focusing. Sulfur compounds eluting from the column were quantified by GC/MS. Using this method, we determined the levels of methanethiol and DMTS in various brands of Japanese commercial beer and happou-shu from different breweries. As a result, it was found out that the levels of these sulfur compounds differ both between the brands and within the same brand from different breweries. We consider that our SIDA methods will be a powerful tool to regulate these sulfur compounds in breweries. This paper will also discuss the influence of pH, headspace air, sulfur dioxide, ferrate, and ethylenediaminetetraacetic acid (EDTA) in beer and happou-shu during aging.

Sachio Iinuma graduated from Tsukuba University in 1992 with a master's degree in agricultural chemistry and then joined Kirin Brewery Company Limited. Sachio worked in the Research And Development Department from 1992 to 2002. Since 2002, Sachio has worked in the Technology Development Department, Research Laboratories for Brewing.

O-9

Development of a Multiresidue Analysis Method of Agrochemicals Using Liquid Chromatography/Tandem Mass Spectrometry

MASAYUKI OMOTE, Kouichi Harayama, Tomoko Sasaki, Naoki Mochizuki, and Hiroshi Yamashita
Asahi Breweries, Ltd.

In Japan, it was decided to enforce the positive list system for regulating pesticide residues by a newly revised legislation governing sanitation, and the first draft on proposed provisional limits has been published to regulate more than 500 agricultural chemicals. After the legislation was introduced, the scope of application has expanded to include not only raw materials but also processed food. Therefore, manufacturers are obliged to confirm their compliance with the legislation by self-imposed inspection. This situation led us to develop a rapid method for simultaneously analyzing multiresidue chemicals with simple pretreatment and high sensitivity. In this study, we attempted to develop a simple method for analyzing multiresidue chemicals using liquid chromatography/tandem mass spectrometry (LC/MS/MS). We were able to determine them in pale malt and beer products with a simple pretreatment process that includes liquid-liquid extraction followed by solid-phase column purification. In the case of hops, coextracted matrix components, for instance pigments and hop oil, may strongly influence the ionization efficiency of target analytes, and these matrix effects should be minimized. We reduced coextracted matrix components using gel permeation chromatography (GPC). As a result, the simultaneous analysis of over 250 chemicals was achieved with high sensitivity and the detection limits were found to be 0.01 mg/kg (ppm) or below. We analyzed raw materials and beer products and confirmed that all of them complied with the proposed provisional limits published in the first draft. These results indicate that our newly developed method has potentially extensive applications to quality assurance.

Masayuki Omote is an analyst 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 the research and development of analytical technology since 2000.

O-10

Wort Turbidity—Comparison of Different Measuring Principles

ARND ROGNER and Ralf Isenberg
Sigrist-Photometer AG, Switzerland

The turbidity or solids content in wort after the lauter tun has a significant influence on the quality of the brewing process and also the final product. The target clearly is to have a turbidity as low as possible. The MEBAK directive for on-line turbidity measurement in wort specifies to use forward-scattered light. The reason is to have a good relation to the suspended solids concentration. On the other hand, other measuring principles, such as 90-scattered light, back-scattered light, and absorption measurement, are used by various manufacturers. In 2003, we had done a couple of investigations with some breweries and a brewhouse manufacturer on these different technologies to learn about the differences and the interpretation of the results. Forward-scattered light indeed gives the best correlation with the suspended solids. Since this is the parameter that should be kept at a low level for improved processing during wort boiling and fermentation, it is the most relevant one. However, back-scattered light gives very similar results, with a more easy technology. 90-scattered light does not help to improve the lautering process but can help to identify bad malt quality. Therefore, it cannot be more than supplemental information. Finally, absorption measurement, although under widespread use, gives unrealistic high values at the end of the process when cutters are applied. The paper compares the different technologies and demonstrates and explains the differences in the results. Generally, the preferred technology depends, in fact, on what you will learn from the wort turbidity measurement and also from the state-of-the-art of the brewhouse technology.

Arnd Rogner received his Ph.D. degree in physics in 1989 from Karlsruhe University in Germany. After working several years as development engineer, development manager, and product manager in the field of fiber optics and optical sensors, he joined Sigrist, a leading manufacturer of brewery turbidimeters, in 1997. As marketing manager, he helped to define and launch the actual Sigrist product line of turbidimeters, color, and dust monitors. Since 2000, he has been responsible for the worldwide sales activities of Sigrist.

O-11

Toward Improved Fermentation Consistency Using Multivariate Statistics

Jeff Hodgson (1), Hilary Jones (1), Jim Robertson (2), Greg McFarlane (2), Steve Bland (2), David Hopper (2), Kate Kemsley (3), Marianne Defernez (3), and BEHNAM TAIDI (1)
(1) Scottish Courage Ltd. Technical Centre, Edinburgh, U.K.; (2) Charles Wells, Bedford, U.K.; (3) Institute of Food Research, Colney, Norwich, U.K.

Beer production can be an inherently variable process due to the involvement of so many biological processes during its production and the complex nature of the raw materials involved. Central to beer making are wort production and fermentation. Wort production can be automated and controlled through accurate real-time data management systems. The fermentation part of the process, however, offers fewer opportunities for such a level of control and human judgement often plays an important role in ensuring each batch of product meets all specifications. While considerable research has been undertaken on analyzing and controlling pharmaceutical fermentations, this expertise is not directly transferable to brewing due to inherent differences from pharmaceutical conditions. There are important commercial benefits to be gained from an improvement in fermentation consistency. The potential business benefits can be divided into two broad areas, namely, management of product supply to customers and brewery capacity increase. An initial attempt to measure the consistency of fermentations at Scottish Courage Ltd. led to the development of centile lines for the measurement of the shape of fermentation curves. This, in turn, led to a larger project involving a consortium consisting of Charles Wells Brewery, the Institute of Food Research, and the U.K. Government's Department of Environment, Food and Rural Affairs. The objectives of this project are as follows. • To understand and characterize natural variability in fermentation performance, as measured by a range of process variates and beer qualities. • To develop generic predictive protocols that will provide early indications of deviations from nominal acceptable fermentation behavior. • To develop models that can predict the end time-point of fermentations, using multivariate data collected in the period immediately after pitching (24–48 h). The approach adopted is very much based on statistical analysis and model construction rather than a mechanistic approach. This presentation will discuss the early challenges encountered and the progress made during the first year of this project.

Behnam Taidi (B.Sc., Ph.D., AMIBREW) is the research and development manager for Scottish Courage Ltd. He is in charge of progressing the strategic research program by initiating and managing process innovation projects. Behnam has more than 10 years of experience in brewing research and, although his expertise is in the area of fermentation and yeast, he manages projects in many diverse areas such as novel raw material usage, yeast management, fermentation control, by-product utilization, rapid microbiology, and beer quality. Behnam serves on the Scottish Section IGB committee and regularly attends scientific and brewing conferences, where he presents aspects of his research.

O-12

Multivariate Analysis of Routine Beer Analysis Methods

KARL J. SIEBERT
Cornell University, Geneva, NY

Brewing companies develop analytical methods and apply as routine those that are found to contribute useful information, often to solve a particular problem. In most cases, the entire set of methods is never examined collectively to see the extent to which some of them may be redundant and to consider the possibility that a well-chosen subset of procedures might provide as much information as all of them collectively. This has the potential of saving both time and money at little or no cost in loss of information. A study of the collective information content of 47 analytical observations applied to at least six samples each of 10 beer brands was carried out. Principal components analysis (PCA) was used to determine the number of fundamental properties represented in the data set and, thereby, to estimate the degree of redundancy. When samples of one of the brands were included, they tended to dominate the PCA because they were so different from the other beers. The data set was then examined with these samples removed. It appears that the number of significant principal components (PCs) is on the order of seven or eight, depending on the criterion used. This indicates that the 47 measurements together only contained information on seven to eight fundamental properties, and there was considerable redundancy. The first two PCs contained information that was sufficient to almost completely separate samples of the 10 brands. Eight PCs were Varimax rotated and the factor loadings were examined to determine the influence of the measurements on the PCs and to estimate the factors that were, to some extent, redundant. It was possible to identify 14 measurements from the 47 used that captured most of this information and retained much of the ability to separate brands. Hierarchical cluster analysis was applied to the transposed data matrix and to a correlation matrix of the measurements to obtain two additional views of the relationships between the measurements. The results from the correlations were intuitively more satisfying and showed both known and some unexpected relationships between measurements. Several pattern recognition procedures were applied to attempt classification of the samples by brand. This was quite successful with linear discriminant analysis (LDA), K-nearest neighbor analysis (KNN) and soft independent modeling of class analogy (SIMCA). Reduction of the number of measurements used by selecting those of greatest classification utility improved the classification ability of LDA and SIMCA; this produced the best results with 11 and 17 measurements, respectively.

Karl Siebert received a Ph.D. degree 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 1990, Dr. Siebert joined Cornell University as professor of biochemistry in the Department of Food Science and Technology. He served 5 years as department chair and now has a predominantly research appointment. Dr. Siebert served on ASBC technical subcommittees and was a member and chair of the Technical Committee. He is serving his second stint on the Journal of the ASBC *editorial board (1980–1992; 1996–present). He is active as a consultant in the beverage industry.*

TECHNICAL SESSION III: Filtration

Moderator: Frederik Havel

Fred Havel received his B.Sc. degree in crop science in 1981 from the University of Guelph's OAC in Guelph, Ontario. He joined the brewing industry as an apprentice maltster with Canada Malting Co. on Bathurst Street in Toronto in 1983. Over the next two decades, he has held a number of positions with Carling O'Keefe, Molson, SUN Brewing, Carlsberg, and as a private consultant. Fred has worked in Canada, the Caribbean, China, Africa, and throughout Europe and the ex-Soviet block. Fred is currently a development brewer in Molson's Global Quality and Innovation Department. Fred is a member of MBAA District Eastern Canada.

O-13

Cost and Quality Comparison Between DE and Crossflow Filtration for Beer Clarification in Industrial Scale

HANS DENNIGER (1) and Reiner Gaub (2)
(1) Westfalia Separator AG; (2) Pall Food & Beverage

This paper compares the individual consumption data with related costs between a traditional kieselguhr filter (plate-frame) and a modern high-efficiency centrifuge/crossflow system (PROFI, Westfalia/Pall). Both technologies have been installed in parallel in a German midsize brewery operating the same beers under identical conditions. During a period of 6 months, all data were measured and recorded by an independent institute (Tech. University of Vienna). Results are as follows. • Investment comparable with crossflow and DE filterline. • Beer and extract losses significantly lower with PROFI system. • Crossflow eliminates filtermedia handling completely. • Water consumption significantly lower with crossflow. • Manpower is significantly lower with crossflow. • Energy consumption for crossflow lower than for DE with poor filterabilty of beer, with good filterability vice versa. • Downtime: CMF is continuous operation, DE is batch operation; this results in smaller sizing for CMF systems. • Flexbility: CMF allows for an easy change between brands within minutes without mixing phases. • Total costs: CMF is comparable to DE filtration, especially with poor filterability beers. • Quality: CMF is, in all aspects, comparable to DE but with better microbiological results, more constant haze, and significant lower oxygen intake. The paper gives detailed facts and figures for each criteria. Based on these results, the brewery has stopped using DE filtration and switched 100% to a PROFI system for all brands.

Hans Denniger was born in 1957, is married, and has two children. From 1972 to 1975, Hans held an apprenticeship as a brewer at the Iserlohner Brauerei, which is part of Brau & Brunnen, one of the German brewery groups. From 1975 to 1978, Hans practiced as a brewer in all production areas at the Vormann Brauerei. From 1978 to 1979, Hans studied at the VLB (Versuchs & Lehranstalt für Brauerei in Berlin) and received a degree as Braumeister VLB (master brewer VLB). From 1979 to 1988, Hans was a chemical/technical assistant and brewmaster of the Institut für chemisch-technische Analyse der VLB, Berlin, under Prof. Eckhard Krüger. Hans was responsible for the research and development of analytical procedures and analyses, as well responsible for the R&D brewery plant at the institute. From 1988 to 1990, Hans was involved in the engineering, commissioning, and running of microbreweries in Germany. Since 1990, Hans has been project manager, beer, at Westfalia Separator AG in Oelde. Hans is responsible for the development of new processes with centrifuges in breweries, especially for the development of a process on DE-free filtration (SWS = Seitz-Westfalia system or PROFI) and continuous stabilization. Hans' hobbies include home brewing, sailing, and fishing.

O-14

The Filterability of Wort and Beer

DR. STEFAN KREISZ, Klaus Hartmann, and Prof. Werner Back
Institute for Brewing Technology I, Freising, Bavaria, Germany

This paper is the summery of two doctoral thesis about the filterability of wort and beer partly already published at the EBC Congresses in Cannes (1999), Budapest (2001), and Dublin (2003). It will describe the influence of the main sources of polysaccharides and proteins (malt, yeast, and bacteria) on the filterability (pressure increase at the filter inlet and turbidity at the filter outlet) of wort and beer. Analytical Methods: All malt, wort, and beer analysis were executed according to the Analytica EBC. Five new methods were invented: a method to predict the filterability of beer by analyzing the wort (published in Cannes); a method to identify polysaccharides after filtration by releasing them from kieselguhr (published in Budapest), a new method to estimate the risk of beta-glucan gel formation by intensive shearing of wort and beer (not yet published), a step control to identify the process step that causes the problems (partly published at WBC 2000), and a method to identify haze particles in filtered beer by use of specific enzymes in combination with haze measurement and staining methods. Results: The risk of beta-glucan gel formation was measured in 144 malt samples (six varieties, eight proveniences, three different malting regimes) and compared with three cytolytic parameters (beta-glucan content, viscosity, friability). The results show coherence between these parameters and the risk of beta-glucan gel formation. The influence of the three malt polysaccharides (alpha- and beta-glucan and pentosan) on the viscosity of wort was measured depending on the cytolytic modification of the malt. Six brews with different modified malts were executed twice: one time under standard conditions and one time by degrading the cell wall polysaccharides using heat-stable enzymes. The differences in lauter performance and filtration time were measured to demonstrate the influence of the cell wall polysaccharides on these production steps. The step control was realized in five different breweries, three of them having problems with poor filterability. The origin of the problems was identified and the filterability improved .Raw materials, including the yeast, can cause turbidity up to 2 EBC, which cannot be eliminated by a standard filtration. The origin of such haze particles can be detected with specific enzymes in combination with haze measurement and staining methods. The knowledge of the substances leads to technological solutions to minimize haze problems.

Stefan Kreisz studied brewing and beverage technology at the Technische Universität München-Weihenstephan, Germany (1991–1997). He graduated as an engineer in 1997. From 1997 until 2002, he completeted his docotoral thesis at the Institute for Brewing Technology I, concerning the filterability of wort and beer. From 2000 until 2002, he worked as a scientific employee and assistant at the malt laboratory at the Institute for Brewing Technology I. From 2002 until the present, he is head of the malt laboratory. His main research interests are barley, wheat, and malt and he also works as a consultant for malteries and breweries.

O-15

Practical Experiences with Membrane Filtration for the Clarification of Beer on an Industrial Scale

T. REINOUD NOORDMAN (1), Marcel van der Noordt (1), Arie F. C. Hardenbol (1), Coen J. Peet (1), Lute Broens (2), and Andre Mepschen (2)
(1) Heineken Technical Services, Zoeterwoude, The Netherlands; (2) Norit Process Technology, Enschede, The Netherlands

At the WBC 2000 in Orlando, Heineken Technical Services and Norit Membrane Technology reported on a new cross flow membrane filtration process as an alternative to kieselguhr filtration. This membrane filtration process eliminates the use of kieselguhr and its associated problems, such as the disposal of spent kieselguhr waste and the workers' safety issues of the possible inhalation of kieselguhr dust. Since the WBC 2000, the commercial-scale membrane filtration units have been installed in breweries. These commercial-scale units are successfully clarifying beer on a daily basis and have proven to be adaptable to a wide variety of beers, including beers with very high yeast concentrations. Depending on the beer type, membrane filtration maintains high filtration fluxes (108 L m^{-2} h^{-1}) at filter run lengths ranging from 7 to 20 h between membrane regeneration. The costs of commercial-scale membrane filtration for bright beer are currently approximately equal to those for kieselguhr filtration. The costs, product quality, operational aspects, and filterability of commercial-scale membrane filtration will be described for various types of beer. Membrane filtration is successful for the clarification of beer due to a new oxidative agent for regeneration of the membranes. This oxidative agent regenerates clogged membranes in about 2 h and the membrane flux rates are maintained for more than 100 regenerations. We believe that membrane filtration is a viable commercial replacement for kieselguhr filtration.

Reinoud Noordman graduated as a chemical engineer in 1991 from the University of Groningen, The Netherlands. From 1992 to 1998, he was a Ph.D. candidate and carried out research work at the University of Groningen on various membrane filtration projects (desalination, wastewater treatment, and modelling) and product development (improvement of the shelf life of sweet products). In April 2000, he received a Ph.D. degree in the field of membrane filtration. Since January 1999, he has worked for Heineken Technical Services as a senior scientist and is involved in the development of new separation processes.

O-16

Crossflow Filtration of Beer—A True Alternative to Diatomaceous Earth Filtration

ALEXANDER MODROK, Dr. Bernhard Diel, Michael Rodenberg, and Dirk Weber
Sartorius AG, Goettingen, Germany

At breweries, crossflow filtration technology can replace diatomaceous earth filters and fine filters, such as sheet filters, disc filters, and trap filters. The subsequent use of sterilizing-grade membrane filter cartridges additionally eliminates the need of flash pasteurization. The combination of crossflow technology and membrane filter cartridges creates a new filtration system for breweries. Breweries who use this new concept receive a completely cold-filtered or nonpasteurized beer of the highest quality.Compared with conventional DE filtration, crossflow filtration of beer offers numerous advantages. The key aspect is that the use of kieselguhr or diatomaceous earth (DE) is no longer necessary. The fact that DE is a limited resource will have a negative impact on its quality and price in the future. Moreover, the disposal of DE generates additional costs. The health risks for the user associated with DE that contains cristobalite should not be underestimated as well. Fully automated crossflow systems are less labor-intensive to operate than are diatomaceous earth filters. In conjunction with lower water consumption and a lower product loss, process costs can be reduced. The use of crossflow technology does not have any negative influence on the quality of the beer, whereas yeasts and beer-spoiling organisms are reliably removed. In addition, crossflow filtration has a positive effect on the service life of downstream sterilizing-grade filter cartridges. Due to this fact, filtration costs can be reduced even more. This is an great additional cost advantage for breweries using membrane filters for the cold sterilization of beer. Further advantages of crossflow technology can be found in its excellent scalabilty. With these systems, scaling up or down is exceptionally easy. Sartocon filter cassettes are at the heart of every Sartflow filtration system. They feature optimized hydrodynamic properties, in which consistent crossflow rates across the membrane and short flow distances inside the membrane cassette modules are guaranteed. The equally optimized pressure ratios during filtration and cleaning allow high flow rates and efficient cleaning. The crossflow systems contains a new PESU membrane specially developed for beer filtration with an extemely low protein adsorption. The use of narrow channel and flat membrane modules with optimal hydrodynamic properties and an optimized process results in high flux rates of 70–100 L/m^2/h and a very low energy consumption. In consideration of these facts, crossflow filtration of beer offers a true alternative to conventional DE filtration with comparable cost.

Alexander Modrok became a brewer and maltster in 1977 and then worked in several German breweries, including Beck's in Bremen. In 1982, he became a brewmaster and maltmaster after he visited the Brewmaster College in Ulm, Germany. He joined Sartorius in the position of technical support, and in 1987, he was promoted to the F&B market manager Europe. In 1995, he moved to Japan in the position of business united director F&B Asia Pacific. After returning to Germany in 1999, he was promoted to the position of head of global market management brewing industry within the Sartorius group. Here, he supported the development of new crossflow technologies for the brewing industry. Alexander is married to his wife Carmen, and they have one 18-year-old daughter. They are living near the well-known university city of Goettingen in Germany.

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O-17

Beer Stabilization Technology, Clearly a Matter of Choice!

MUSTAFA REHMANJI, Chandra Gopal, and Andrew Mola
International Specialty Products

Stabilization is an important stage in the production of beer, in which an attractive appearance and flavor are considered key quality determinants. The methods adopted to achieve good colloidal stability have changed over time. Advances in brewing technology, cost effectiveness of the technology employed, avoiding products that may leave residue in the final beer or detract from beer quality, and safe product handling, in terms of generation of dust and package size, are some of the key considerations in the selection of a suitable stabilizer/regime. The history of beer stabilization is reviewed in this presentation to understand how the raw materials, technology adopted, and optimization of the brewing process have reached their current state and have impacted the final quality of the beer produced. Drivers for improvement in beer stability include the following.

- Increased competition from imports.
- Expanded distribution areas: beer traveling farther from the brewery.
- Consumer expectations for better quality and product consistency.
- Need to reduce costs from returns of beer. While current procedures usually concentrate on addition of the stabilizer after fermentation—e.g., on transfer to maturation or at filtration—little has recently been reported on determining efficacy of stabilization earlier in the brewing process. A procedure for upstream clarification/stabilization of wort in the brewkettle will be discussed. This should simplify the downstream stabilization and processing before filtration and reduce cost. This could be adopted in developing markets to achieve good colloidal stability without capital investment in specialized equipment. Elsewhere, it could provide an additional mechanism to chill-proof 'difficult' beers in challenging environments. The possible future developments of stabilization technology are considered in light of past experience and likely future drivers.

Mustafa Rehmanji has more than 20 years of experience in the malting and brewing industry. He is section manager, beverage products, research and development with International Specialty Products based at the ISP Technical Center in Wayne, NJ, U.S.A. His current interest is in the area of beer stabilization and technical service for commercial treatment of beverages. Mustafa started his brewing career with Kenya Breweries. Later, he moved to Canada and was director of technical service with Prairie Malt Limited. Mustafa holds a B.Sc. degree in chemistry, a business degree, and a diploma in brewing technology. He is an active member of the ASBC and MBAA. Mustafa has presented a number of brewing-related papers at industry conventions at IGB, ASBC, and MBAA.

O-18

Precoat Filtration, Not a Dead End Street: Introduction of a New Generation of Candle Filters

THOMAS A. WEIGAND (1), Jürg Zuber (1), Ralf Brandau (2), and Cristian Rusch (2)
(1) Filtrox AG, St. Gallen, Switzerland; (2) Filtrox North America

Recent developments in the area of beer filtration, namely the introduction of a number of cross flow filtration systems on an industrial scale may suggest that conventional beer filtration with precoat filters using DE and/or other filter aids may become obsolete soon. This paper will highlight recent developments in the design of candle filters as commonly used throughout the brewing industry and review results from the industrial-scale introduction.The developments include the following. 1) Increased filter area per vessel. New production techniques allow the reduction of the diameter of the filter candle. This increases the effectiveness by achieving a higher packed density within a given filter vessel, thereby reducing dead volumes by approximately 20%. 2) Reduction of cleaning fluid consumption and beer losses. A new vessel shape and an adapted cake discharge process allow further reductions of cleaning fluid and beer water interface volumes. 3) Improved cleaning system. Cake discharge and internal cleaning can be improved by replacing the conventional spray bar. This feature turned out to be especially beneficial in PVPP filter applications. 4) Creating an open system. Further enhancements center around the flow pattern inside the filter vessel. By introducing a dual-path inlet distributor with adjustable flow rates, the upward and sideward flow direction inside a filter vessel can be adapted to a wide variety of different filter materials such as different DE grades or alternative materials, such as cellulose, perlite, or the recently introduced synthetic polymers. This ensure that the candle filter will not become obsolete even in case DE may be phased out in the future. 5) Introduction of a new precoat material. A new preformulated precoat material, Celtrox PC, was introduced to reduce precoat quantities and reduce the number of precoats necessary to only one. At the same time, the cristobalite content is reduced to below 1%. In recent industrial applications, reduced haze readings during filtration and zero yeast counts throughout the whole filter run could be achieved. Quantities applied were 800 g/m^2 filter area, a reduction of 44% against the conventional process.

Thomas Weigand received a diploma in brewing technology from the Technical University Munich-Weihenstephan in 1983. He has been working as a sales and project engineer for beer filtration applications since 1985. In May 1999, he joined FILTROX AG, where he looks after the Americas as a key account manager. His hobbies are his three children, motorbikes, cooking, and skiing.

TECHNICAL SESSION IV: Hops

Moderator: Dave Hysert

As vice president, technical director for John I. Haas, Inc., in Yakima, WA, since 1992, David Hysert is responsible for research and development (R&D), technical services, and quality assurance (QA). Prior to joining Haas, he enjoyed an 18-year career at Molson Breweries of Canada, where he held various positions in R&D, technical services, and QA, including vice president, research, and QA from 1985 to 1992. He received a Ph.D. degree from the University of Toronto in bioorganic chemistry in 1971. David is an active member of many professional societies including the MBAA, ASBC, and Institute and Guild of Brewing. He was president of the ASBC in 1998–1999.

O-19

Organoleptic Profiling and Interactions of Hop Oil Fractions in Various Beer Types

RAY MARRIOTT
Botanix Ltd.

The chemistry of hop oil and hop oil fractions has been extensively studied over the last two decades but their organoleptic properties, their application in various beer types, and their interaction with other beer flavor molecules is less well understood. Trials have been carried out with analytically defined soluble hop oils and hop oil fractions in a range of beer types to determine the negative and positive changes in organoleptic profile using an expert taste panel. These can be expressed numerically and graphically to demonstrate the impact of hop aroma products on key beer flavor and aroma characters. The results have shown that it is possible to both enhance positive beer aroma notes, such as "citrussy" and "floral", and also mask or reduce negative flavor characters, such as "worty". Combinations of hop oil fractions can be used to create a new flavor profile to meet changing market requirements or to adjust current products to accommodate changes in manufacturing. The work that has been carried out also shows that some volatile hop aroma molecules interact synergistically with nonvolatile isomerized alpha-acids and modify the perceived bitterness and flavor/aroma balance. Further work is being undertaken to precisely identify the molecules responsible for this interaction. It is concluded that a better understanding of the organoleptic impact of hop oil fractions can assist brewers in the creation of new and enhanced products using an alternative and versatile source of hop aroma.

Ray Marriott received his B.Sc. degree (Hons) in biochemistry from Cambridge University and his Ph.D. degree in terpene chemistry from Bath University. After 20 years of experience in essential oil chemistry, he joined Botanix Ltd. (formally English Hop Products) in 1996 as its chief executive. He is a member of the IGB and has a particular interest in terpene enzymology.

O-20

Bitter Quality of Beer as Affected by Isocohumulone Levels

THOMAS H. SHELLHAMMER (1), Alix I. Gitelman (2), and Mina McDaniel (1)
(1) Department of Food Science & Technology, Oregon State University; (2) Department of Statistics, Oregon State University

The quality of hop bitterness is a subtle but powerful driver of beer quality and contributes significantly to the "drinkability" of the final product. Anecdotal reports indicate that varieties high in cohumulone lead to an inferior bitter quality in beer. The objective of this study was to identify the impact of isocohumulone levels on the bitter quality of beer. A commercial beer with low inherent bitterness, Michelob Ultra, was spiked with pre-isomerized alpha-acid extracts that varied in isocohumulone levels. An extract from the variety Topaz was high in isocohumulone (~52% of total iso-alpha-acids), while Horizon was the source for low isocohumulone (~20%). The extracts were spiked in Michelob Ultra to yield an additional 10 and 20 ppm of total iso-alpha-acids and then compared by a panel of 14 experienced tasters using time intensity (via CompuSense data acquisition) and Free Choice Profiling descriptive technique. To eliminate olfactory influences, panelist wore nose clips throughout training and data collection. For the purpose of comparison, tetrahydroiso-alpha-acids and dihydroiso-alpha-acids were individually spiked at levels yielding roughly equal bitterness to the +20-ppm Topaz/Horizon samples. Using panelists as blocks in a randomized block design, data were collected from four to five independent replications. In general, the differences in bitter quality between the high and low isocohumulone samples were subtle, with some panelists clearly differentiating the two, while many not. As a point of comparison, differences within the high and low isocohumulone samples were less than the difference between theses samples and the tetra and rho extracts. More specifically, the relationships between concentration and each of peak intensity, duration, and time to maximum intensity were not different between high and low isocohumulone levels. Paired t-tests of time-intensity parameters indicated that the low isocohumulone extract had greater peak bitter intensity than did high isocohumulone. From the Free Choice Profiling study, the low isocohumulone extract appeared to be harsher than the high isocohumulone extract; this result was likely related to higher bitterness intensity and lingering qualities. The tetra sample was significantly different from all other hop extracts, with high bitterness plus harsh and lingering qualities. While the impact of isocohumulone levels on bitter quality appears very subtle, our results do not rule out the possibility that other, non iso-alpha-acid components in high cohumulone hops may contribute to harsh bitter quality.

Thomas Shellhammer is associate professor of brewing and food engineering in the Department of Food Science at Oregon State University. He received his B.S. degree in fermentation science and his Ph.D. degree in food engineering from the University of California, Davis. He currently serves as member of the ASBC Foundation Board.

O-21

Analysis of Hop Terpenes in Beer and Wort Using the SBSE Method with GC-MS

TORU KISHIMOTO, Noboru Kagami, and Katsuyuki Kawatsura
Asahi Breweries, Ltd.

Hop aroma components contribute to the aroma character of beer. For the analysis of hop aroma components, pretreatment is necessary. This involves steam distillation, extraction with conventional solvents such as dichloromethane, solid phase extraction, or purge and trap extraction. However, they each require time and labor and are somewhat inconvenient. We employed the stir bar sorptive extraction (SBSE) method with GC-MS as a very sensitive and easy method. This extraction method requires a very small quantity, 4–30 mL, of wort or finished beer. In addition, very few impurities are extracted. We determined main hop terpenes, linalool, geraniol, citronellol, myrcene, caryophyllene, humulene, humulene epoxide1 and 2, alpha-eudesmol, beta-farnesene, and beta-damascenone in finished beer or wort. A low cross-validation value (below 10%) and a high correlation between the peak area and the internal standard ratio (over 0.99) were obtained for each substance. With this method, we traced the behavior of these terpenes during the wort boiling process. From our results, the decreasing pattern of terpenes are largely divided into two: one is substances that decrease gently and linearly, and the other is substances that decrease rapidly, drawing a quadratic curve. So, the hop terpene concentration determined by this method reflects the time hops are added and, in part, the hop variety.

Toru Kishimoto received his M.S. degree in agricultural chemistry from Kyoto University, where he majored in molecular biology of wheat protein. He began employment with Asahi Breweries, Ltd. in April 1999 in the beer development section. Since September 2000, he has been engaged in hop research, especially in hop aromas.

O-22

Utilization of the Polyphenol Fraction from Hop Bract Part as Functional Food

MOTOYUKI TAGASHIRA, Msami Kurumatani, Rumi Fujuta, Yoko Akazome-Nagasako, Tomomasa Kanda, and Mitsuo Ikeda
Fundamental Research Laboratory, Asahi Breweries, Ltd.

As a worldwide tendency in recent years, although beer production is slightly increasing, demand of alpha-acid is not going up. The total hop crop continues to decrease because of low alpha dosage for beer and breeding improvement of bitter hop species. Indeed, statistics data suggested that the acreage of hop in 2003 was 55,029 ha, which was only 57% of that in 1992 (95,535 ha). In these situations, it will be meaningful to study the new way of hop utilization for nonbrewing applications. Hop bract part is a by-product discarded from the hop concentration process (making process of hop type 45). This by-product does not contain bitter acids, so it is thought to be a useless part for brewing beer. Therefore, most hop bract part is pelletized and used for cattle feed, but it may contain something useful. In this paper, we report that the valuable utilization of hop bract part as a functional material of food. We developed the method to extract and separate the polyphenol fraction from hop bract part. The polyphenol fraction can be used for food materials because this method uses only water, ethanol, and materials permitted for industrial food processing. This polyphenol fraction is characterized by its rich content of high-molecular-weight polyphenols, which are presumed as highly condensed catechins. Although hop has been used as food material and thought to be safe, we also checked the safety of this fraction by several assay methods, such as acute (14-day and 28-day) toxicity and mutagenicity. Recently, some studies have shown that the polyphenol fraction had several activities such as antidental caries and antibacterial toxins. For example, this fraction showed potent anticavity activity through inhibiting the biofilm-making enzyme produced by *Streptococcus* bacteria (M. Tagashira et al., Biosci. Biotech. Biochem. 61:332-335, 1997). These studies are responsible for the potential of this polyphenol fraction as not only food addition for taste improvement, but also as a functional food material. It will be possible to develop the anticavity gums (or candies) that contain this polyphenol fraction. This finding shows the possibility of industrial utilization of hop bract part. Through this study, we hope to contribute to the development of a new aspect of hop utilization that is not limited to only brewing purposes.

Motoyuki Tagashira received a master's degree from Tokyo University in Tokyo, Japan. He began employment with Asahi Breweries, Ltd. in 1992 as a research scientist. He is working primarily on developing new food materials that have positive functions for human health.

O-23

A Proteome Approach for Detection and Characterization of Hop Inducible Proteins Involved in Hop Resistance of Beer-Spoiling Lactobacilli

JÜRGEN BEHR, Michael G. Gänzle, and Rudi F. Vogel
Technische Universität München, Freising, Germany

The resistance to hop is a prerequisite for the capability of lactic acid bacteria to spoil beer. Therefore, the knowledge on the hop resistance mechanisms allows the specific and sensitive detection of beer spoiling lactic acid bacteria, and may enable the evaluation of targets for mild preservation techniques. Several enzymes involved in hop resistance of lactobacilli have recently been characterized on biochemical and genetic levels. However, the enzymes characterized do not fully account for the hop resistance of lactic acid bacteria. Additional hop resistance mechanisms are known to be involved in beer spoilage. To obtain a global view on the response of lactobacilli to a challenge with hop, a proteome approach was taken to determine hop inducible proteins that contribute to the hop resistance of *Lactobacillus brevis*. The highly hop-resistant beer-spoiling isolate *Lactobacillus brevis* TMW 1.465 was cultured in modified MRS to the exponential growth phase at pH 6 (reference conditions), pH 4.0 (acid stress), and pH 4.0 in the presence of hop (86 µmol/L isohumulone; hop stress). For cells from each condition, extraction procedures were performed for cytoplasmic proteins, as well as enhanced recovery of membrane proteins. For proteome analysis, two-dimensional polyacrylamide gel electrophoresis with immobilized pH gradients was applied. The identified hop inducible proteins were blotted on a PVDF membrane and are being sequenced. A reference map with proteins of *L. brevis* expressed at pH 6 was established and compared with those proteins expressed by the same strain under conditions of acid stress or hop stress. More than 20 proteins were overexpressed more than 1.5-fold in the presence of hop as compared with the reference. The majority of these hop inducible proteins were present in the membrane protein-enriched fraction only and were selectively induced by hop. The induction of hop inducible cytoplasmic proteins was below detection level. Sequencing of hop-induced proteins is currently underway to obtain a global view on the cellular response of beer-spoiling lactobacilli to challenge with hop compounds. The genes coding for hop inducible proteins are identified by reverse genetics, and novel hop resistance mechanisms identified by this proteome approach are characterized on a biochemical level.

Jürgen Behr was born in 1974 in Kulmbach, Germany. During his study of "Technology and biotechnology of foods" in Weihenstephan, Freising, Germany, he acquired experience in food science as well as brewing technology. After projects in the field of yeast proteomics and the physiological basics of lactobacilli (beer spoilers), he concluded his study with a master's thesis about high-pressure resistance of beer-spoiling lactobacilli to obtain the degree of a Dipl.-Ing. Currently, he is working on his Ph.D. thesis at the Chair of "Technische Mikrobiologie" (Technische Universität München). The investigations are focused on the molecular mechanisms of hop resistance of beer-spoiling lactobacilli.

O-24

Potential of Reutericyclin as a Tasteless Hop Analogue in Beer Preservation

Clarissa Schwab, Michael G. Gänzle, and RUDI F. VOGEL
Technische Universität München, Freising, Germany

Reutericyclin is a heat-stable, low-molecular-weight, antibacterial compound produced by cereal isolates of *Lactobacillus reuteri* that shares structural similarity to hop iso-alpha-acids (1). It is active toward gram-positive bacteria but inactive toward yeasts. Various species of thermophilic lactobacilli are employed in sour wort fermentations to improve beer flavor and to adjust the wort pH to the desired level. Selected strains with antimicrobial activity may be used in sour wort fermentations to additionally contribute to beer preservation. In this work, the mode of action of reutericyclin toward beer-spoiling lactic acid bacteria was characterized. Its formation was determined by *L. reuteri* in wort. The mode of action of reutericyclin toward a beer-spoiling *Lactobacillus plantarum* was compared with the known mode of action of hop iso-alpha-acids. Based on its structural similarity to hop iso-alpha-acids, the cytoplasmic membrane was examined as a major target for reutericyclin activity. The fluorescent dyes propidium iodide, carboxyfluorescein-diacetate, and dipropyl-thiadicarbocyanine-iodide were employed to determine the effect of reutericyclin on the integrity and the proton and potassium gradients across the membrane, respectively. Comparable to hop iso-alpha-acids, reutericyclin acted as proton-ionophore, thereby dissipating the proton gradient across the membrane of sensitive cells in a pH-dependent manner. The inhibitory effect of reutericyclin alone or in combination with hop extracts was determined toward two beer-spoiling isolates of *L. plantarum* and *Lactobacillus brevis* exhibiting intermediate and high hop resistance, respectively. Using either indicator strain, reutericyclin could functionally substitute hop compounds. Furthermore, hop resistance of these two strains correlated to the reutericyclin resistance, indicating that hop resistance in beer-spoiling lactobacilli confers reutericyclin resistance. Fermentations with *L. reuteri* in wort were carried out at static-pH conditions to determine whether reutercyclin is formed in cereal substrates. It was demonstrated that reutericyclin is produced in active concentrations during growth of *L. reuteri*. Optimal pH values for reutericyclin formation ranged from 4.0 to 5.0. In conclusion, reutericyclin is produced to active concentrations during growth of *L. reuteri* in sour wort fermentation and is active toward beer-spoiling lactic acid bacteria. Therefore, reutericyclin-producing strains of *L. reuteri* have a potential for use as biopreservatives in brewing applications. (1) Gänzle et al. 2000. Appl. Environ. Microbiol. 66:4325.

Prof. Dr. Rudi F. Vogel was born in 1955 and is a biochemist (Universität Tübingen, Germany) interested in food microbiology and biotechnology. Since his habilitation on the genetics of lactobacilli (Universität Hohenheim, Germany), he is head of the Technische Microbiologie in the Department for Food and Nutrition of the Technische Universität München, Germany. He supervises and coordinates research on lactic starter culture development ranging from ecology and biochemistry to functional genomics, including several projects in brewing science and high pressure in food and biosciences. He is a member of the editorial board of scientific journals, international associations, and advisory comittees on food safety and genetically engineered organisms.

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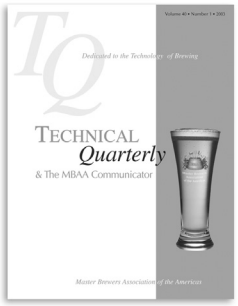

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O-25

A Rapid and Low-Cost Method for Quantification of Reduced Iso-Alpha-Acids in Brewing

Alexis Bolívar, MÓNICA GASPARRI, and Carsten Zufall
Cervecería Polar, C.A.

Reduced hop extracts (rho-, tetrahydro-, and hexahydro-iso-alpha-acids) are in widespread use in breweries around the world for the purpose of achieving light-stable products with foam and cling enhancement. Brewers can take advantage of blending these iso-alpha-acids in order to produce beers with different flavor profiles.The traditional UV bitterness units (BU) method cannot be used for quantifying the components within a composition of reduced iso-alpha-acids. The HPLC method is currently the only analytical tool for controlling hop-dosing and bitterness in beers brewed with reduced iso-alpha-acids. Furthermore, it permits detection of iso-alpha-acid contaminations in light-stable beers. However, it is much more expensive and time-consuming than the BU method. Production of light-stable beers typically requires hop dosage during filtration. Thus, in large-scale production, time is very limited for BU measurements before and after dosing. Initially, we used the HPLC method with sample pretreatment by manual solid-phase extraction (SPE) and analysis by C-18 reverse-phase column with a relative standard deviation (RSD) 1.6%. We have developed a novel HPLC method for routine analysis, making it less expensive and faster by direct injection using a new-technology HPLC column, Chromolith™. The 60 min required previously has now been reduced to just 8 min. This has resulted in an 86% savings in time and a 60% savings in cost. The method permits direct analysis of wort or beer after disc membrane filtration. It leads to the calculation of a profile concentration of the different iso-alpha-acids. Finally, with the varying relative bitterness intensity, it yields organoleptic bitterness units. The improved method with RSD 0.9% has been validated and implemented in all five of our laboratories. In order to fulfill the validation requirements, we have tested linearity, accuracy, precision, specificity/selectivity, range, and ruggedness/reproducibility, as well as detection limit.

Mónica Gasparri is chromatography coordinator in the Corporate Laboratory at Cervecería Polar C.A. During her 20 years at Polar, she has managed various responsibilities in the chromatographic area. Monica received her Docteur de Troisième Cycle in organic chemistry in the Sciences Faculty of Poitiers University, France.

TECHNICAL SESSION V: Environmental/Engineering

Moderator: Kathy Kinton

Kathy M. Kinton began her career in the brewing industry at Miller Brewing Company in 1979. She has worked in various positions in quality services and corporate environmental engineering, and she became the quality services manager at the Irwindale Brewery in 2001. Kathy joined MBAA District Milwaukee in 1988 and has served as district president in 1994 and 1995. She served as chair of the MBAA Scholarship Committee from 1993 to 1995 and chair of the MBAA Education Committee from 1996 to 1998. Kathy has been an instructor for MBAA courses and authored the chapter, "Environmental Issues Affecting Brewery Operations" in the new edition of The Practical Brewer. *She has presented various papers on environmental issues and facilitated the first Environmental Workshop at the 2001 ASBC Convention. Kathy was MBAA president in 2001 and is cochair of the WBC 2004. She also is a member of the ASBC Foundation Board. Kathy received her bachelor of science degree in food science from North Carolina State University in Raleigh, NC, in 1973 and is a graduate of the 1979 MBAA Brewing and Malting Science Course.*

O-26

ECO-MATRIX: A New Economical Pipe System

KRISTINA BOEE
Tuchenhagen Brewery Systems, Buechen, Germany

Vision becomes reality. ECO-MATRIX.…The new, efficient piping concept for process plants! The new Tuchenhagen piping system, ECO-MATRIX, offers cost effectiveness and efficiency so far unreached in systems engineering. By comparison to ordinary systems, ECO-MATRIX reduces considerably the number of instruments required and allows for essential optimization of process sequences. This helps you to manage your capital investment and provides a much faster payback. Production processes in modern brewery and beverage plants are determined increasingly by economic factors and product quality requirements. There is a continual requirement to improve product quality, increase operational safety, and at the same time, reduce capital and operating costs and minimize product losses. Quite a challenge! The response to this challenge is ECO-MATRIX. ECO-MATRIX is a new system of piping from Tuchenhagen in which the process pipes and process valves are connected directly beneath the tank outlet. The process valves may be arranged either laterally at the tank outlet tree, at the tank cone, or vertically at the tank bottom flange. This innovative system significantly reduces the length of piping required, thereby reducing product losses and minimizing the risk of contamination during the brewing or distribution processes.The technical advantages of ECO-MATRIX at a glance. • Simple and quick to install. • Reduced space requirement. • Short tank outlet pipes, minimized product losses. • No dead ends at the tank outlet.

Kristina Boee is head of engineering international. She holds a B.Sc. degree in process engineering and a Dipl.-Ing. from the Technical University Hamburg-Harburg, Germany. Kristina Boee has 6 years of experience in the beverage and brewing industry. Her personal project contributions include project engineer for process units (wort aeration and yeast pitching); product manager for process units (carbonation, mix-processing, deaeration, wort aeration, and yeast pitching)—presentations, sales material, support, technical developments; project manager for beverage plants (complete integration, new developments, design, engineering, installation, and start up); technical support for Tuchenhagen North America and process units (55 units, 1995–1999, each 0.1–0.5 Mio. Euro; Lasko Brewery/Slovenia, two plants, 1997–1999, 0.5–1 Mio. Euro; and Union Ljubljana Brewery/Slovenia, one plant 1998–1999, 3 Mio. Euro). Kristina studied until 1995. She then worked for Tuchenhagen Brewery Systems GmbH, Germany, as product manager (1996–1998), project manager (1998–1999), and head of engineering international (2000–present).

O-27

Asahi's Approach to Reduction of Energy Basic Unit to Half

AKITOSHI YOSHIZAWA
Asahi Breweries, Ltd.

In December 1997, the COP3 conference for the prevention of global warming was held in Kyoto, and a worldwide agreement was reached regarding an approach to addressing the problem. In Japan, there is also a growing recognition that society as whole must make a concerted effort to further curb CO_2 emissions. In response to such a trend, Asahi Breweries decided to tackle the task to reduce the energy basic unit to half. The amount of CO_2 emission resulting from fuel and electricity consumption was 70% of all the CO_2 emitted at the breweries. Therefore, the reduction of fuel and electricity consumption would be greatly effective for energy saving and also for CO_2 reduction. This paper will introduce the approaches to energy saving at Asahi Ibaragi Brewery. Until 2000, 4 years ago, the energy basic unit of Ibaragi Brewery was rather high, 134 MJ/hL in fuel and 166.5 MJ/hL in electricity, (= 16.26 kWh/hL × 10.24 MJ/kWh as in the calculation method of Japanese Law concerning the Rational Use of Energy). Due to our energy-saving efforts, in the 2003 year-end, the fuel basic unit became 103 MJ/hL, down 23% from the year 2000, and the electricity basic unit became 117.4 MJ/hL (11.46 kWh/hL), down 30%. Furthermore, in 2006, we will try to achieve an energy basic unit of 121 MJ/hL in fuel and 37.7 MJ/hL (3.68 kWh/hL) in electricity, and to introduce the 5,000-kW cogeneration system. Regarding the approaches, first we created the energy balance sheet on fuel and electricity to grasp the situation. In clarifying the problems, we compared Ibaraki Brewery with Nishinomiya Brewery, which was marked as our top energy-saving brewery. This gave Ibaragi Brewery the top level of energy basic unit among our breweries. Second, we calculated the theoretical energy basic unit and compared it with Ibaraki's improved energy balance sheet to pinpoint further problems. These two steps made us promote energy-saving approaches effectively.One example of actual measures is an establishment of a heat exchanger that utilizes the cool thermal energy before the CO_2 vaporizer. The previous CO_2 vaporizer used steam to heat up and vaporize CO_2 liquid of –7.6°F to 86°F. Ibaragi Brewery used to use 14,000 t of CO_2 and more than 6 million MJ of fuel per year. By establishing the heat exchanger with propylene glycol before the CO_2 vaporizer, we reduced electricity consumption of a freezer and the amount of required heat for the vaporizer. This resulted in a reduction of 5.15 million MJ of fuel and 0.45 million kWh of electricity per year. Other majors taken between 2001 and 2003 rose to seventy, with 31 MJ/hL in fuel and 49.2 MJ/hL (4.8 kWh/hL) in electricity reduced as a total.

Akitoshi Yoshizawa received a B.S. degree in mechanical engineering from Meiji University in Tokyo, Japan. He began employment with Asahi Breweries, Ltd. in April 1995 as an engineer in the brewery. He has worked for about 7 years as an engineer (brewing, packaging, etc.). Since September 2001, he has approached the reduction of the energy basic unit to half in the R&D Promotion Office of Asahi Breweries, Ltd.

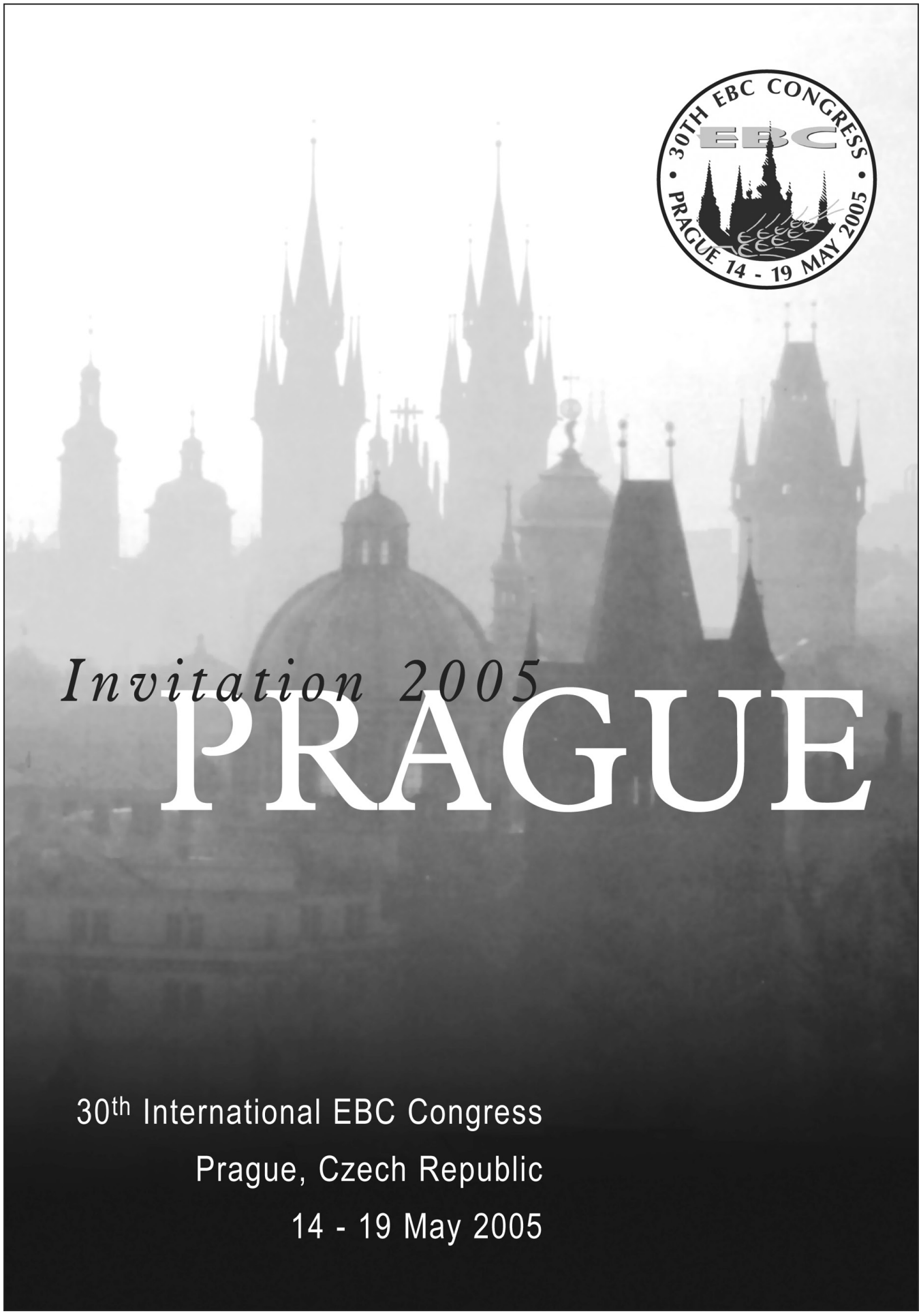
O-28

Membrane Separation Activated Sludge Processes: Method of Purifying Warm Water for Warmer

YASUHIRO SASAKI
Asahi Breweries, Ltd.

Asahi uses the device, Warmer, that warms cans or bottles to normal temperature by circulating warm water after filling with beer, because dew condensation on beer containers affects the rest of the processes. This circulated warm water gets dirty by beer components clinging onto beer containers during filling. Therefore, we used to do a daily job of exchanging water and washing Warmer. The new method, membrane separation activated sludge processes, made it possible for us to keep it clean with only a once-a-week job. This enabled us to improve production efficiency with longer operation hours and to cut down utility expenses. Furthermore, processed water with this method has a high quality and a possibility of reuse in another processes, which we investigated for a closed system. Membrane separation activated sludge processes is the method that simultaneously performs both biological processing and filtration with microfiltration membranes whose 0.4-µm surface is where microbes are adhered. It has two features: a simple composition and easy maintenance. This device is composed of an activated sludge tank, membranes filtration units, a pump, and a blower for aeration. We set it up at a working can line and used this processing method to purify circulated warm water in Warmer. Regarding the processing conditions, the quantity of Warmer's holding water is about 9 m^3, the pollution rate of circulated warm water is between 5 and 12 mg/L/h as COD, the processing capacity is between 2 and 4 m^3/h, the device volume is about 5 m^3, the purifying method is consecutive processing , and the temperature is from normal temperature to 45°C. As for the result, the quality of wastewater is changed through the method. Between 30 and 180 mg/L as COD in wastewater is reduced to be 10 mg/L or less. The turbidity, ranging between 2.0 and 9.5 NTU, in wastewater becomes 0.15 NTU or less. pH ranging between 5.3 and 7.0 becomes between 5.8 and 7.8. Unusual odor and color of wastewater becomes usual. The number of bacteria in the standard plate count is greatly reduced, from more than 8×10^4 CFU/mL to less than 200 CFU/mL to nil. Regarding the water quality in Warmer after the five-consecutive-day performance of the method, COD becomes 60 mg/L or less, the turbidity becomes 4 NTU or less, pH ranges between 5.6 and 7.3, and both odor and color become usual. These results show that the water processed with this method becomes pure and that the method is useful. Therefore, we think it is possible to continue to use the processed water for a much longer time, without disposing it.

Yasuhiro Sasaki received a B.S. degree in chemical engineering from Chuou University in Tokyo, Japan. He was employed with Asahi Breweries, Ltd. in August 1997 as an engineer in the brewery. He has worked for about 6 years as an engineer (brewing, packaging, etc.). Since September 2002, he has been researching membrane separation activated sludge processes in the Research and Development Promotion Office of Asahi Breweries, Ltd.



Invitation 2005

PRAGUE

30th International EBC Congress

Prague, Czech Republic

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O-29

Happy Fish Due to or In Spite of an Optimized Wastewater Treatment System?

VERA GROOT KORMELINCK (1), Bernd Franzmann (2), and Shashi Gorur (3)
(1) Paques, The Netherlands; (2) Karlsberg Brauerei, Homburg, Germany; (3) USFilter, U.S.A.

The importance of an excellent effluent quality has to be met by the Karlsberg Brewery in Homburg, Germany. They discharge their purified wastewater into a small river. A necessary condition for discharging into this river is that there should be no ecological damage to the existing ecosystem. Until the late 1990s, the Karlsberg Brewery discharged their wastewater to the municipal wastewater treatment plant. Economical factors and the belief that the stringent effluent demands could be met with an on-site wastewater treatment plant made Karlsberg decide to build their own. This paper presents the historical background of the project and a description of the technologies applied. Operational data, including any problems that occurred during startup are discussed, as well as the economical benefits of the wastewater treatment plant. This enables an overview of the current state of art in the treatment of brewery effluent.

Vera Groot Kormelinck graduated in food technology at the Friesland College of Food Technology in 1989. After graduation, she started her professional career at the laboratories of Vriezo bv. Her employment with Paques bv began in 1989, where she lead the biological startup of a large demonstration project at Heineken in Den Bosch. In 1996, having served several years as a startup engineer at various industrial effluent treatment projects, she joined the process engineering department of Paques. In 1998, she started her function as a proposals manager, in preparation for a more commercially oriented career. In 2000, she became area sales manager for Germany with a focus on the beer and beverage industry. At the beginning of 2004, she accepted responsibility as branch manager, beer and beverage market, for Paques.

O-30

Best Available Techniques in the Brewing Industry

P. W. VAN OEVEREN
Heineken International B.V.

Introduction: The European Union Council Directive 96/61/EC concerning integrated pollution prevention and control (IPPC) came into force in October 1996. The purpose of the directive is to achieve a high level of protection of the environment through an integrated approach to prevent emissions to air, water, or soil. The IPPC permit shall include measures based on the so-called Best Available Techniques (BATs). All breweries with an output of over 1 million hL per year shall have an IPPC permit in 2007 ultimately. The role of the Best Available Techniques in the brewing industry will be described in this presentation. A Best Available Technique (BAT) is defined as being the most effective ("Best") and accessible technology on a scale that allows implementation under economically and technically viable conditions ("Available"). A BAT is not a single solution but depends a.o. on local environmental conditions. The directive promotes the dissemination of such techniques by maintaining so-called BAT Reference Documents or BREF. One of those BREFs covers food, milk, and drink, including breweries. Branch organizations, such as the CIAA and the Brewers of Europe, had an important contribution to this BREF. Challenges ahead: The Brewers of Europe have followed the BREF development very closely and anticipated it by preparing a Guidance Note for establishing a BAT in the brewing industry. The reason was to summarize the 520-page BREF into a document of 30 pages, not only to help the breweries understand the BREF but also to explain to the permitting authorities what the environmental impact of breweries comprises. Another important factor is the assessment of the environmental benefits against the investments. The Technical Working Group "Economics and cross media effects" is investigating the ingredients to improve objectivity, transparency, and consistency of the decision-making process. The Brewers of Europe have developed a decision tree to evaluate candidate BATs. The stepwise approach assesses the technological feasibility of such things as beer recipe and product safety. These subjects should be valued against the environmental benefits. The economic consequences should be based on feasibility and affordability. Conclusion: The IPPC Directive refers to the BREFs, which provide an instrument to consider measures concerning a broad range of environmental impacts. The breweries should be aware of the degrees of freedom and to be alert to negotiate with the authorities the proper permit. The Guidance Note of the Brewers of Europe should help the breweries in this process. The EBC Technology & Engineering Forum will start a Working Group BAT to keep the Guidance Note up-to-date.

Pjotr van Oeveren received an M.Sc. degree in chemical engineering from the Technical University in Delft, The Netherlands. He currently works with Heineken International B.V. and has worldwide responsibility for safety and environment policies. He is a member of the IPPC-BAT committees of CBK, Brewers of Europe, CIAA, EBC, and the Technical Working Group.

O-31

Greener Beverage Product Security and De-Casing Solutions

PAUL LIGON and Neal Gutkin
WM IPS

This presentation will present a strategic alternative to beverage destruction sourcing that emphasizes cost-effective resource efficiency through on- and off-site product destruction, liquid recovery, and container recycling practices. The presentation will assess the product security and de-casing industry in the context of several established and emerging business trends, including performance-based contracting, outsourcing of "non-core" functions, strategic partnering, and the movement from leveraging physical capital to intellectual (knowledge, information, and learning) assets. Each of the points below will be elaborated on in more detail. 1) The de-casing industry structure and fit within the brewing industry value chain, and how de-casing contracts can be structured to produce superior services and mutual, profitable gains. 2) Models and case studies of effective de-casing and product security operations and relationships that produce tangible savings, security value, and environmental results. 3) Overcoming the purchasing mentality.
- Appropriating value from the product destruction and de-casing supply chain. - How to ensure product security and de-casing services are sourced as a systems buying practice. The presentation will provide a thorough analysis of these points while also providing practical information and resources for those wishing to take this emerging model to the next level.

Paul Ligon is a business development manager with Waste Management's In-Plant Services Division (IPS). IPS is a leading provider of environmental sourcing solutions to a wide range of industries. Between 1990 and 2001, Mr. Ligon was a senior scientist at the Tellus Institute, a global environmental research and consulting firm in Boston. In this capacity, he has advised companies and governmental agencies in the U.S., Australia, Central America, and Egypt on environmental strategies related to supply chain initiatives, information systems, reporting and disclosure, financing, accounting, and project management. He is widely published in environmental trade and academic journals and speaks regularly at professional conferences on environmental best management practices. Paul holds an M.B.A. degree from the Tuck School of Business at Dartmouth and a B.S. degree from the University of Vermont.

O-32

Aware of Water

PAUL J. M. BRUIJN, Pjotr W. van Oeveren, and Sietse W. Montijn
Heineken

Heineken is a worldwide brewer with more than 130 breweries in 60 countries. During the last 20 years, Heineken has monitored the water supplies for these breweries. We have seen lower water tables, have closed wells due to chemical contamination, and in one extreme case, closed a brewery for 2 months during a severe drought due to no water. In 1999, due to these concerns and in support of our Environmental Policy, we developed a global Water Policy. This policy resulted in a four-part Aware of Water program. 1) Documentary film series "Water the Drop of Life". Heineken supported the production of 13-part documentary series on water. Each part is 50-min long and is intended to increase awareness of water use by the general public. This television series has been broadcast in more than 100 countries. 2) CEO Panel of World Water Forum. Heineken's CEO is a member of the World Water Forum CEO Panel. The panel represents a range of businesses, with a shared commitment to water management. In 2001, the Panel issued a statement addressing four major water themes and, in 2003, reviewed the results of five significant water projects. 3) Water usage. Water use by beer production chain was quantified with a life cycle assessment. This assessment began with barley growing, ended with water use by consumers, and included water use for packaging, malting, and brewing. Barley growing used the most water, about 200 hL of water for every hL of beer (200 hL/hL), which was largely rainwater. Clearly, brewers have difficulty in reducing this use. Breweries used, on average, about 10 hL/hL. This use can be influenced by brewers. Next, a benchmarking study with both Heineken and non-Heineken breweries was carried out. The study showed that water use varied greatly, from a low of 4 hL/hL to a high of 24 hL/hL and also related water use to volume, location, and packaging mix. Based on this study, Heineken established a maximum water target of 7 hL/hL for every brewery, irrespective of size, location, or packaging mix. 4) Reduced water usage in Heineken Breweries. To meet this target, an educational workshop, "Aware of Water", was developed. The outcome was a water savings plan for each brewery, developed by the people from that brewery. These plans were implemented and the results recorded by Heineken environmental reporting system. In the 3 years since these workshops were held 1) all Heineken breweries have reduced water use, 2) the weighted average water use has been reduced by 1 hL/hL, and 3) 50% of the breweries that were above the target now meet the target. Based on the success of the Aware of Water program, a second edition is being developed for breweries that have not yet met the target and an Aware of Energy program is being carried out.

Paul Bruijn received a degree in biology from the University of Leiden, The Netherlands. He began his employment with Heineken in 1989 as a research scientist at Heineken Technical Services. Research topics included anaerobic and aerobic wastewater treatment, cleaning and disinfection, and valorization of brewery coproducts such as brewers spent grains and surplus yeast. Since 1996, he has functioned as an environmental specialist and has been involved in various improvement programs including "Aware of Water". Furthermore, he is involved with internal and external safety & environmental reporting for the Heineken maltings, breweries, and soft-drink plants.

TECHNICAL SESSION VI: Malting

Moderator: Xiang Yin

Xiang S. Yin is the technical manager for Cargill Malt Americas, based at Prairie Malt Limited, Canada. He obtained his first degree in engineering in fermentation technology at Wuxi, China, and received his Ph.D. degree in 1986 from Heriot-Watt University, Edinburgh. He carried out his postdoctoral research at the University of Edinburgh and then at the Grain Research Laboratory in Winnipeg. As the recipient of the 1990 Centenary Research Award of the Institute of Brewing, Xiang worked at the Brewing Research International, England, on beer flavor in the same year. He was an associate professor at the Wuxi Institute of Light Industry in China for 3 years before joining Prairie Malt as director of technical services in 1991. Xiang is the author or coauthor of more than 30 scientific and technical papers. He recently served as the district executive and representative on the Board of Governors for District Western Canada of MBAA.

O-33

Raw Barley as Adjunct—Optimal Application of Malt and Commercial Enzymes for Beer Production

DECLAN L. GOODE (1,2) and Elke K. Arendt (1)
(1) Department of Food and Nutritional Sciences, National University of Ireland, University College Cork, Ireland; (2) National Food Biotechnology Centre, National University of Ireland, University College Cork, Ireland

In traditional brewing, malted barley is the grain of choice. It acts not only as a raw material, supplying starch and protein, but it also contains a sufficient supply of enzymes necessary for the efficient production of wort. However, in different parts of the world, barley-growing conditions may be poor, malting facilities and malting conditions are quite often less than optimal, and the importation of malted barley can be expensive. Considerable savings can thus be made by replacing part or all of the malted barley by unmalted cereals, such as raw barley, together with exogenous enzymes. Brewers are often in a dilemma as to the level of malt replacement and commercial enzyme addition that is possible without negatively affecting the quality of their products. The objective of this study was, therefore, to evaluate the effects of both endogenous malted barley enzymes and exogenous commercially produced enzymes on final wort quality when mashing with raw barley. Laboratory-scale trials were carried out to determine the effects of malted barley addition, when mashing with raw barley. Additional laboratory-scale brewing trials were carried out in which a range of different commercial enzymes (proteases, alpha-amylases, and beta-glucanases) was added during the mashing process at different dosage rates. These enzymes, which were added in both cocktail form and individually, were assessed and characterized with respect to their effects on mash filterability, wort quality, and fermentation characteristics when mashing with raw barley as a substrate. With the addition of malt, increases in extract, fermentable sugars, free amino nitrogen levels, and fermentability were observed. Increasing the amount of bacterial protease also gave corresponding increases in free amino nitrogen. Commercial alpha-amylase addition yielded increases in the rate of filtration. However, at increased levels, negative effects on filtration were observed. Without the aid of malt enzymes, the inclusion of a commercial heat-stable alpha-amylase was necessary to yield a starch-negative wort. Commercial beta-glucanase addition was necessary at low levels to reduce wort viscosity and beta-glucan content of the wort. By comparing the data of the malt addition trials together with the data of the commercial enzyme addition trials, suggestions were made concerning barley brewing with the overall aim of maintaining or increasing wort quality while reducing costs.

Declan L. Goode received a B.Sc. degree in food technology from The National University of Ireland, Cork, Ireland, in 1998. He received his M.Sc. degree in the area of brewing at the National University of Ireland, Cork, in 2001. The title of his thesis was "Brewing with unmalted sorghum and commercial enzymes". He is currently employed as a senior research scientist at the Research Malting and Brewing Facility of the National University of Ireland, Cork, Ireland, where he takes responsibility for the running of the research brewery. He is also working toward his doctorate degree. His areas of research include enzymes and unmalted cereals. He has previously presented at international conferences and has recently published in the Journal of the Institute of Brewing *and the* Journal of the ASBC.

O-34

A New Technique for Combined Milling and Mashing in the Brewhouse

Gary J. Freeman (1), Michael Ruth (1), Michael Todman (2), and F. RICHARD SHARPE (1)
(1) Brewing Research International; (2) Pursuit Dynamics PLC

Currently, a brewery mash is performed using a sequence of operations. The malt is carefully milled to a suitable particle size distribution and mixed with other solid grist material as required. Brewing liquor is heated to a target temperature so that, when mixed with the cool grist, the correct starting temperature is obtained in the mash. The liquor and grist are then mixed using a masher that produces a homogenous suspension of the grist in the liquor. The work described assessed the feasibility of employing an innovative new technology to simplify this process sequence. The new process relies on a "PDX" unit, a patented system. The PDX is able to function simultaneously as a pump, mixer, heater, and macerator. Steam is injected into a stream of malt and liquor. The injection point comprises an annular ring around the pipe. With sufficient steam flow, the entry velocity is supersonic and the resultant shock wave is sufficiently energetic to macerate ("mill") the malt grains and disperse them. Some of the mash heating is provided by the steam injection. Potentially, a combined milling and mashing process based on PDX could enable savings in capital expenditure, energy, manpower, maintenance requirements, and space. The feasibility study presented was designed to investigate the potential applicability of PDX in the brewhouse. Initial work enabled a preliminary unit design to be selected. Subsequently, the technology was evaluated in a pilot plant (100-L brewlength). Results have been interpreted in terms of economic value, wort quality, and the selection of the appropriate wort separation technology.

Richard Sharpe obtained his first degree in chemistry. He then studied for his Ph.D. degree at the Brewing Research Foundation, where he investigated the chemistry of beer flavor, hop oil, and the extraction of hops and liquid carbon dioxide. He joined Whitbread plc in 1979 and, after a 20-year career in science and technology, left his position as director of beverage research and development to join Brewing Research International as their technical director, where he is responsible for the sales and marketing function. He is a visiting professor at Luton University and is the author of 60 publications and two patents. He is a fellow of the Royal Society of Chemistry, a fellow of the Institute of Food Science and Technology, and a fellow of the Institute of Brewing. He is chair of the Institute & Guild of Brewing's Analysis Committee and a member of the Heriot Watt Research Committee.

O-35

Physiochemical Changes in Barley/Malt During the Malting Process with Particular Emphasis on Beta-Glucan and Beta-Glucanases

John O'Flaherty and EOIN LALOR
Quest International Ireland Ltd.

A detailed study on the effect of various germination programs on malt modification was carried out on European barley. Particular attention was paid to the effect of germination time and temperature on final malt quality as determined by EBC mashing experiments on a laboratory scale. Parameters measured were mash filtration efficiency, extract yield, and malt beta-glucanase and malt/wort beta-glucan content. Changes to malt beta-glucanase and malt beta-glucan (content and molecualr weight) were monitored at different stages during the malting program. The information obtained gives a clear insight into malt modification and explains where and why problems might arise in subsequent processing in the brewery.

Eoin Lalor graduated from Trinity College Dublin with an honors degree in biochemistry. Having worked in medical research (cancer and multiple sclerosis) for a number of years, Eoin joined the Whitbread Brewing Company as a brewing research scientist. In 1991, Eoin joined Quest International as a senior scientist for their brewing products division. After a number of years working in company headquarters in Holland as an applications manager, Eoin returned to Ireland. Eoin is currently business development manager for brewing products working with all major brewing companies worldwide.

BCOJ

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Organization

The BCOJ was established within the BAJ—Brewers Association of Japan—in 1989, consisting of Japan's 5 major beer companies, ASAHI BREWERIES, LTD., KIRIN BREWERY CO., LTD., ORION BREWERIES, LTD., SAPPORO BREWERIES LTD. and SUNTORY LTD. The BCOJ comprises a Secretariat, Analysis Committee and Program Committee. Regional beer producers are not represented by the BAJ.

Objectives & Activities

(1) To standardize analytical methods for the evaluation of materials and products adopted in beer brewing and other related industries
- Publication of "Methods of Analysis of BCOJ" (1996)
- Publication of "BCOJ Microbiology Methods" (1999)
- Publication of "BCOJ Sensory Analysis Methods" (2002)

(2) To facilitate scientific and technological research through mutual communication among beer brewing industry specialists
- Holding of the Annual Meeting (1991-)

(3) To work in collaboration with other foreign organizations
- Cooperative Agreement with ASBC (1998)
- Declaration of Partnership with EBC (2001)

The 14th Annual Meeting

DATES: Thursday 11 and Friday 12 of November 2004
VENUE: Seiryo Kaikan
2-16-2, Nagata-Cho, Chiyoda-Ku, Tokyo 100-0014, Japan

For further information, please contact the BCOJ.

O-36

Malting Characteristics of Three Canadian Hulless Barley Varieties, CDC Freedom, CDC McGwire, and CDC Gainer

YUESHU LI (1), Rob McCaig (1), Aleksandar Egi (1), Michael Edney (2), Marta Izydorczyk (2), and Brian Rossnagel (3)
(1) Canadian Malting Barley Technical Centre, Winnipeg, MB, Canada; (2) Canadian Grain Commission, Grain Research Laboratory, Winnipeg, MB, Canada; (3) Crop Development Centre, University of Saskatchewan, Saskatoon, SK, Canada

Several malting trials at micro and pilot scales were carried out with Canadian hulless barley, CDC Freedom, CDC McGwire, and CDC Gainer, of the 2001 crop. Their malting behavior and malt quality were evaluated in comparison to a covered two-row malting variety, AC Metcalfe. Trial results indicated that all three hulless varieties could be malted successfully and produced quality malt under processing conditions that were tailored to each variety's requirement. The required total malt processing time was up to 7 days. In the trials, all three barleys showed rapid water uptake and rapid chitting, and the progress of modification was similar to that of the control AC Metcalfe. However, excessive acrospire damage by the turner during germination was recorded, which was attributed to the lack of husk protection. This suggested that turning frequency needed to be adjusted during germination to reduce the damage. These hulless barleys were more sensitive to kilning conditions, and varying the kilning regimes significantly affected malt quality, especially malt friability, more than it did in the control. In the trials, CDC Freedom, CDC McGwire, and CDC Gainer produced malt with very high extracts, about 2–4% higher than that of the control AC Metcalfe. Malt soluble protein and diastatic power were comparable to those of the control malting variety, while wort viscosity was higher and alpha-amylase level was lower. In comparison, CDC McGwire's pilot malt had more balanced quality, with the highest friability and lowest beta-glucan content among the three hulless varieties. In micromalting trials, the beta-glucan levels of the trials was reduced from that seen in the pilot-scale maltings, and the varietal differences seen in pilot malting trials disappeared. This suggested that the difference in malt beta-glucan content was mainly contributed by the difference in malting conditions. Wort analysis also indicated that the wort quality was comparable to that of covered barley in terms of sugar compositions.

Yueshu Li is director of malting technology at the Canadian Malting Barley Technical Centre in Winnipeg, Canada. He joined the Centre in August 2000. Previously, he was senior technical consultant for malting barley in the Market Development Department of the Canadian Wheat Board. Dr. Li has more than 14 years of malting industry experience and has held several senior research and management positions in the malting industry in both North America and China, including Prairie Malt Limited, Canada; Schreier Malting, U.S.A.; and CUC Nanjing Malt Limited, P.R.C. Yueshu was born in China and educated in both China and Canada. He obtained his B.Sc. and M.Sc. degrees in China and a Ph.D. degree from the University of Saskatchewan, Canada. He is a member of MBAA, ASBC, and AACC.

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Brewing with Canadian Hulless Barley Varieties, CDC Freedom, CDC McGwire, and CDC Gainer

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Brewing trials were carried out with malt made from Canadian hulless barley varieties, CDC Freedom, CDC McGwire, and CDC Gainer, generated from pilot malting trials at the Canadian Malting Barley Technical Centre. All-malt brews were done with 100, 90, and 70% hulless malt. Those brews done with 90 and 70% hulless malt were supplemented with 10 and 30% normal commercial malt. For all brews, the following standard procedure was used to facilitate the comparison. Malt was milled using a hammer mill. Mash in was at 48°C for 30 min. The temperature was increased to 65°C, held for 30 min, and finally raised to 76°C for mash off. Wort separation was carried out using a mash filter. The brews were boiled for 90 min, and hops were added at 90 and 5 min before the knockout, respectively. For all the brews, the finished wort was cooled to 12°C, pitched with a commercial lager yeast, and fermented at 15°C. The beer was aged for 7 days at –1.5°C, filtered using a cellulose acetate pad filter, carbonated, packaged into bottles, and pasteurized (10 pasteurization units). No difficulties were experienced during mashing for all three malt varieties. Conversion times for the trial hulless varieties were longer than for the control commercial malt. The control converted in 11 min, while the trial hulless varieties converted after 25 to 30 min. Conversion time in the trials was reduced as the proportion of commercial malt in the trials increased. Wort separation time from the mash filter was also significantly higher for the hulless trials, although it was found that there was no correlation between the beta-glucan content of the blend and the runoff time. CDC McGwire malt exhibited a faster runoff, followed by CDC Freedom and CDC Gainer. Under the same fermentation conditions, all brews fermented well and the achieved attenuation was comparable to that of the control brew with commercial malt. Beer foam stability was equal to or better than that of the control brew. Beer residual sugars of hulless brews were also comparable to those of the control brew. Physical stability of the beer produced from the trial varieties was poorer than that of the control, although there was variation among the varieties. Beer sensory results indicated that the quality of beer brewed from the hulless barleys was satisfactory and no quality defects were noticed.

Rob McCaig has more than 22 years of brewing industry experience with Molson Breweries. Starting his career in 1981 with Molson in Quebec, Rob has held a number of positions including research microbiologist, brewer, corporate brewer, and brewmaster. In February of 2003, he left Molson to take the position of managing director and director of brewing for the Canadian Malting Barley Technical Centre (CMBTC) in Winnipeg. Rob is a member of the American Society of Brewing Chemists (ASBC), serving as both local chair and as president of the national ASBC. He is also a member of the Master Brewers Association of the Americas and the Institute and Guild of Brewing. While working as a research microbiologist, Rob presented and published more than 20 research papers. He has a M.Sc. degree in applied microbiology from the University of Guelph.

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WITHDRAWN

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Investigation into Conditions During the Early Stage of Kilning to Improve Beer Flavor Stability

TSUTOMU UEDA (1), Katsuya Sasaki (1), Hiroshi Itagaki (2), Kumiko Inomoto (1), Noboru Kagami (1), and Katsuya Kawatsura (1)
(1) Asahi Breweries, Ltd., Brewing R&D Laboratory; (2) Asahi Beer Malt Co., Ltd.

A cardboardlike flavor is still noted as one of the stale flavors in aged beer, and it is well-known that *trans*-2-nonenal (T2N) is responsible for the cardboard flavor. While there were several studies of curing conditions in malting process for reducing the T2N level, there have been few investigations into the early kilning (withering) stage. Therefore, withering conditions were evaluated by using two indicators: lipoxygenase (LOX) activity and malt *trans*-2-nonenal potential (M-T2N-P), a recently found malt indicator of T2N formation in aged beer. In this study, we conducted malting trials with different parameters of humidity and temperature of inlet air and the airflow level in the withering process and compared the changes in LOX activity during the kilning process, LOX activity, and M-T2N-P in the finished malt. As a result, while each measure of reducing the temperature of inlet air and increasing the airflow level was observed to be effective, the measure of reducing the relative humidity of inlet air was considered as a most effective measure to decrease peak LOX generation in the kilning stage, LOX activity, and M-T2N-P in malt. Furthermore, the best practice in a commercial malting plant was performed with the above three withering measures combined with a previous measure of increasing the curing temperature. The optimization of these parameters enabled a considerable 70% reduction in LOX activity and a 30% reduction in M-T2N-P, although there was no particular difference in the other standard malt analyses. In addition, the significance of these measures was also confirmed in comparative brewing studies that evaluated beer flavor stability based on T2N reduction and sensory tests. Taken together, we concluded that kilning conditions are potentially important factors in reducing the T2N level in aged beer.

Tsutomu Ueda graduated from Osaka University in 1992, majoring in bioengineering. Since graduation he has worked in various positions for Asahi Breweries Ltd. From 1992 to 1995, he was assigned to the Mashing Section staff of the Fukushima Brewery. During this time, he worked on the development of the bottom-entry mashing-in system for improving beer flavor stability. That work was presented at the 26th EBC Congress (Maastricht, 1997). From 1995 to 1997, he worked as a malting supervisor at Asahi Beer Malt Ltd. In 1997 and 1998, he served as chief in the Quality Assurance Section. He spent 1999 as a visiting researcher at Brewing Research International (BRi) in the U.K. Upon returning to Japan, he was appointed malt specialist in the Brewing R&D Laboratory. His primary area of interest is malting technologies for improving beer flavor stability. He is currently malt specialist and assistant section manager in the Brewing R&D Lab of Asahi Breweries Ltd.

TECHNICAL SESSION VII: Flavor
Moderator: Sue Thompson

Suzanne Y. Thompson is sensory manager at Miller Brewing Company, Milwaukee, WI. She has 24 years of sensory experience in the brewing industry. At Miller, she is responsible for establishing and administering company-wide sensory programs that include descriptive panels, quality assurance panels, and consumer panels. Suzanne received a B.S. degree in food science from the University of Wisconsin–Madison in 1980. She is currently president of the American Society of Brewing Chemists (ASBC) and has been past president elect (2002–2003), vice president (2001–2002), ASBC Newsletter *editor (2000–2001), and secretary (1996–1998) of the ASBC. She has been an active participant of several ASBC subcommittees, chaired the Difference-From-Control Sensory Test subcommittee in 1999, and lead several taste training sessions at the ASBC annual meeting. Suzanne is an experienced judge at the World Beer Cup and the Great American Beer Festival. She is also a member of the Institute of Food Technologists and American Society for Testing and Materials.*

O-40
A Survey About Different Fractions of Hydroxy Fatty Acids During Malting and Brewing and Their Importance for Beer Flavor Stability

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Hydroxy fatty acids have been known as indicators for oxidative reactions and aging processes in any kind of living organism (plants, animals, and even human beings) for many years. These lipid oxidation products are also found to be a precursor of flavor intensive carbonyls in foodstuffs and, therefore, are also of importance for beer flavor stability. Foam-negative reactions and a bitter flavor are further properties of such hydroxy fatty acids in beer. This study gives a survey about the different fractions (e.g., free and triglyceride-bonded components) and concentrations of these acids in barley, malt, wort, and final beer, measured by gas chromatography-mass spectrometry. Moreover, the influence of some technological parameters in the malt- and brewhouse on the hydroxy fatty acid concentration is shown, e.g., behavior during the whole malting process; influence of kilning temperature, milling, mashing-in temperture, and oxygen supply in the brewhouse; aeration during fermentation; etc. One essential result was that lipid oxidation already starts with the barley growing on the field due to defense mechanisms of the plant (activation of lipoxygenase pathway). A noticeable increase of, especially, trihydroxy fatty acids during 6 months of proper barley storage was also found. Thus, different barley varieties were also stored under extreme conditions (very high and low temperatures) and then malted to get detailed information about the influence of barley storage parameters on later beer flavor stability. From the produced malts, beers were brewed under constant conditions in a 1-hL pilot plant and the flavor stability of the beers was evaluated by different analytical and sensory methods. Additionally, seven common barley varieties from the 1999 and 2000 crops, stored for 3 resp. 4 years were also analyzed concerning their amount of hydroxy fatty acids and the results were compared with those measured in the fresh state and after the mentioned 6-month storage period. Furthermore, these barleys were malted and, from the malts, beers were produced and evaluated concerning flavor stability.

Stefan Meyna studied in the field of brewing science at the University of Technology of Berlin (1993–1999), graduating as an engineer (Dipl.-Ing.) in 1999. Since 1999, Stefan has done research work concerning beer flavor stability and lipid oxidation as a doctoral candidate (PhD) at the Chair of Brewing Science, University of Technology of Berlin and FBM der VLB Berlin (head: Prof. Dr.-Ing. Karl Wackerbauer). In 2000, Stefan became a research assistant with instructional work at the Chair of Brewing Science, and in 2001, he became head of the laboratories of the FBM.

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Relationship Between the Flavor Compounds Formation and the Gene Expression Profiles of Brewing Yeast

ATSUSHI FUJITA (1), Nobuyuki Fukui (2), Hiroto Kondo (1), and Yasutsugu Kawasaki (1)
(1) Suntory Ltd., Institute for Beer & RTD Development; (2) Suntory Ltd., Process Development Department

The progress of DNA microarray technology has made overall analysis of gene expression possible; thereby, we are now able to obtain comprehensive information about the physiological state of the yeast during fermentation and to disclose the relationship between the manner of gene expression and the development of various flavor compounds. Although the microarray technology is currently based on the genomic sequence of the yeast *Saccharomyces cerevisiae*, S288C, we have already reported in ASBC 2003 held in Albuquerque that it could be applicable to the analysis for general brewing lager yeasts, *Saccharomyces pastorianus*. In this study, we conducted two distinct beer fermentations using all-malt and adjunct, 25% malt ratio, worts with the same brewing lager yeast. We investigated the fermentation performance, esters or fusel alcohols formation, and gene expression profiles of the yeast cells during the course of fermentation using a DNA microarray. We found that difference in nitrogen contents between all-malt and adjunct worts resulted in distinct gene expression profiles, fermentation performance, and flavor compounds formation. This enables us to identify the genes corresponding to the synthesis of various compounds and to obtain useful information on the physiological states of the yeast affecting the formation of flavor compounds during beer fermentation. Our study may guide the adjustment of the brewing process so as to realize our desired qualities and moderate aroma.

Atsushi Fujita is a researcher in the Institute for Beer & RTD Development of Suntory Ltd. The main subject of his work is the optimization and development of the fermentation process of beer. He majored in nutritional chemistry in Kyoto University and engaged in clarification of effects of nutritional compounds on the formation of adipose tissue that stores fat. He joined Suntory Ltd. in 1992. He moved to Kyoto Brewery after the first 6 years in the laboratory for research on yeast metabolism and its modification by genetic engineering. Since 2002, he is again in this laboratory and is now engaged in the development of fermentation for happou-shu that has poor nutritional compounds.

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WITHDRAWN

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Improvement of Beer Flavor Stability by Reducing Deterioration Precursors in Malt

TAKAKO INUI, Nobuo Tada, Norihiko Kageyama, Seisuke Takaoka, and Yasutsugu Kawasaki
Suntory Ltd.

Stale flavor substances of beer, exemplified by some kinds of aldehydes, are generated by various chemical reactions during the brewing process and storage. Some aldehydes are generated by enzymatic or nonenzymatic reactions of lipids and fatty acid and others by heat chemical reactions, where amino acids are add to amino-carbonyl compounds or ox-phenolic compounds. We investigated the influence of these deterioration precursors in malt on flavor stability. It was found that beer flavor stability was improved by reducing deterioration precursors in malt. Based on these findings, we developed our novel method that removed the lipid, fatty acid, amino acid, and polyphenol adequately from malt. As a result, we succeeded in vastly improving beer flavor and flavor stability.

Takako Inui graduated from Kyusyu University. She began employment with Suntory Ltd. in 1989 as a researcher in the Institute for Fundamental Research. Since 2002, she has worked at the Institute for Beer Development. She has been studying the development of brewing technology.

O-44

Sensory Techniques for Understanding Consumer Preference

DEBBIE PARKER and Sarah Norman
Brewing Research International

In today's highly competitive environment, it is becoming increasingly difficult for companies to maintain a competitive advantage. It is no longer simply a case of producing a good product—the whole marketing mix has to be right and consistent product quality has to be delivered. Recent studies at BRi show that the mix is often not right, with drinkers being frequently impressed by a drink proposition but then being disappointed by the taste of the product. One of the reasons for this is that many product development decisions are made primarily on the basis of traditional consumer research techniques. However, these techniques have a number of inherent faults. Market research techniques are excellent tools for establishing what consumers like, but they are not very reliable when it comes to understanding why consumers prefer one product to another. This is due to either consumers not being able to find the right words to describe why they like something or because they use the wrong words, which can be misleading to those interpreting the results. Sometimes consumers simply do not know why they prefer one product to another. This problem can be overcome by using a combination of trained sensory panels and consumer research. Unlike consumers, trained tasting panels operate objectively and can accurately describe the sensory attributes present in a range of beverages and the extent to which each influences the overall characteristics of an individual product. Recently, advances have been made, employing multivariate analysis, that involve combining sensory and market research techniques. In this way, it is now possible to understand the underlying sensory characteristics that are driving consumer preference. Furthermore, analytical studies can measure the balance of key flavor compounds that contribute to the overall flavor and can be mapped together with sensory and market research data. These chemical analyses can provide the information necessary to change sensory attributes of a product in the certain knowledge that these changes will increase consumer acceptance. This unique approach to consumer research provides actionable and reliable diagnostic information that companies can use for a product's formulation, packaging, and brand positioning. This paper describes work using these techniques and presents consumer, sensory, and analytical data for different beverage categories and provides an insight into the individual flavor notes that drive consumer acceptance.

Debbie Parker joined BRI in 1988 with an Honours degree in biochemistry, passed the Institute of Brewing Associate Member Examination in 1991 and has recently been awarded a doctorate in brewing science. She is a frequent lecturer at industry training courses and technical meetings and is an experienced taster. Debbie is also a member of the EBC Sensory Subgroup. An accredited trainer (City and Guilds 7307), Debbie now designs and delivers sensory training courses and workshops. A professional beer taster for 13 years, Debbie has applied her tasting skills as a judge at competitions such as 'The Beauty of Hops' and the Great British Beer Festival.

O-45

Unraveling Beer Flavor Through the Use of Gas Chromatography-Olfactometry

Alicia Carruthers, Meaghan Culbert, Michel Libon, DAVID MARADYN, Mick McGarrity, Jerome Pellaud, Robert J. Stewart, and Don Thompson
Global Innovation and Development, Interbrew

Flavor is arguably the most important attribute of beer, but one of the least understood. A greater understanding of beer flavor, particularly what individual chemical compounds are responsible, their origins and concentrations would be of great benefit to the brewer. This knowledge could lead to greater product quality and consistency, reduce the incidence of flavor defects, and allow manipulation of beer flavor through ingredient selection and/or process changes. Identification of chemical compounds important to flavor is a difficult process. These compounds are typically present in extremely low concentrations and can be reactive or fragile with respect to sampling techniques. Separation by gas chromatograph is complicated since non-flavor-active compounds overshadow those of interest. The detector of choice for flavor research is the human nose, with the ability to detect only those compounds important to flavor and also differentiate each flavor-active compound in terms of its odor descriptor and intensity in the matrix. This technique is termed gas chromatography-olfactometry (GCO). It has enjoyed widespread use by those investigating the flavor of fruit, juices, wine, and spirits, but reports of its use in the brewing industry is limited. This paper will illustrate how we have used the GCO technique in profiling two of our lager beers and briefly investigated the effect of cold aging on the flavor. Aroma extract concentration analysis (AECA) was performed on two lager beers (A and B) at five different flavor dilutions and analyzed by GCO to identify and rank important flavor clusters in each. Sixty-three flavor clusters were identified in lager A and 54 flavor clusters were identified in lager B. Flavor cluster identification was accomplished by GC/MS spectral matching, relative retention index (RRI), and odor descriptor comparison to literature values. Forty-five of the flavor clusters in lager A and 43 of the flavor clusters in lager B were identified to a characteristic flavor compound. Although there were many flavor clusters common to both lager A and lager B, both possessed distinctive flavor clusters that contributed to their respective flavor. GCO was used to look for flavor differences between fresh, 9-and 12-month cold-stored lager B. Three flavor dilutions of each product were evaluated by the GCO panel. It was found that the fresh and cold-stored lager differed significantly; fruity, estery, and floral flavor clusters present in the fresh product were of less importance to the overall beer flavor, while smoky, cheesy, rubbery, and malty flavor descriptors increased in importance. Our research demonstrates that the GCO technique can be a valuable tool for the brewer interested in investigating beer flavor and flavor stability.

David Maradyn received a B.Sc. degree in chemistry in 1991 and a Ph.D. degree in organic chemistry in 1996 from the University of Western Ontario, London, Ontario, Canada. He joined the Labatt Brewing Company as a post-doctoral fellow in 1995, working in the Advanced Development department. Since October 1997, he has been working as a research scientist with the Global Innovation and Development department of Interbrew. David has served the ASBC as member and chair of technical subcommittees and is currently a member of the Technical Committee.

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Actual Aspects of the Analytical Prediction of Flavor Stability

OLIVER FRANZ and Werner Back
Lehrstuhl für Technologie der Brauerei I, Technische Universität München, Freising, Germany

A very important field of research is the analytical prediction of flavor stability. Many analytics have been introduced, such as the Lag-Time, which can be measured by electon spin resonance-spectrometry; the determination of flavor compounds (aging indicators) by gaschromatography, which increase significantly during aging; the content of sulfur dioxide in beer, produced by the yeast; the polymerization index, related to the content of phenolic substances, which represents the oxidative stress during mashing; the reducing power, which is related to melanoidins; and finally, the sensory test, which is used as a reference for all analytical systems but is sometimes not seen as an analysis by itself, which you have to take care of in the same way. It has to be considered what kind of aging test you are using: natural aging or a forced aging test, which is important for the prediction. From experience, we know that people have difficulties in evaluating and judging the results of the tests. The question is whether only one test is enough to determine flavor stability. Breweries often have problems in a methodical approach to technological problems. Flavor stability is often seen as a luxurious product and not as routine quality control. But it should be the consequence of a high level technology. So the whole brewing process should be considered and a step control should be established. There are published methods to determine free radicals in malt by ESR. It could be shown that the amount of free radicals depends on the variety and the provenience. The content of phenolic substances did show a relationship as well. With a chemiluminescene detector, oxidation reactions during mashing could be detected and specific behaviors of different malts could be evaluated. These analytics could be new quality criteria for malt with regard to flavor stability. Disinfection agents, based on hydrogen peroxide, could decrease the flavor stability clearly, if the tanks are rinsed inadequately. This effect can be seen by the Lag-Time measurement. Ferrous ions from filter aids can also influence the Lag-Time and flavor stability negatively. The spectrum of phenolic substances is clearly modified by PVPP treatment. Within a brewery, using a constant dosage of PVPP, tannoids can be a good indicator for flavor stability. A comparison of a forced aging test and natural aging did show a discrepancy in the analytical results of the aging indicators. During natural aging, you can see the impact of the migration of oxygen into the bottle (depending on the quality of the crown cap). To specify the flavor stability of the fresh product beer, a forced aging test is useful. You can also detect technological improvements easily.

Oliver Franz studied brewing and beverage technology at the Technical University of Munich-Weihenstephan and graduated September 1998. Since February 1999, he is working on his doctoral thesis at the Chair for Brewing Technology I (Prof. Back) in Weihenstephan. His theme was "Systematic investigations on the endogenous antioxidative activity of beer in consideration of technological features". Since May 2000, he has been working as the head of the laboratory for GC/HPLC–Analytics at the Chair for Brewing Technology I in Weihenstephan. His areas of research are the impact of raw materials and brewing technology on beer flavor and flavor stability, analytical methods to determine flavor stability, and antioxidant activity of beer and its optimization during the brewing process.

TECHNICAL SESSION VIII: Analysis

Moderator: Jean-Pierrre Dufour

Prof. Dr. Ir. Jean-Pierre Dufour has received M.Sc. (1975) and Ph.D. (1979) degrees (Louvain). Jean-Pierre was a research fellow at Johns Hopkins University, School of Medicine, Baltimore, MD, from 1979 to 1981. Jean-Pierre has been professor and head of the Department of Brewery and Food Industries, Catholic University of Louvain (1981–1993); visiting professor, Escola Superior de Biotechnologia (Porto, Portugal) (1989–1994); associated professor, University Senghor (Alexandria, Egypt) (1992–1995); expert for EEC and UNIDO (1994–1996); and professor (1995–present) and chair and head of the Department of Food Science, University of Otago, Dunedin, New Zealand. Jean-Pierre's expertise is in flavor science, fermentation science and technology, malting and brewing sciences, and yeast biochemistry/enzymology. Jean-Pierre is a member of EBC Brewing Science Group, ASBC, IOB, IFT, and ACS. Jean-Pierre is president and fellow of the NZIFST and the New Zealand delegate to IUFoST.

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The Enrichment of Foam-Positive Substances by the Use of Ultrafiltration

DENIZ BILGE, Karl Wackerbauer, and Marc Rauschmann
University of Technology of Berlin, Chair of Brewing Science; FBM der VLB Berlin

Molecules in liquids can be separated according to their molecular size by the application of ultrafiltration. A couple of test series were carried out with a pilot plant using membranes with effective cut-offs in the range of 10 to 300 kDa in order to evaluate the application of this filtration technique. In practice, ultrafiltration could be used for the enrichment of high molecular substances in beer in order to improve head retention. It could be shown that this is an appropriate measurement to increase head retention of beer. The degree of the improvement of head retention depends basically on the cut-offs and the concentration rates. The performance of the filter in terms of flux in $L/m^2/h$ is mainly influenced by temperature, transmembrane pressure, cut-off, and the chemical composition of the beer. Analyses of the retentates and permeates confirmed that mainly high-molecular protein fractions, beta-glucans, polyphenols, and anthocyanogens are held back by the membranes and remain in the retentate. Color and viscosity are likewise increased. Permeates, as well, show lower values and reduced amounts of the according substances. Due to the enrichment of proteins and polyphenols in the retentates, the shear forces in the unit turbidity is increased and nonbiological stability is considerably reduced. By filtration and prestabilization, turbidity could be decreased and stability improved to the level of the initial beer.

Deniz Bilge attained his degree as graduate engineer for brewing technology at the University of Technology of Berlin. He began employment in November 1999 at the Chair of Brewing Science of the above-mentioned University as scientific assistant to Prof. Wackerbauer. Areas of activity are the supervision of official research projects in the institute and of students working on their diploma thesis. Among other things, he has worked on research projects dealing with flavor stability and cross-flow microfiltration. Currently, he is working on his Ph.D. degree about the application of ultrafiltration to improve head retention of beer.

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The Relative Significance of Physics and Chemistry for Beer Foam Excellence

CHARLES W. BAMFORTH
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The foaming of beer can be considered from the perspective of both physics and chemistry. In terms of physics, we may invoke phenomena such as nucleation, drainage, bubble size distribution, and disproportionation. From the aspect of chemistry, emphasis is placed on the relative proportions of foam-stabilizing and foam-destabilizing surface-active molecules. Seldom, if ever, have the two halves of the foam scenario been discussed together in the context of their relative significance. This paper presents a theoretical consideration of the interaction between the physics and the chemistry of foaming, informed by the myriad of studies that have been performed on beer foam in this and other laboratories. It looks, inter alia, at the relationships between bubble size, bubble wall thickness, molecular dimensions of foaming polypeptides and other surface-active species, kinetics of intermolecular interactions, and rates of gas diffusion.

Charlie Bamforth became the first Anheuser-Busch Endowed Professor of Malting and Brewing Sciences at the University of California, Davis in February 1999. He has more than 25 years of experience in the brewing industry, previously holding senior positions with Brewing Research International and Bass. Charlie was the founding chair of the European Brewery Convention Foam Sub-Group. A fellow of the Institute of Brewing and fellow of the Institute of Biology, he is editor-in-chief of the Journal of the ASBC. *His book,* Standards of Brewing, *was published in 2003, together with the second edition of* Beer: Tap into the Art and Science of Brewing. *His latest book,* Beer: Health and Nutrition, *will be released in 2004. He has also published books on biotechnology and soccer goalkeepers.*

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Comparison of Methods for Assessing Protein in Beer

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There are numerous methods for determining proteins in beer. Many of these suffer biases and give differing responses depending on the nature of the protein or polyphenol molecules in a sample. Several important classes of beer proteins have been shown to have quite different amino acid compositions. These differences determine both the functional properties of the proteins and their responses in a number of analytical methods. The beer haze-active (HA) proteins are rich in proline and glutamine and respond very poorly in the Bradford method (Coomassie brilliant blue dye binding, CBB). Beer foam-active (FA) proteins, on the other hand, are rich in basic and aromatic amino acids and respond well to CBB. Conversely, haze induction upon addition of tannic acid (TA) responds well to HA protein and poorly to FA protein. HA polyphenols have at least two sites that can attach to HA proteins and, thus, bridge them together. Some of these bind more strongly to proteins than do other polyphenols and have been demonstrated to be more haze active. Some polyphenols have only a single binding site; they can attach to HA protein but do not lead to haze. Beer samples contain differing amounts of HA and non-HA protein, as well as HA and non-HA polyphenols. It was of interest to systematically compare the responses of a number of protein determination approaches on samples containing combinations of HA and non-HA proteins and HA and non-HA polyphenols. In a preliminary study, water-soluble gliadin and methyl gallate were used as surrogates for beer HA protein and non-HA polyphenol, respectively. Development of a procedure to isolate water-soluble hordein from malt and the use of epicatechin, a beer polyphenol that has been shown to be non-HA at modest temperatures, provide more realistic alternatives. Mixtures containing various combinations of HA and non-HA proteins (water-soluble hordein and lysozyme, respectively) and HA and non-HA polyphenols (tannic acid and epicatechin, respectively) were prepared in buffer model systems. A battery of protein methods (the Bradford method, TA haze induction, the Bicinchoninic acid (BCA) method, and 280 nm absorbance) were applied to each sample and the results were compared. The various methods gave quite different responses to the different test compounds. With concentrations of the various substances roughly equivalent to those found in beer, 280 nm absorbance and BCA suffered strong interference from the polyphenols. The CBB and HA protein methods, on the other hand, responded very little to polyphenols. CBB response was much greater to lysozyme than to hordein. TA haze induction responded only to HA protein, but exhibited some nonlinearity. Results obtained when these methods are applied to beer must be interpreted with caution.

Karl Siebert received a Ph.D. degree 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 1990, Dr. Siebert joined Cornell University as professor of biochemistry in the Department of Food Science and Technology. He served 5 years as department chair and now has a predominantly research appointment. Dr. Siebert served on ASBC technical subcommittees and was a member and chair of the Technical Committee. He is serving his second stint on the Journal of the ASBC *editorial board (1980–1992; 1996–present). He is active as a consultant in the beverage industry.*

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Beer Foam Stability—The Role of Specific Polypeptides

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The ability of beer to produce a stable foam is an important feature in the attractiveness of the product to the consumer. Beer foam is affected by many factors, such as lipids, iso-alpha-acids, metal ions, melanoidins, polyphenols, ethanol, and polypeptides. The structure of beer foam is complex, with a network of hexagonal bubbles, the walls of which comprise surface-active compounds. Primarily, polypeptides associate with carbohydrates, metal ions, and iso-alpha-acids to form a network of bubbles, giving a stable head of foam. Beer polypeptides (small proteins) are a mixture of complicated proteinaceous substances, several of which are associated with foam stability. Studies in this laboratory have focussed on beer foam stability from three aspects. • The effect of silica gel. • The negative effect of high-gravity brewing and fermentation on foam stability. The fate of foam inducing polypeptides during this process. • Isolation, cloning, and characterization of beer foam polypeptides. The studies confirm that the major polypeptides associated with beer foam formation and stability are hydrophobic polypeptides. Specifically, they are lipid transfer protein (LTPI), a 17-kDa polypeptide, and protein Z, a 40-kDa molecule.

Graham Stewart received B.Sc. degrees in microbiology and biochemistry from the University of Wales and Ph.D. and D.Sc. degrees from the University of Bath. He was a lecturer in biochemistry at Portsmouth University from 1967 to 1969. He began employment with the Labatt Brewing Company in 1969, based in London, Ontario, Canada. He held a number of scientific/technical positions with Labatt's, and from 1986 to 1994, held the post of technical director. From 1994 to the present, he has been professor and director of the International Centre for Brewing and Distilling at Heriot-Watt University in Edinburgh, Scotland. He is a member of the Master Brewers Association of the Americas, the American Society of Brewing Chemists, the Institute of Brewing Studies, and the Institute and Guild of Brewing and, in 1999 and 2000, was this Institute's president.

O-51

Comprehensive Quality Assurance of Asahi Breweries, Ltd.

HISANORI OKITA (1), Yutaka Miyamoto (1), Hidetoshi Tezuka (1), and Yoshifumi Nishino (2)
(1) Quality Control Center, Asahi Breweries, Ltd.; (2) Production Headquarters, Asahi Breweries, Ltd.

The Asahi Breweries Group manufactures a wide variety of products, including beer, whisky, wine, liqueur, and *shochu* 'Japanese white liquor'. We also import beverages from abroad. Customer satisfaction is our primary concern. The following quality assurance system is adopted to rigorously guarantee the safety and quality of our products. 1) High-quality raw materials. To acquire high-quality raw materials, Asahi performs acceptance inspections based on our specifications, cross-checks analyses with suppliers, sampling inspections on particular items, and strict evaluation of our suppliers. In our evaluation of suppliers, we examine the compliance with our quality standards, inspect their plants, and recommend the required improvement to suppliers with low evaluations. 2) Effective monitoring of production processes. Every day we collect process-control index and analyze data obtained from every step of production processes. These efforts are to make sure the processes comply with our standards in every detail. The sensory test, one of the most important inspections, is conducted by in-house specialists. This test includes the daily evaluation held at each brewery and the regular corporate-wide test on products from all the breweries. The latter aims for standardizing and improving flavor characteristics of products manufactured by our breweries. 3) Swift distribution process through freshness management. We significantly reduced the time for distribution to satisfy the demand for freshness by Japanese customers. As a result, the sales volume has increased. Our efforts to further minimize the distribution time are currently in progress. 4) High-quality domestic and imported products. To assure safety and quality, we perform routine analyses of raw materials and products based on criteria specified by the regulations. As for imported products, we perform product analyses prior to the decision on marketing, conclude a quality agreement with manufacturers, and conduct acceptance inspections and routine analyses. We only purchase from the manufacturers that fulfill Asahi's quality standards. If an issue arises, corrective measures are discussed with manufacturers for solutions to the problem.

Hisanori Okita received a B.S. degree in fermentation engineering from Hiroshima University in Japan in 1983. He joined Asahi Breweries, Ltd. in April 1983. He has served as brewmaster in the Hokkaido Brewery, Suita Brewery for 11 years. He worked at Bass Brewing in 1990. He has also functioned as trainer in the Technical Training Center (1996–1999). Now he serves as deputy manager in the Quality Control Center (2002–present). He works to assure the quality of alcoholic beverages.

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Application of a GC/MS Method Using SPE Columns for Quantitative Determination of Diacetyl and 2,3-Pentanedione During Beer Fermentation

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Diacetyl and 2,3-pentanedione are important contributors to beer flavor and aroma. A new GC/MS method for the determination of diacetyl and 2,3-pentanedione was developed. The GC/MS method has good sensitivity and is currently the most accurate method available. Diacetyl and 2,3-pentanedione were derivatized with 1,2-diaminobenzene to form 2,3-dimetylquinoxaline and 2-ethyl-3-methylquinoxaline, respectively. The amounts of formed 2,3-dimetylquinoxaline and 2-ethyl-3-methylquinoxaline were proportional to the concentrations of diacetyl and 2,3-pentanedione present in the sample. 2,3-Dimetylquinoxaline and 2-ethyl-3-methylquinoxaline were extracted by solid-phase extraction (SPE) columns and determined by gas chromatography using a mass selective detector. Extraction by SPE columns proved to be very rapid, simple, and precise. This method can be used for simultaneous determination of diacetyl and 2,3-pentanedione concentrations in beer in a great number of samples. This method was applied for the determination of diacetyl and 2,3-pentanedione concentrations during beer fermentation (primary fermentation and maturation). During fermentation, diacetyl and 2,3-pentanedione were quantified to demonstrate the suitability of the method. Primary fermentations were carried out at different temperatures (8 and 14°C) and an industrial bottom-fermented yeast strain, *Saccharomyces uvarum* (*carlsbergensis*) was used. The aim of this investigation was to determine the influence of primary fermentation temperature and wort composition on diacetyl and 2,3-pentanedione concentrations. Corn grits, beside malt, was used for wort production. Level of corn grits varied from 10 to 40%. Diacetyl and 2,3-pentanedione formation and reduction were strongly influenced by temperature, and the rates for both increased with the increase of primary fermentation temperature. The highest diacetyl and 2,3-pentanedione concentrations (0.6365 and 0.8192 mg/L, respectively) were obtained during fermentation of wort with 40% of corn grits, at 14°C. This accurate determination of diacetyl and 2,3-pentanedione was a valuable tool for analyzing the influence of wort composition or fermentation conditions, such as primary fermentation temperature, on their formation and reduction. It is also well suited for the quality control of beer during fermentation.

Jelena D. Pejin was born in 1975 and has been employed as a teaching assistant for the course of Malt and Beer Technology at the Faculty of Technology, University of Novi Sad, since September 1999. Jelena graduated at the Faculty of Technology, Department for Microbiological Processes, in June 1999. At the beginning of the academic term for 1999/2000, she enrolled in postgraduate studies at the Microbiological Processes course. She received an M.Sc. degree for the field of beer fermentation in December 2003. Her professional work has included engagement in practical lessons for the course of Malt and Beer Technology and for B.Sc. papers for the same course. Parallel to the teaching process, Jelena has been included in the scientific work, and the results of these investigations have been already presented at domestic and international scientific and professional meetings and published in the respective proceedings as well as in domestic journals.

O-53

Beverage Appearance and Flavor Protection from Carbon Dioxide Quality Excursions

CHRIS DUFFELL and Robert Scrafton
domnick hunter ltd.

Carbon dioxide is used in the beverage industry for brewing, carbonation, packaging, and dispense. In recent years, there has been increased awareness to the importance of carbon dioxide (CO_2) quality and its effects on beverage products. Quality guidelines for CO_2 used in the beverage industry are published by bodies such as the International Society of Beverage Technologists (ISBT) and European Industrial Gas Association (EIGA). These guidelines are intended to offer protection against naturally occurring CO_2 contaminants that could result in flavor defects of the beverage. Contaminants may also affect the appearance of the foam head and, hence, presentation of the beer. In addition, contaminants are controlled by regulation for the prevention of physiological detriment. Detailed in this paper are measures that may be applied from plant-level protection, including HACCP, to retail dispense. In the event of a CO_2 quality incident, these measures will ensure beverage quality and freshness for the consumer. In-line purifiers have been designed that act as a final multilayer barrier filter against trace contaminants in a CO_2 gas supply. The performance of these purifiers was evaluated by introducing contamination to beverage-grade CO_2 to provide an inlet challenge in excess of the ISBT specification. The data presented show that removal of typical contaminants, including aromatic hydrocarbons and sulfur-containing compounds, can be achieved. This multilayer barrier filter technology is currently being utilized globally at a plant level and, more recently, has been applied to offer the same benefits to draught beer dispense outlets.

Chris Duffell received an M.Phys. in astrophysics from Cardiff University in 1997. He then began employment at the National Engineering Laboratory in Scotland as a project engineer in the oil and gas laboratories in Flow Centre. Chris achieved chartered physicist status in 2000. He then joined the Postgraduate Training Partnership scheme between NEL and Strathclyde University. His Ph.D. project was entitled "The optimisation of ultrasonic flowmeter design". Chris presented details of his work in four technical papers at international conferences. Upon completion of this scheme, Chris began employment with domnick hunter ltd. as senior development engineer in Newcastle. His work now involves product verification and development as well as the production of technical literature.

TECHNICAL SESSION IX: Microbiology

Moderator: Candace Wallin

Candace E. Wallin is an instructor for the brewing science and technology courses offered through University Extension, University of California, Davis. She also manages the brewing laboratory and pilot brewery at UC Davis. She has more than 25 years of experience in the brewing industry, including 18 years at Miller Brewing Company, Milwaukee, WI, where she worked initially as a microbiologist and then as a development brewer. She also gained 4 years of experience in the microbrewery segment of the industry while working as the microbiologist for Sudwerk Privatbrauerei Hubsch in Davis, CA. Candace is an associate member of the Institute & Guild of Brewing, as well as a member of the American Society of Brewing Chemists and the Master Brewers Association of the Americas.

O-54

Microbial Attachment and Biofilm Formation in Brewery Bottling Plants

ERNA STORGÅRDS (1), Kaisa Tapani (2), Peter Hartwall (3), Riitta Saleva (4), and Maija-Liisa Suihko (1)
(1) VTT Biotechnology, Finland; (2) Oy Sinebrychoff Ab, Finland; (3) Oy Hartwall Ab, Finland; (4) Olvi Oyj, Finland

Microbiological risk management is essential in the production of high-quality beer since quality defects may lead to substantial economic losses. The hygiene of process surfaces essentially affects the quality of the final product. The brewing industry is prone to biofilm formation due to the abundance of water needed at every stage of production. Biofilms develop when attached microorganisms secrete extracellular polymers, which in turn protect them effectively against cleaning and sanitation. In the current study, sterile stainless steel coupons were mounted onto critical sites of the fillers in three brewery bottling plants. Microbiological samples were taken from the coupons to reveal the pioneer organisms in biofilm formation. Microbiological samples were also taken from different horizontal and vertical surfaces close to the open product at the filler and crowner in order to be able to compare the microflora on the coupons with process surfaces in use. The pioneer bacteria were identified by ribotyping, carbohydrate fermentation tests, and partial DNA sequencing. The effect of sugars and sweeteners on attachment of pioneer organisms to stainless steel was studied in 1 mM phosphate buffer and analyzed by epifluorescence microscopy. The biofilm formation rate was studied for 8 weeks by successively dislodging the test coupons from each sampling site and examining them by epifluorescence microscopy. The results showed that pioneer microbes accumulated on new stainless steel surfaces within hours after the start of production. Regular daily cleaning reduced the number of microorganisms on the surfaces only momentarily. Canning machines were markedly less prone to accumulation of microorganisms than bottling machines. Gram-negative bacteria, yeasts, and molds were the first to colonize the surfaces. Attachment of pioneer species to stainless steel was increased substantially by sugars and, surprisingly, also by intense sweeteners. Horizontal surfaces were prone to microbial accumulation and should be avoided in constructions as much as possible. Furthermore, biofilm formation occurred on certain surfaces despite daily cleaning and disinfection.

Erna Storgårds holds a first degree and a Ph.D. degree in microbiology from Helsinki University. She began employment with VTT Biotechnology in May 1988 as a research scientist in the microbiology department. Since January 2002, she has been group manager of the Microbial Diagnostics and Taxonomy research group. Her special field of expertise is process hygiene in beer production and dispensing. During her time at VTT, she has coordinated and participated in several national and international research projects, as well as been responsible for carrying out confidential contract research for industrial partners in Finland and abroad. Her current activities include research on biofilms and surface-microbe interactions. She has been a member of the EBC Microbiology Group, later the EBC Brewing Science Group, since 1992 and its vice chair since 2001; chair of the EBC Microbial Contaminants Subgroup since 1993; and member of the EBC Analysis Committee Microbiology Subcommittee since 1998.

O-55

Molecular Methods for Detection and Identification of Microbial Contaminants in Brewing Quality Control

AULI HAIKARA, Riikka Juvonen, Maija-Liisa Suihko, Teija Koivula, and Erna Storgårds
VTT Biotechnology, Finland

Current cultivation-based methods used by most breweries for microbiological quality control reveal possible contamination only after several days or weeks of delay. Moreover, they do not discriminate between spoilage and nonspoilage microbes or allow the detection of viable but noncultivable cells or tracing of contamination sources. In recent years, several promising molecular biological applications have been described for the detection, characterization, and identification of brewery contaminants. Group-, genus-, and species-specific PCR tests have been designed and evaluated for brewery contaminants, i.e., for lactic and acetic acid bacteria (*Lactobacillus*, *Pediococcus*), strictly anaerobic bacteria (*Pectinatus*, *Megasphaera*, *Selenomonas*, *Zymophilus*), enterobacteria, and wild yeasts. Various PCR detection formats (PCR-ELISA, LightCycler™ PCR, standard PCR) have been set up for most of these organisms. In order to detect the very low amounts of microbes in brewing samples, an enrichment method has been devised. Practical pre-PCR treatment methods, including collection of cells, DNA extraction, and removal of PCR inhibitors, have been developed for filterable (such as bright beer and process water) and nonfilterable (pitching yeast, wort, fermenting wort) samples. Modular PCR kits for standard PCR and real-time PCR have also become available from several companies. All developed PCR applications are, despite the enrichment step, more rapid and specific than the cultivation methods. Currently, PCR without prior cultivation is less sensitive and more expensive to use than cultivation. Denaturing gradient gel electrophoresis (DGGE) for separation of bacterial or eukaryotic ribosomal DNA amplicons is a valuable tool for characterizing microbial communities in specific environmental niches. This technique has also been applied to study and compare microbial communities during beer, wine, and whisky production. The automated ribotyping system (RiboPrinter® System DuPont Qualicon, U.S.A.) is a rapid molecular biological method for the identification and characterization of bacteria to species or even below species level. A comprehensive identification database has been created for brewery contaminants, such as *Lactobacillus* spp., *Pediococcus* spp., *Pectinatus* spp., *M. cerevisiae*, and *Obesumbacterium proteus*, using three different restriction enzymes. In addition to identification and renaming of bacteria, the database has been applied to tracing of contamination sources and detection of troublesome house flora in industrial processes.

Auli Haikara is chief research scientist at VTT (Technical Research Centre of Finland) Biotechnology in the research field of microbiological safety. She graduated in 1965 from the University of Helsinki with an M.Sc. degree in nutrition chemistry. In 1984, she received a Ph.D. degree in microbiology from the University of Helsinki. Since 1993, she has been a docent in industrial microbiology in the Department of Applied Chemistry and Microbiology of the University of Helsinki. Her areas of research have included cereal microbiology focusing on gushing, active and toxigenic fungi, anaerobic beer-spoilage organisms, rapid detection methods, and antimicrobials produced by lactic acid bacteria. She has coordinated an EU-funded project developing PCR technology for use in breweries and has participated in an EU project on prevention of ochratoxin A in cereals. She is a member of the EBC Brewing Science group, chair of the Gushing subgroup, and a member of the Microbial Contaminants subgroup. She is also a member of ASBC.

O-56

Microsieves and Fluorochromes—A New Application to Detect Beer-Spoiling Microorganisms

KARL-JOSEF HUTTER (1), Dieter Kemenji (2), Frank Nitzsche (3), and Britta Kuhmann (1)
(1) Eichbaum Brauereien AG, Mannheim, Germany; (2) Schleicher & Schuell, Dassel, Germany; (3) Koenig Brauerei, Duisburg, Germany

Indirect membrane filtration followed by incubation on selective artificial media at 28–30°C for detection of beer-spoiling microorganisms is routinely used in brewing laboratories, although this procedure is very time consuming. Microorganisms that are able to form a colony on selective media were counted (CFU). Contaminants that are in their quiescent growth phase, senescent cells, and membrane-damaged cells do not form colonies on selective media during the short investigation time of 2–3 days. Furthermore, only those contaminants form colonies that are able to metabolize the artificial media. We have developed a direct and rapid method to count all viable (quiescent and not culturable cells) and dead contaminants without pre-enrichment on artificial media. Instead of membrane filters, we used microsieves. This new filter material consists of silicone strings with a mesh size of 0.45 µm. The contaminants were stained by different dyes, fluorogenic substrates, or dye combinations. Yeast cells were stained simultaneously with Fluorescein Diacetate (FDA) and Propidium Iodide (PI), while bacterial contaminants were fluorochromized with BacLight. Beside these dye combinations, we employed other stains like Sytox orange, Sytox orange in combination with FDA, Sytox green, Oxonol, and Berberine. In order to identify important beer-spoiling contaminants, we raised antibodies against *Lactobacillus* and *Pediococcus*.This rapid method to assess total counts and viability of beer-spoiling microorganisms will improve the microbiological quality control in the brewing industry. Furthermore, this method could also be applied to determine the health and viability of brewing yeast and hence improve fermentation performance and yeast handling procedures.

Karl-Josef Hutter was born in 1943 in Dietfurt/Altmühl, Bavaria. Karl-Josef's native country is the Federal Republic of Germany. Karl-Josef had vocational training at Brauerei Frankenheim, Düsseldorf (1960–1962), and studied brewery technology at the TU-Berlin (VLB) (1965–1970) and graduated from there in 1974. Karl-Josef has worked as a scientist at Fraunhofer-Gesellschaft (1970-1979) and as a scientist at the German Cancer Research Center, Heidelberg (1979–present). Karl-Josef has had lectureships at the University of Heidelberg (1985–1992), the University of Hohenheim (1994–1999), the Fachhochschule Mannheim (1995–present), and the TU-Dresden (1999–present).

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Microbiological Quality Control in Breweries Based on Real-Time PCR—Implementation Experiences and Future Potential for Brewery Application

ANDREAS BRANDL and Eberhard Geiger
Technische Universität München, Center of Life Sciences Weihenstephan, Chair for Brewing Technology II, Germany

Common routine brewery quality control methods based on cultivation do not allow proactive process control because possible contaminations will often be detected after several days or weeks of delay. Contrary to these methods, real-time PCR assays have been developed that allow rapid and specific detection of low levels of microbes. Various real-time PCR formats (LightCycler™, TaqMan) are available now for group- or species-specific detection of virtually all beer-spoilage bacteria (*Lactobacillus* spp., *Pediococcus* spp, *Megasphaera* spp., *Pectinatus* spp.). During the last 2 years, the implementation of the method into laboratory routine was evaluated in several European breweries. Process samples were examined with PCR and established in-house methods in parallel. The achieved results were recorded and extensive data on practical PCR performance was obtained. In the context of the brewery trials, PCR assays were improved for bright beer and yeast-containing process samples and pre-PCR steps, such as pre-enrichment and DNA isolation, were optimized in respect of analysis time, user-friendliness, and sensitivity. Both real-time PCR and standard PCR were tested in the breweries, but real-time PCR was shown to be the preferred method. Using PCR, it was possible to achieve results faster and more exact than with the conventional methods. Especially for troubleshooting purposes and the tracing of infection sites, PCR has been proven to be a very helpful tool. Nevertheless, it is recommended to use the method in combination with a short pre-PCR enrichment step to achieve the sensitivity required and to ensure that the detected cells are viable. Using PCR without pre-enrichment causes higher costs due to more laborious pre-PCR sample preparation steps. Based on these results, several developments are ongoing to make further use of the potential of PCR. A promising approach to differentiate between viable and dead cells by real-time PCR using ethidium bromide monoazide (EMA) has currently been tested. Thus, it is possible to avoid false-positive PCR signals that may be caused by dead cells, e.g., after pasteurization. Moreover, real-time PCR assays for the detection of brewery-relevant wild yeasts (*S. diastaticus*, *S. bayanus*, *Dekkera* spp., *Pichia* spp., *Zygosaccharomyces* spp.) are being developed at the moment. Since for the detection of wild yeasts (*Saccharomyces* and non-*Saccharomyces* wild yeasts), there is no unique cultivation method available up to now. PCR based methods will improve and facilitate wild yeast identification.

Andreas Brandl was born in 1973. From 1993 to 1995, Andreas was a technical graduate as a brewer at the brewery Aldersbach. From 1995 to 2001, Andreas studied brewing and beverage technology at the Technical University Munich-Weihenstephan. Since 2001, Andreas has worked on his doctoral thesis at the Chair for Brewing Technology II at the Center of Life Sciences and Food Science in Weihenstephan. In the framework of his Ph.D. thesis, he is engaged in the EU-Project "Development and demonstration of polymerase chain reaction (PCR) based methods for process control in the brewing industry".

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A New Improved PCR Method for the Detection and Identification of Live Spoilage Organisms

KARIN M. D. PAWLOWSKY, Samantha Walker, and John R. M. Hammond
Brewing Research International

Spoilage of beer by microorganisms is of great concern to the brewer. Consequently, the need for rapid and reliable microbiological detection methods is ever present. While traditional microbiological methods for the detection of beer-spoilage organisms are extremely accurate and sensitive, they are laborious and slow. Methods based on the polymerase chain reaction (PCR) can be of great help here since they are highly specific and provide results much faster than traditional microbiology techniques. These methods are increasingly being adopted by the food and beverage industries for high throughput analysis and microbiological troubleshooting. One of the drawbacks of PCR methods is the inability to differentiate between live and dead cells. This can be partially overcome by the use of a pre-enrichment step, where the sample is incubated in liquid medium for a short period. While the pre-enrichment step increases the number of live cells, it adds 1–3 days to the time elapsed before detection and has the drawback that the initial cell concentration cannot be calculated. Recently, a novel method for live/dead cell determination has been described. This method has been adapted for brewing samples and shows promise in initial laboratory studies. Ethidium monoazide bromide (phenanthridium, 3-amino-8-azido-5-ethyl-6-phenyl bromide) or EMA is a chemical agent that can traverse dead cell membranes and bind irreversibly to DNA. The bound DNA cannot be amplified by PCR, thus preventing the detection of dead cells. This methodology has been tested using *Saccharomyces cerevisiae* and *Lactobacillus brevis* cells. A range of cell inactivation methods were investigated employing the EMA-PCR technique. For example, cultures of the organisms were pasteurized, EMA was then added and PCR carried out. No PCR product was detected, indicating that EMA did indeed inhibit the amplification of dead cell DNA. The EMA-PCR technique was tested using two different PCR methodologies, standard PCR and real time PCR, with detection by gel electrophoresis and fluorescence, respectively. In both cases, the results were good. Real-time PCR was the more sensitive of the two methods and allowed discrimination between live and dead cells in mixed cultures. Clearly, this technique should reduce the 'false-positive' signals from dead organisms, often obtained with current methods. The evolution of live/dead assays for the quantitative detection of beer-spoilage organisms by real-time PCR represents one of the most exciting developments in brewing microbiology over the past few years. The EMA-PCR technique could provide a simple, cost-effective method for the rapid detection and identification of viable beer-spoilage microorganisms.

Karin Pawlowsky studied physics in Germany and obtained an M.Sc. degree in molecular biotechnology from Leicester University in the U.K. She then worked in research at the Food Science Department at Leeds University before joining Brewing Research International (BRI) in 1998. At BRI, she has been involved with consumer trials studying beer mouthfeel and drinkability. Later, she moved to the Raw Materials Team, where she worked on lipid-binding proteins in barley and malt. Currently, she is in the Process Team working in the area of molecular biology.

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Detection and Identification of Beer-Spoilage Bacteria Using Real-Time PCR

Cordt Grönewald (1), MATTHIAS KIEHNE (1), and Frédérique Chevalier (2)
(1) BIOTECON Diagnostics GmbH, Germany; (2) Roche Diagnostics GmbH, Germany

For some years, real-time PCR has been used by several breweries on a routine basis to detect beer-spoilage bacteria more rapidly than with conventional, i.e., cultural, methods. The first generation of PCR chemicals allowed the detection of single organisms or, in a later version, a group of bacteria, e.g., all lactic acid bacteria. With the LightCycler foodproof Beer Screening Kit in combination with the dedicated sample preparation kit, Roche offers a new generation of PCR kits now detecting and identifying specifically the group of obligatory beer-spoilage bacteria in one single test. The newest kit comprises primers and probes for the detection of the most relevant beer-spoilage bacteria worldwide (22 species and subspecies). It also allows the identification of the most troublesome organisms in the same test without additional efforts by using the melting curve analysis of Roche Diagnostics' LightCycler instrument. The time to result of the method is about 48 h compared with more than 5 days with classical microbiology. The analytical procedure has been adjusted to the requirements of routine QA laboratories of breweries. Different sample preparation procedures were compared and tested for their applicability in a routine laboratory. The different procedures tested (three) were two manual procedures, one with and the other without DNA purification, and an automated sample preparation using Roche Diagnostics' MagNA Pure LC. The comparison was done by analyzing a broad range of samples from different breweries, e.g., pitching yeast, fermenting beer, finished products, water, CIP solutions, glue, etc. The method also is used to identify bacteria more specifically than is possible with other methods. This identification helps to control and monitor the hygiene status of the complete process from raw materials to auxiliary materials and finished products as well as trace sources of contamination. Different isolates of important species from several breweries and culture collections were tested and the reproducibility of the identification via melting curve was determined. The new tool allows the easy introduction of PCR into a brewery's routine testing. It reduces the time to result and, by identification of the contaminant, it allows the optimization of the hygiene measures during the entire brewing process.

Matthias Kiehne has studied bioprocess engineering at the Technical University of Berlin, Germany. He finished his Ph.D. degree in 1996 while already employed at BioteCon, the predecessor of BIOTECON Diagnostics, a German-based company engaged in molecular diagnostics in the food and beverage industry. Since 1998, he has been responsible for the marketing and sales of the brewing and beverage area of the business and, since 2001, has been head of marketing and sales at BIOTECON Diagnostics.

O-60

Evaluation Study of the Actual Frequency of Different Beer-Spoiling Bacteria with the VIT Analysis

Karin Thelen, Dr. Claudia Beimfohr, and DR. JIRI SNAIDR
vermicon AG

In a recent evaluation study, the trace detection of beer-spoiling bacteria with the rapid detection system VIT-Bier plus *L. brevis* was approved with 500 different brewery samples taken from ongoing production of a large South German brewery. The results that were obtained with VIT-Bier after a short pre-enrichment of 2 days were compared with the results of the conventional analysis after an enrichment time of 7–9 days. The VIT-Bier plus *L. brevis* method was found to be of equal sensitivity for detecting traces of beer-spoiling bacteria, like the applied standard detection method, even though all results were obtained at least 5 days earlier. In addition, the analyzed samples were used to broaden the knowledge regarding the actual frequency of contamination regarding the different beer-spoiling bacteria. This screening analysis revealed that *Lactobacillus brevis* is the most common beer-spoiling bacterium. It was identified in 77% of all samples with positive findings. After this, *Lactobacillus plantarum* (10%) and *Lactobacillus buchneri* (7%) were identified to be the next abundant contaminants. In the frequency of contamination, *Lactobacillus lindneri* and *Pediococcus damnosus* played a minor role. Both were detected in 3% of all analyzed samples with positive findings. The obtained data were compared with already existing data regarding the frequency of contamination in German breweries and a good match of these results was found. The information about the distribution can be a very helpful tool to assess the risks of a potential spoilage with a certain kind of bacterium and will help to conclude in practice what kind of appropriate measure should be taken.

Dr. Jiri Snaidr received his master's of biology degree at the Technical University in Munich, Germany. After studies at the Technical University in Munich, as well as at the Max-Planck Institute in Bremen, Germany, he received his Ph.D. degree in 1997. His work was about the application of molecular biological methods for the detection of hitherto unknown microorganisms. In 1999, he started his studies at the Open University in England and received his degree for senior management in 2000. From 1997 until today, he has been the CEO/president of the vermicon AG in Munich. Dr. Jiri Snaidr founded the vermicon AG in 1997 and focused the company on the development and distribution of test kits for rapid and specific detection of microorganisms. In 2000, the Henkel KGaA took a minor share in the company. In 2001, the first product of a series of subsequent test kits for the detection of microorganisms was launched on the market. In 2003, RWE as well as the energy supplier MVV Energie acquired shares in vermicon. The company is today considered to be a international important supplier of microbiological rapid tests based on leading gene probes technologies.

TECHNICAL SESSION X: Fermentation

Moderator: Dave Ryder

David S. Ryder is vice president–brewing, research and quality assurance at Miller Brewing Company. David began his brewing career in England at Associated British Maltsters. He then joined the South African Breweries Beer Division and was later named director of research & development for that group's brewing and malting concerns at the Delta Corporation Ltd. David was subsequently technical consultant with Artois Breweries in Belgium. Before joining Miller Brewing Company, he was vice president–technical services at J.E. Siebel Sons' Co. Inc., Chicago, and director of education of the Siebel Institute of Technology. David is a member of the Brewing Science Group of the European Brewery Convention (EBC) and currently chairs the subgroup for studying emerging fermentation systems. He is past president of the American Society of Brewing Chemists (ASBC) and past chair of the Program Committee (1988–1992) and the Publications Committee (1992–1994). He has also served on the editorial boards of the Journal of the ASBC *and the* Journal of the Institute of Brewing*. He is past chair of the International Section of the Institute and Guild of Brewing (IGB). He is also a member of the Master Brewers Association of the Americas (MBAA). David has published widely in the brewing literature, which includes the* Proceedings of the European Brewery Convention, *the* EBC Monograph Series, Journal of the ASBC, Brewers Digest, Bebidas, Beverages, *and the MBAA* Technical Quarterly. *In 1982 and again in 1994, he was coauthor of papers that won the MBAA Presidential Award in Brewing.*

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New Results with an Immobilized Yeast System: Secondary Fermentation with IMMOPORE

DR.-ING. GERRIT BLÜMELHUBER (1), Univ.-Prof. Dr.-Ing. Roland Meyer-Pittroff (1), and Dr.-Ing. Frank Nitzsche (2)
(1) Technische Universität München-Weihenstephan, Lehrstuhl für Energie und Umwelttechnik der Lebensmittelindustrie, Freising, Germany; (2) Easyproof Laborbedarf GmbH, Voerde, Germany

Due to the development of IMMOPORE in 1999, there is an inexpensive carrier material based upon glass for immobilized yeast systems for secondary fermentation. Such immobilized yeast systems have been well-known since the work done by E. Pajunen and J. Kronlöv. While at the beginning, we tried to use multilayer capsules with alpha-acetolactate-decarboxylase to convert 2-acetolactate to avoid a thermal treatment, now we are able to use IMMOPORE as well as a carrier for the yeast and for immobilized enzyme. Therefore, we had to make a small modification on the surface of IMMOPORE. The main principle in the modified plant scheme is based on the known plant layout for immobilized yeast systems for continuous beer maturation. After removal of yeast with a centrifuge, the yeast-free green beer will pass a flash pasteurizer for biological safety (duration of treatment about 30 s). Then it passes a reactor that is filled with alpha-acetolactate-decarboxylase immobilized on IMMOPORE. The major advantage of this carrier material is that the enzymes have a very high activity compared with conventional glass immobilized enzymes. The immobilized alpha-acetolactate-decarboxylase will convert 2-acetolactate into acetoin. For the conversion, there is no thermal decomposition necessary and, therefore, only for biological safety does a short thermal treatment of the green beer have to be done. Tasting tests have shown that this "converted" green beer has the same quality as the original green beer. This is different from the heat treatment process, where a marked change of beer taste is obvious. After enzymatic conversion of 2-acetolactate, the green beer will pass a second fermenter, where the removal of the green beer flavor will take place. In this fermenter, IMMOPORE is placed with immobilized yeast for maturation. The duration of the process is not different from the "old" process layout. It takes about 10 min for conversion of 2-acetolactate to acetoin in the first reactor and about 2–3 h for the maturation process in the second fermenter. A pilot plant has been built, and the resulting beers show a very high quality. This plant layout offers the opportunities first to produce beer at "cold" temperatures within 5–6 days and, second, the use of this novel carrier material offers for the first time a cost-effective industrial-scale secondary.

Gerrit Blümelhuber, né Höhn, received a Dr.-Ing. degree from the Technische Universität München in 2002. After studying brewing and beverage technology at the Technische Universität München-Weihenstephan, in 1996 he began employment at the Chair for Energy and Environmental Technologies in Foodstuff Industry. Since 1998, he is a scientific assistant there.

O-62

Solid State Fermentation (SSF)—Alternative Fermentation Creating Greater Added Value for Grains

MARK LYONS
Alltech Inc.

Many Japanese traditional food and beverage products such as sake, miso, and soy sauce are produced using solid state fermentation (SSF). SSF has also been used for many centuries as a way to utilize waste agricultural materials and to improve the protein content of grains. This paper will review the basics of SSF, including its historical origins in Japan and how these beginnings led to the evolution of SSF globally. Relevant applications in the ethanol industry, such as cellulose conversion, will be discussed. The intricacies of one such solid state process (a fungal species grown on wheat bran under sterile conditions) and the extraction of enzymes from this solid fermentation medium, will be discussed. Solid state enzymes currently manufactured include commercial amylases and proteases, which are now routinely used by the ethanol industry globally. The Alltech SSF plant in Serdan, Mexico, will be used as a case study. This state-of-the-art facility has been in commercial production for 3 years and is the only SSF facility for enzyme production in North America.

Mark Lyons studied at the University of Chicago followed by postgraduate work at Heriot Watt University, Edinburgh. He received his master's degree in brewing and distilling from Heriot Watt in 2000. He is currently the director of Alltech Serdan, a plant extract and enzyme production facility located in Mexico. The solid state component of the plant was designed and developed under his guidance. He is dedicated to expanding the area of solid state fermentation to incorporate additional by-products and to expand the technology to new applications.

O-63

Primary Beer Fermentation by PVA-Immobilized Brewing Yeast in a Gas-Lift Bioreactor

VIKTOR A. NEDOVIC (1), Dejan Bezbradica (2), Bojana Obradovic (2), Ida Leskosek-Cukalovic (1), and Branko Bugarski (2)
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Immobilized yeast technology is nowadays a well-established technology for beer maturation and alcohol-free beer production, while its application for primary beer fermentation is still under scrutiny on the laboratory or pilot level. The most commonly used yeast carriers in these processes are DEAE cellulose, porous glass, silicon carbide, and recently, wood chips. These carriers provide a simple immobilization procedure and good mechanical properties but are limited by relatively low cell concentrations and significant cell leakage. Porous matrices present an alternative solution for yeast immobilization providing higher cell concentrations and better cell retention. In the current work, we have studied the application of LentiKats® (polyvinyl alcohol particles produced by a simple gelling technique at a room temperature) for immobilization of brewing yeast and primary beer fermentation in a gas-lift reactor. Viability and growth potential of immobilized yeast were assessed in 6-day cultivation studies in complete growth medium in shake flasks. Activity of immobilized yeast was tested in fermentations of industrial wort in internal-loop gas-lift bioreactors of 1 and 3 L of working volume. Results of growth studies indicated that the lag phase was longer for immobilized cells than for cells in suspension. In addition, the specific growth rate was around 50% lower for immobilized cells. Nevertheless, high cell concentrations were achieved in LentiKat® carriers due to a prolonged exponential phase of immobilized cells. Fermentation studies in gas-lift bioreactors demonstrated high fermentation activity of immobilized cells. Apparent attenuations in the range of 80 to 86% were achieved for less then 24 h with solid loading of around 10% mass. The quality of the obtained beer was comparable to the quality of beer produced by suspended cells. Concentration of cells in carrier was 1.4×10^9 cells/mL, while the final concentration in medium was 2.1×10^7 cells/mL. Results of this research indicated LentiKats® was a suitable carrier for brewing yeast cells, especially when applied in gas-lift reactors. This carrier, due to its lenticular shape, provided good mass transfer properties and an easier and more efficient separation procedure from the fermentation broth as compared with microbead carriers. In addition, LentiKats® provides excellent mechanical properties, which extends its potential applications to long-term and large-scale continuous beer fermentation processes.

Viktor A. Nedovic received B.Sc., M.Sc., and Ph.D. degrees in food technology, biochemical engineering, and biotechnology, respectively, from Belgrade University in Belgrade, Serbia. He is employed at Belgrade University, Department of Food Technology and Biochemistry, as assistant professor for the subjects technology of beer and malt production and biochemical engineering. He has conducted several research projects in the fields of beer fermentation, immobilization and bioencapsulation of cells, and bioactive molecules. He is a member of Management Committee of COST 840 Action (Bioencapsulation Innovations and Technologies). He is a member Bioencapsulation Research Group (BRG) and founder and secretary general of the Biochemical Engineering Society. He has served as coeditor of two major books (publisher: Kluwer Academic Publishers) covering the fundamentals and applications of immobilized cell technologies: Fundamentals of Cell Immobilisation Biotechnology *(published in Dec. 2003) and* Applications of Cell Immobilisation Biotechnology *(in press). Recently, he has served as guest coeditor of the special issue of the journal* Chemical Industry, *which was devoted to the 11th BRG Conference "State of Art of Bio&Encapsulation Science and Technology", held in Strasbourg, 2003. He has served as reviewer of scientific papers for the journals* Biotechnology and Bioengineering, Journal of Agricultural and Food Chemistry, *and* Food Microbiology.

O-64

Detection of Beer-Spoilage Microorganisms Using the Loop-Mediated Isothermal Amplification (LAMP) Method

YOUICHI TSUCHIYA (1), Masahiro Ogawa (1), Yasukazu Nakakita (1), Yasunobu Nara (1), Hirotaka Kaneda (1), Masachika Takashio (1), Harumi Minekawa (2), and Takahiro Soejima (2)
(1) Sapporo Breweries Ltd.; (2) Eiken Chemical Co., Ltd.

Draft beer is an area of market growth in many parts of the world, which has made the biological monitoring of beer-spoilage microorganisms even more important. Loop-mediated isothermal amplification (LAMP) developed by Eiken Chemical Co., Ltd. (http://loopamp.eiken.co.jp/e/index.htm) is a nucleic acid amplification method that reacts under isothermal conditions and produces large amounts of DNA. The LAMP method requires a set of four specifically designed primers and a DNA polymerase with strand displacement activity. The amplification products are stem-loop DNA structures with several inverted repeats of the target and cauliflowerlike structures with multiple loops. Thereby, after the LAMP reaction, white precipitates identified as magnesium pyrophosphate are observed in the reaction mixture; thus, the presence of these precipitates confirms that DNA was amplified. We designed the primers specific to 11 species of yeasts and bacteria defined as spoilers for our products, optimized conditions for LAMP, and developed the rapid detection and identification kit containing all these primers in one mixture. When LAMP was carried out using this kit at 63°C for an hour and a half, all beer spoilers could be specifically detected by generation of the white precipitates in the reaction mixture. *Lactobacillus brevis* and *Pediococcus damnosus* are known as representative beer spoilers and include beer-spoilage as well as nonspoilage strains. The primers specific to the beer-spoilage strains were designed based on the sequence of the *gyr*B gene, including sequence alteration between beer-spoilage and nonspoilage strains (1). *Saccharomyces* species include both bottom fermenting yeasts and beer-spoilage wild yeasts. Optional primer sets based on the sequence of the *MEL* gene were also prepared to distinguish them. This kit is simple and easy to perform, requiring only a regular water bath or heat block for reaction. Given the simplicity and cost-effectiveness of the reagents and equipment involved, LAMP has an advantage over PCR requiring the expensive real-time instrument or a regular thermal cycler with additional detection system such as electrophoresis or ELISA. The LAMP should contribute greatly to microbial quality assurance in breweries. 1. Nakakita, Y., Maeba, H., and Takashio, M. Grouping of *Lactobacillus brevis* strains using the *gyr*B gene. J. Am. Soc. Brew. Chem. 61:157-160, 2003.

Youichi Tsuchiya was born in 1963. Youichi graduated from Kyoto University, Japan (Department of Food Science and Technology, Faculty of Agriculture) with a bachelor's degree, 1987; a master's degree, 1989; and a Ph.D. degree, 1999. Youichi's Ph.D. thesis was 'Application of genetic analyses to brewing'. Youichi joined Sapporo Breweries Ltd. in 1989 and was with the Quality Assurance Department, Brewing Research Laboratories until 1996; the Microbiology Department, Brewing Research Laboratories until 2002; and the Frontier Laboratories of Value Creation as lead microbiologist until the present.

O-65

Genetic Characterization of Hop-Sensitive Variants Obtained from Beer-Spoilage Lactic Acid Bacteria

KOJI SUZUKI, Kazutaka Ozaki, and Hiroshi Yamashita
Asahi Breweries, Ltd.

A limited number of species belonging to lactic acid bacteria represent the majority of beer-spoilage bacteria. Most species of lactic acid bacteria fail to grow in beer because the hop compounds, added to confer bitter flavor to beer, is the major neutralizing agent. Interestingly, some strains belonging to one species have a strong hop-resistance ability and are capable of vigorously growing in beer, whereas some others, belonging to the same species, have no beer-spoilage ability. Nonetheless, the hop-resistance ability has been reported to be a stable character, and the origin of beer-spoilage lactic acid bacteria is one of the mysteries for brewing microbiologists. In this study, we attempted to obtain a hop-sensitive variant from beer-spoilage *Lactobacillus brevis* ABBC45. As a result, it was shown that the incubation temperature, higher than optimal, caused the permanent loss of the beer-spoilage ability of this strain. Genetic characterization of the non-beer-spoilage variant revealed that two genetic regions, containing *horA* and ORF5, respectively, were lost concomitant with the loss of beer-spoilage ability. It was found that *horA* and ORF5 were carried independently by two plasmids, designated as pRH45 and pRH45‡U, and the presence or absence of these two genetic markers were highly correlated with the beer-spoilage ability of various species of lactic acid bacteria. Strikingly, all the beer-spoilage lactic acid bacteria in our culture collection were found to possess at least one of the two genetic markers, indicating that the beer-spoilage ability can be determined by these *trans*-species genetic markers. The sequencing analysis of *horA* and ORF5 homologs, identified in various beer-spoilage species, revealed approximately 99% nucleotide sequence identity with those of *L. brevis* ABBC45. These results indicate that *horA* and ORF5 have not evolved with the speciation processes. Indeed, the loss of *horA* and ORF5 occurred with the loss of hop-resistance ability of seven beer-spoilage strains other than *L. brevis* ABBC45, suggesting that these markers are not innate genetic regions. Taken collectively, these *trans*-species genetic markers are most likely to be acquired by horizontal transfer and confer the beer-spoilage ability on originally innocuous lactic acid bacteria. This insight gives a theoretical foundation for using *trans*-species genetic markers for differentiating the beer-spoilage ability of lactic acid bacteria.

Koji Suzuki received an M.S. degree in agricultural chemistry from Tokyo University in Tokyo, Japan. He began employment with Asahi Breweries, Ltd. in April 1992 as a microbiologist. Since April 2003, he has functioned as chief researcher in the Analytical Technology Development Section of the Analytical Technology Laboratory.

O-66

Hygiene Monitoring in the Food Industry—A New Approach for Control of the Microbiological Situation

DR. FRANK NITZSCHE
Koenig Brauerei GmbH

Stable processes for the production of food are necessary for a safe production. Upcoming regulations require known processes without the risk to deliver unsafe products. Beside the risk of a chemical contamination that might be detected, very fast microbiological contaminations might cause a major damage to the health of the consumer. But, as a major disadvantage, microbiological analysis methods last at least several days. Due to the problem of growth prior to the detection of the microorganisms, the analysis result will be available too late. Different strategies have to be set up in a food-producing company to keep the number of microorganisms as low as possible. Beside the reduction of the growth of biofilms in pipes, the risk of secondary contamination has to be decreased. For the first question, the internal stabilization of the supplied water with the help of chlorine dioxide might be a helpful choice. The reduction of the risk of the secondary contamination within the filling lines might be lowered due to better education of the operating personal. Increasing the knowledge of personal hygiene through education of the workers together with simplified pictures and demonstration of growing germs enable them to be in more hygienic working conditions. Second, the optimization of the technical equipment with cheap but successful mechanical improved cleaning processes (e.g., short washing steps within the filling plant will help to reduce the availability of organic material as a nutrition and growing source) will reduce the risk of a secondary contamination. In combination with hot-water rinsing steps, two major basic conditions for growing of germs will be removed. The next step in optimization of the "stabilization" process, the work with chlorine dioxide, will decrease cleaning costs and increase cleaning results. Chlorine dioxide is a gas that is soluble in water. It is allowed to be used as a water stabilization agent, but the use as a disinfectant without any negative influence on flavor or other product properties is possible. Chlorine dioxide produces no organic chlorine compounds, such as chlorophenols or halogenated hydrocarbons. Introducing of new methods in the laboratory for detecting live germs without pre-enrichment will be the next step on the way to increased product quality at cheaper costs with increased product safety. This fast microbiology allows the production plant to optimize the cleaning processes in real time. This will allow the opportunity to save cleaning costs and to reduce the environmental impact (water and cleaning agent consumption).

Dr. Frank Nitzsche (born in 1960) studied to become a brewer and maltster at Veltins Brauerei, Germany, between 1981 and 1983. He received a master's degree in brewing science from TU Muenchen-Weihenstephan in 1988. His Ph.D. work was done with Prof. Dr. Narziss until 1991. Since then he has been working for Koenig Brauerei as head fo the R&D department at Koenig Brauerei until 1994, as head of QA until 1997, and nowadays, he is responsible for production and QA. In 1999, he founded Easyproof Laborbedarf GmbH, which works mainly on fast microbiological detection methods.

TECHNICAL SESSION XI: Packaging

Moderator: Christopher Nunes

Christopher Nunes is a graduate from The University of Toronto in biochemistry and has a diploma in brewing technology from the Siebel Institute of Technology. He has worked for Molson Breweries for the last 20 years in packaging, maintenance, continuous improvement, and reliability. Chris is currently the director of continuous improvement at the Molson Toronto Brewery.

O-67

WITHDRAWN

O-68

Development of a Hybrid Canning Line with High Productivity in a New Kyushu-Kumamoto Plant

KOICHI HOTTA
Suntory Ltd., Kyushu-Kumamoto Plant

Japanese beer companies are recently turning into total beverage companies that also produce soft drinks. In order to meet this demand, our Kyushu-Kumamoto Plant started production in April 2003 as a total hybrid beverage factory including beer, soft drinks, and in future, low alcoholic beverages. Because this is our only factory on the Kyushu Island of Japan, it is required to produce all kinds of products consumed in the area and to deliver them quickly to the customer. Therefore, high flexibility of production is strongly required for the factory. Packaging section consists of three lines, that is, PET bottling, canning, and kegging lines. They are basically designed to handle all products except for aseptic ones. The canning line is a hybrid line of beer and soft drinks, such as coffee, oolong tea, etc. Therefore, it should produce various kinds of products with relatively small volume. It is essential to achieve quick product change while keeping good product quality. First of all, to achieve quick changeover, two fillers have been introduced into the line to run alternatively. One filler is for beer and the other one is for soft drinks. This contributed to the reduction of shutdown time for CIP, especially long ones to prevent flavor contamination among different products. Secondly, a block changeover system was adopted. Hybrid line has a problem of trip time difference, depending on the products. Beer cans pass through the line in 1.5 h, while it takes 3 h for coffee cans. As a solution, the whole line was divided into eight blocks and the product in each block can be changed independently. To keep good product quality, counter-pressure of the filler bowl during beer introduction and CO_2 gassing before seaming are precisely controlled automatically. As a result, in spite of frequent product changes, CO_2 volume and O_2 pickup are controlled within a small deviation. Next, to deal with complexity of materials, a pallet identification system with QR code was adopted. Each pallet of material has a unique code on it. Before getting into use, they are compared with the production plan and misuse of different materials has been prevented. And in order to raise the online detection ability, an empty can inspector with high flexibility was installed with great success. Furthermore, about 4,000 signals and data, such as temperatures, pressures, and motion of valves are collected and they are easily accessed from every PC in the office. With these measures, Kumamoto canning line is handling more than 10 kinds of cans and producing twice as many kinds of products a week as the other factories. At the same time, high level quality assurance has been achieved.

Koichi Hotta received a master's degree in mechanical engineering from Kyoto University in Japan. He began employment with Suntory in April 2000 as a mechanical engineer in the packaging section of the Tonegawa Brewery. In August 2001, he became a member of the new Kyushu-Kumamoto Plant Installation Project. In this project, he was in charge of designing the entire packaging section. Since it started production, he has been working as a technical staff member of the plant.

O-69

Plastic Beer Bottles: Where Are We Today?

NINA GOODRICH
Amcor

Plastic beer bottles have been available commercially for the last 5 years but have only begun to gain momentum. North America has seen a few introductions, but Eastern and Western Europe have been more active. This talk will focus on what has changed? It will provide an overview of the technology improvements required to fuel new market development and sources of these technology changes. Specifically, it will cover the following. • Plastic's impact on the environment. Plastic offers some sustainable lifecycle options that are different than glass. • Product protection. Barrier has always been a challenge when we consider beer in plastic. Measurement of barrier, barrier options for oxygen, light, and carbon dioxide will all be covered. • Shapes and sizes: What shapes are possible? Plastic offers new decoration options and differentiation options. • Cost. Security of supply and resin stability will be addressed. • Process compatibility. To pasteurize or not to pasteurize? What are the plastic bottle implications? What does it mean for filling lines? It will also include a review of current launches globally.

Nina Goodrich is the director, value creation and business innovation for Amcor PET Packaging, in the Diversified Products Division. In the past, Nina has led Amcor PET's Centre for Technology. This group developed one of the first commercial barrier plastic beer bottles in North America. It pioneered the use of a monolayer active scavenging bottle. In this technical role, Nina was very active in the development of recycling systems for sustainable bottle-to-bottle recycling. Prior to joining Amcor, Nina was the director of operations for the Guelph Food Technology Centre. Nina has a degree in molecular biology from Wellesley College and has done graduate work in management. She is a frequent speaker at food and packaging industry events and conferences.

O-70

Shortening the Changeover Time of a Can Line into Less than 10 Minutes

TAKAHIRO YONEDA and Go Hasegawa
Asahi Breweries, Ltd.

In the Japanese market, bottles, cans, and kegs are used for beer containers. Among them, 350- and 500-mL cans are the most popular in the market. Besides a case of 24 cans, they are sold as Loose with individual 24 cans, and Multi Pack with bundled 6 cans. Therefore, the four most popular packaging forms are 350-mL Loose, 350-mL Multi Pack, 500-mL Loose, and 500-mL Multi Pack. Asahi Breweries, since 1992, has worked on fresh management activities, and the main brand, Super Dry, has increased its market share. In order to improve freshness of the beer, each brewery is required to produce the suitable beer volume in the number of containers demanded in the market every day. However, the changeover time between the 350- and 500-mL can forms in the line used to be 300 min, and the time to switch between Multi Pack and Loose used to be 60 min. It was inefficient to produce the above four kinds every day. Therefore, we pooled our efforts to achieve the goal of shortening the time to less than 10 min in order to provide more fresh beer to the market. As for three basic policies of our efforts, first, those works that only manpower is able to do should be kept as is. Examples are to check leftover cans of the previously processed kind, the quality of contents and packaging, and the operation status of each inspector. Second, automation with IT and machinery should be taken with the consideration of profit. Third, the established works should be reconsidered in terms of time reduction. Regarding the actual measures, we introduced, even developed, the automatic changeover systems with the pneumatic or electromotive powers, instead of manpower. This made the time shorter as well as reduced troubles resulting from the changeover. Another is to divide one line into several areas. Instead of finishing one consecutive works in a line for one kind, when we finish works of one area for one kind, we change into the different kind to do the same works of that area. Also, we introduced automation in changeover and production starts. Instead of human judgment, we set up a system that judges the conditions for automated changeover and start by networking necessary equipment. Additionally, we introduced swivel joints in the product in-feed pipe toward the filling machine, since we cannot expose the nonsterilized part that directly touches beer to the air while changing filling machines. Finally, these alterations raised operators' consciousness positively on changeover and made them perform many efforts for improvement called *Kaizen*. Therefore, we achieved the goal of shortening the changeover time to less than 10 min.

Takahiro Yoneda received a B.S. degree in chemical engineering from Kyoto University in 1990 and started his job in the central research center of Asahi Breweries, Ltd. During the first 4 years, he researched and developed packaging materials such as metal cans and PET bottles with strength, among other assignments. Also, he developed the direct distilling system in draft kegs. While working at five different locations, he also engaged in production, being in charge of startup and responses in packaging lines. In 2000, he studied packaging at Michigan State University as an exchange-visiting scholar for a year.

O-71

Development and Introduction of High-Performance Full-Bottle Inspector

HIROHIKO INOUE and Hirohisa Suzuki
Asahi Breweries, Ltd.

The requirements of bottle packaging are correct fill level, secure crowning, no foreign substance in the beer, cleanliness of bottles, no cracks or scuff on bottles, and others. The recovery rate of beer bottles in Japan is high, and most of the bottled beer products are packed in the recovered bottles. About 5% of recovered bottles is defective. The consumers have high expectations toward product quality, and we manage the production processes so as not to produce any defective products that can induce customer complaints. Asahi Breweries had performed empty bottle inspections before and after rinsing by machines and visual bottle inspection by manpower. In building the new Kanagawa Brewery in 2002, the visual bottle inspection was abolished and the full-bottle inspector was introduced. In the same year, we, together with Matsushita Electric Works, developed a type of the full-bottle inspector that is compatible with our other breweries. In November 2003, two of our breweries introduced it. During development, we reconsidered the requirements in the former bottle inspections, which are newly included in the design of the new full-bottle inspector. The defects in recovered bottles and insufficiency in rinsing are discovered and managed at the rinser and the empty-bottle inspector. Therefore, the full-bottle inspector can mainly focus on checking the defects that can be generated in filtration and crowning. The focus made more effective and precise inspection possible. Also, we considered the stability in conveying bottles, maintenance, information processing of data of inspection, and pictures to make the inspector usable. Regarding outlines of the inspector, the maximum inspection speed is 720 bpm, and the conveyor is a single and linear line. The inspection items are foreign substances, leakage, cracks in the bottle lip and bottom, fill level, and crowns. The inspector can analyze data of the numbers of defects and can save the pictures of defects.The competence of the inspector is proved at the two breweries, since they achieved the goals identified in the beginning. The inspector raised productivity and reinforced the quality management system. Furthermore, it is planned to be introduced to our other breweries.

Hirohiko Inoue received a B.S. degree in mechanical engineering from Kagoshima University in Japan. He began his employment with Asahi Breweries, Ltd. in 1990. For 9 years, he was engaged in engineering of the production facility (on brewing and packaging) in the breweries. Since 1999, he has been with the Technology Department of Asahi Production Headquarters. He has worked on raising productivity of packaging lines.

O-72

Impact the Bottom Line: A Business Case for Reliability-Driven Maintenance

Christopher Nunes (1) and PAUL LANTHIER (2)
(1) Molson Canada, Toronto, ON, Canada; (2) Ivara Corporation, Burlington, ON, Canada

Many external factors are forcing brewing companies to focus on cost efficiencies to gain a competitive advantage. Maintenance organizations are now being charged with the responsibility to contribute to the bottom line. The condition, availability, and reliability of plant assets affect a brewing company's ability to meet fluctuations in market demands, maintain quality and safety levels, and minimize product losses. Improving asset reliability impacts the bottom line. This paper discusses how to develop a business case to justify reliability-driven maintenance. The resulting business case assesses the current state of maintenance and clearly identifies the financial benefits/costs and the roadmap to achieving those benefits. • Gain a clear understanding of maintenance performance as it compares to world class standards and the benefits that can be realized. Look at the way maintenance is conducted in an organization and the degree to which specific requirements support an effective maintenance process. • Learn how to identify financial benefits associated with improving reliability, such as maintenance costs savings, maintenance-related downtime reduction, and waste reduction. Define metrics for current and future state and provide benefit/cost/effort projections. • Develop a roadmap to achieve a reliability-driven approach to maintenance. – Focus on maintenance as a business process. The business process defines what must be done consistently to optimize reliability. – Ensure that reliability practices are established to identify the right work to do on the right equipment at the right time. – Support the data-intensive maintenance business process with technology. – Manage the change from reactive to proactive maintenance to ensure results are sustainable. This paper describes how to realize significant value in adopting a reliability-driven approach to maintenance. By embracing the business process, training, and empowering employees and giving them the right supporting practices and tools, the maintenance organization will work more effectively and, in turn, impact the bottom line.

Paul Lanthier is a graduate from Queen's University in electrical engineering and a certified professional engineer in the provinces of Ontario and Québec. Paul is also a certified RCM2 (reliability centered maintenance) practitioner. Over the past 23 years, he has worked in the reliability engineering, process control and process optimization fields, the material and structural testing field, and the quality inspection field. Paul is currently a member of Ivara Corporation's Reliability Solutions group.

TECHNICAL SESSION XII: Beer/Brewing

Moderator: George Reisch

George F. Reisch is a corporate brewing staff brewmaster for Anheuser-Busch in St. Louis. He is a fifth generation brewmaster. His family owned and operated the Reisch Brewing Co. of Springfield, IL, from 1849 until it ceased operations in 1966. George graduated in 1979 with a B.S. degree from the University of Wisconsin. He was hired by Anheuser-Busch upon graduation and, in 2004, is celebrating 25 years of service to Anheuser-Busch. George is an active member of both the MBAA and the ASBC. He is a past president of MBAA District Southern California and is currently serving on the Education and Technical Committees for the national MBAA office. In addition, he is a member of the Board of Advisors for the North American Brewers Association (NABA). George's current duties include overseeing Budweiser, Bud Light, Busch, and Busch Light production at the Labatt breweries in Canada. George, his wife Kathy, and his four children live west of St. Louis in Wildwood, MO.

O-73

Two Different Brewing Processes Disclosed from Two Ancient Egyptian Mural Paintings

HIDETO ISHIDA
Kirin Brewery Co., Ltd.

Our trial of reproducing two kinds of ancient Egyptian beer was successful. Two different mural paintings were referred to in order to know the beer-brewing scene. One was the painting in Niankhkhnum and Khnumhotep's tomb from the Old Kingdom era (2650–2180 BC, Saqqara) and the other was the painting in Kenamun's tomb from the New Kingdom era (1570–1070 BC, Thebes). Each tool and scene described in these two mural paintings was significant in that they follow the Common Pathway of world alcoholic beverages in detail. The same tools and replicas, such as pots and anforas, were imported from Egypt to conduct the test brew under the same conditions of those ages, which depended on the nature of the clay and the shapes of the pots and anforas.The brewing process in the Old Kingdom era was similar to the modern beer-brewing process in that fermentation was continued to mashing by a single mash decoction process. The brewing process in the New Kingdom era was not similar, because converting starch and fermentation were carried out simultaneously in the same pot. There were significant differences in the purification of yeast between those two eras. People in the Old Kingdom era were baking sour bread to defeat lactic bacteria and were utilizing the remainder of the lactic acid to select suitable yeast from its effect of avoiding bacterial contamination. People in the New Kingdom era found a purification method of yeast by kneading sourdough with alcohol without baking it. Especially, unique fermentation in the solid body was taken in this process. As main yeast, *Saccharomyces cerevisiae* was chosen in both methods. Date played an important role in yeast selection and in keeping them pure in each case. New Kingdom beer contained malt, full-steamed bread, and unbaked dough. Samuel's SEM observations into residual starch granules of an ancient Egyptian pottery vessel agreed with our process. Since alcohol concentrations of both final beers were over 8% (v/v), it might be possible to transport and stock them at some degree.
Niankhkhnum's beer tasted like sophisticated white wine with a slightly malty after-note, which was caused by similar concentrations of lactic acid. Although Kenamun's beer was like an alcoholic yogurt drink with a very sour taste and was similar to the Egyptian drink Bouza, it had mysterious charms to make people want to drink it again.

Hideto Ishida graduated in the biochemistry field from Kyushu University in Fukuoka, Japan. He began employment with Kirin Brewery in April 1969 as a chemist in the analytical laboratory of the Yokohama Branch. He has engaged in brewing, malting, QC circle activity, environmental management, corporate technical planning, bottle making, operations research, technical consulting in the China plant, and public relations management in the Kobe plant.

O-74

Miller Valley Brewery as a Development Tool in the 21st Century

JEANNE L. MARAIS, David S. Ryder, Susanne S. Terharn, and Gerald Czernicki
Miller Brewing Company

Miller Valley Brewery (MVB), Miller's state-of the-art pilot brewery and packaging facility within its Milwaukee Technical Center, started its operations in 2000. The brewing facility has a capacity of 12 hL as wort per batch, complemented by a smaller 40-L brewing system. The MVB is the first of its kind in the U.S. and has enabled Miller to greatly improve its capabilities in new product development. Consumer needs and preferences are becoming more diverse, thus making new product development an area of critical performance. Recent years have shown that survival in the U.S. market requires not only new products but also the diligent evaluation of processes and ingredients to sustain customer satisfaction. It has also shown that not only the product itself, but also the timing, are critical factors. The MVB was designed and built to enable the fastest possible response to market trends and to support critical marketing initiatives. Its cutting-edge technology is used to enhance and accelerate the testing and development of new and existing products and processes without disrupting normal brewery production. The result is a critical savings in time and cost, as well as enhancement in production efficiency. Before 2000, Miller's commercial breweries averaged about 110 brewing trials per year. Now, more than 200 trials are done at the MVB annually, using both novel and traditional technologies to craft products to delight the taste buds of future consumers. In this report, the following topics will be discussed: 1) structure and function of pilot brewing within Miller Brewing Company, 2) MVB design and equipment, 3) MVB successes and achievements, and 4) the outlook for the future of pilot brewing at Miller.

Jeanne Marais received a B.S. degree in chemical engineering from the University of Cape Town in South Africa. She began employment with South African Breweries in 1997 as a technical trainee and, later, was a process engineer at the Ohllson's Cape Brewery in Cape Town, South Africa. She joined Miller Brewing Company in 1999 as a staff brewer in the Corporate Brewing Department at Miller's Headquarters in Milwaukee, WI. Since August 2002, she has functioned as pilot brewing manager in product and process innovation, reporting to Susanne Terharn.

O-75

Design, Planning, and First Practical Experience—The New Grolsch Brewhouse in Enschede, The Netherlands

Guy Evers (1) and THOMAS BUEHLER (2)
(1) Grolsch Innovation and Technical Services Department, Enschede, The Netherlands; (2) The Huppmann Group, Kitzingen, Germany

The paper will present the design and first experience with the new brewhouse at the new Grolsch brewery in Enschede, The Netherlands. Six years ago, Royal Grolsch Brewery decided to invest in a new brewery site. Reasons for the decision to invest into a completely new site were the projected savings in labor and energy as well as environmental and increased safety aspects on one hand. On the other, it was the growth potential of the brand. The targets will be presented and discussed. In process execution, one of the challenges for Huppmann was to meet the narrow time line. Due to the complexity of the installation, the design phase involved a complete 3D planning of the brewhouse. Despite a fast project execution, brewers and engineers paid much attention to the engineering and technological details. Already in this stage and especially during installation, the investment in 3D planning paid back. The new Huppmann brewhouse, with a total capacity of 4,000,000 hL of wort per year (producing wort in three shifts 5 days a week) is a two stream setup that accomplishes the aforementioned criteria of efficiency and quality. The setup of the plant and the reasons behind the layout will be presented in this paper. During commissioning, which took place at the beginning of 2004, the brewers could gain first experience with the new brewhouse. Important aspects are the adaptation of the beer style to the new brewhouse as well as the performance parameters. The paper will present these results.

Dr. Thomas Buehler started brewing with an apprenticeship as a brewer and maltster. In 1991, he graduated with a Diplom-Ingenieur in brewing from the Technical University of Munich-Weihenstephan. In 1991, Thomas was employed as a scientist at BRI, Nutfield, U.K. In 1995, he started as manager training and technology at APV, Dortmund, Germany. Thomas graduated with a Ph.D. degree in chemical engineering from Loughborough University, U.K., in 1997. From 1996 until 2003, he was managing editor for Brauwelt *at Fachverlag Hans Carl, Nuremberg, Germany. Currently, Thomas is director marketing and R&D at The Huppmann Group, Kitzingen, Germany.*

O-76

Wort Aeration—A Critical Approach

CHRISTOPH TENGE and Eberhard Geiger
Technische Universität München, Center of Life Sciences Weihenstephan, Chair for Brewing Technology II

A current topic in brewing research is the area of flavor and colloidal stability of beer. Oxygen uptake is considered to be the single largest negative factor affecting stability. Therefore, modern brewing technology endeavors to prevent oxygen uptake from all steps in production, from mashing to bottling. However, in one step of the process, oxygen is desired in large amounts, that is, during wort aeration. The air is introduced into the wort in order to supply the yeast with oxygen. At the beginning of primary fermentation, the yeast requires oxygen for aerobic metabolism and growth and synthesis of membrane lipids. It is more precise to discuss yeast aeration rather than wort aeration because the wort does not require oxygen. Despite preventative measures, such as the introduction of air into the wort at a low temperature and in the presence of yeast, a loss in reductones is detectable. This oxidative deterioration was measured with an electrochemical ITT test and will be presented. As stated above, supplying the yeast with oxygen is essential; however, wort aeration is not the only option. Modern yeast cultivation, such as propagation technology, produces yeast in excellent physiological condition while providing them with an adequate oxygen supply. Will yeast of this quality ferment unaerated wort? In order to answer this question, it was necessary to conduct brewing and fermentation experiments on a laboratory and pilot scale. Technological analyses were carried out, such as degree of attenuation, the formation of metabolic by-products, etc. A sensory evaluation of each of the beers was performed and the flavor stability was tested. These results provide a basis for evaluating the possibility of working with nonaerated worts. The experiments show that by using yeast in good condition, it is possible to ferment nonaerated wort. The degree of attenuation was comparable to beer production using aerated worts. High-quality beers are able to be produced using this method. Additionally, by preserving the antioxidative capacity of the wort, the flavor stability of the beer is enhanced. Results obtained in the laboratory were confirmed using a pilot plant. These initial findings show that it is possible to maintain a high wort quality through shifting aeration from wort aeration to yeast aeration during the propagation process.

Christoph Tenge was born in 1972. From 1991 to 1998. Christoph studied brewing and beverage technology at the Technische Universität München-Weihenstephan, Germany, and earned the degree of Diplom-Ingenieur with a doctoral dissertation of "Developing a technology to produce alternative beverages out of grain extracts with specifically isolated fermentation-organisms" (1999–2002). Christoph has been employed as a freelancer for molecular biology studies, Dr. Vogeser, D-Tect GmbH in Freising, Germany (1998–1999); research assistant at the Chair for Brewing Technology II, Technische Universität München-Weihenstephan, Germany (1999–2001); and assistant professor at the Chair for Brewing Technology II, Technische Universität München-Weihenstephan, Germany (2001–present).

O-77

Observations on a Lauter Tun with a New Design

PROF. DR.-ING. HEINZ MIEDANER (1), Matthias Weinzierl (2), and Klaus Wasmuht (2)
(1) Staatliche Brautechnische Prüf- und Versuchsanstalt, Freising, Weihenstephan, Germany; (2) Anton Steinecker Maschinenfabrik GmbH, Freising, Germany

Lautering is one of the major steps in beer production. Here, the efficiency of the brewhouse is determined. But lautering also affects the wort quality. The requirements on modern lautering systems rise continuously. Whereas quality and quantity of the extracted wort used to be the main topic, today's recurrent demand is to increase profitability and flexibility as well. Currently, lauter tuns for 10 brews/day are used in many breweries all over the globe. With a little more technical expenditure, 12 brews/day are already state of the art. To take all these points into account, a completely new lauter tun was conceived that surpassed the expected improvements in practice by far.The new lauter tun bears the name of Pegasus, going back to Greek mythology. Pegasus is a winged horse that emerged from Medusa after having been beheaded by Perseus. The name is to illustrate the speed and the quality of the new lautering method. The design of the new lautering system has the following advantages: Even mash storage from center, arrangement and dimensioning of the source areas enable uniform flow conditions, the extract intake is faster, the soluble extract is low, the yield is increased, the weak wort concentration is low, the spent grains are drier, 12 brews/day are achieved with higher specific loads of 14 brews/day are possible, and the total of solids and the turbidity are unobjectionable. This paper illustrates the principle of the system and the results of recent acceptance tests.

Prof. Dr.-Ing. Heinz Miedaner was born in 1941 in Munich. where he spent his childhood and youth. From 1960 to 1965, he studied at the Technische Universität Munich-Weihenstephan "Brewing Technologie" and graduated as Diplom-Ingenieur. In 1965, he started working as the assistant of Prof. Dr. Ludwig Narziss at the Chair of Brewing Technology and graduated as Dr.-Ing. The thesis of his doctoral was "Influence of barley variety and malting conditions on the formation of higher alcohols and esters during fermentation and storage". From 1969 to 1971, he started working as quality control manager at the Erste Kulmbacher Aktienbrauerei, Kulmbach. From 1971 to 1995, he started working as chief engineer of Prof. Dr. Ludwig Narziss, where he could focus on different working fields, such as practical training of students, lectures in international brewing methods and technological quality control, flavor research (GC and GC/MS), and consultancy of breweries and malting plants. In 1980, he wrote his doctoral with the topic of "Some aspects of fermentation and maturation". In 1990, he was nominated as professor. Since 1995, he is working as director of the Staatliche Brautechnische Prüf- und Versuchsanstalt, Freising, Weihenstephan.

O-78

Today's Small Brewer: An Industry Partner

DANIEL BRADFORD
Brewers' Association of America

Small brewers are the leading edge of a dramatic shift in the marketplace. They accomplished this through a pair of strategies. As the most dynamic part of the industry, small breweries can be found on the leading edge in many areas. Although securely entrenched in the industry, this segment is threatened by the evolving industry political and economic climate. During the past year, the small brewing industry was the fastest growing category of the beer industry. With numbers reported ranging from 3 to 5% market share and up, this category is clearly the star. As trading up to higher-priced brands turned from a trend to an industry pattern, small brewers provided both core brands as the bulk of the business and product innovation that continued to inspire and vitalize the segment. Although there are exceptions to the rule, these brewers continued to introduce a steady stream of diverse, innovative, and exciting brands. During a period when the big news has been spirits branded malternatives and low carbs, small breweries persisted in stretching the envelope. Beyond style innovations, small breweries are innovators in creating environmentally friendly breweries and using alternative energy sources. Within the brewhouse, small breweries are also known for their innovations in technology, packaging, and marketing. Furthermore, the grass roots passion surrounding small breweries has revived the traditional loyalty for local breweries and inspired a whole new segment of beer "aficionados". Although the most aggressive, innovative, and expanding segment, small breweries face unique challenges. As they expand their market and their consumer base, small brewers face an increasingly restricted marketplace. The globalization of the beer industry has elevated the competition. The structure of the distribution and retail channels makes it more difficult for small brewers to successfully reach consumers. In conclusion, domestic small brewers are providing the industry with positive impacts in all areas. However, consolidation in the three-tier system is making it increasingly difficult for small breweries to access the market and succeed.

Daniel Bradford assumed his current position, president of the Brewers' Association of America, in September 1999. He is responsible for directing the activities of the small brewing industries' trade association, including political, promotion, and advocacy. Prior to holding this position, Daniel published All About Beer Magazine *for 10 years. One of the earliest consumer beer magazines,* All About Beer Magazine *now ranks as the leading magazine on beer. Before purchasing* All About Beer Magazine, *Daniel was the marketing director for the Association of Brewers and the director of the Great American Beer Festival. He has published articles on beer in most beverage trade publications in the United States, Great Britian, and Germany. He is also a partner in Top of the Hill Brewery, Chapel Hill, NC. His wife edits* All About Beer Magazine *and contributes a weekly column on beer to the* Raleigh News & Observer.

TECHNICAL SESSION XIII: Yeast

Moderator: Greg Casey

Greg Casey, born and raised in Toronto, Canada, graduated from the University of Guelph in 1979 with a B.Sc. degree in applied microbiology, continuing on to obtain a Ph.D. degree in 1984 in applied microbiology at the University of Saskatchewan (thesis: "Ethanol tolerance of brewers yeast in high gravity brewing"). Following 2 years as a NATO postdoctoral scientist at Carlsberg Laboratories in Copenhagen researching yeast chromosome fingerprinting and diacetyl production by lager yeasts, he returned to the University of Saskatchewan as an assistant professor in the Food Biotechnology Department (1986–1987). Since then, Greg has been employed as a senior research scientist with Anheuser-Busch in St. Louis (1987–1991), senior project leader in charge of the Strain Development Laboratory at Red Star Yeast and Products in Milwaukee (1991–1992), and senior director responsible for the Corporate Laboratories at the Stroh Brewery Company in Detroit (1992–1999). Greg joined Coors Brewing Company in April 1999 and, since that time, has served in the capacities of director of corporate quality assurance (1999–2003), director of brewing R&D (2002–2003), and since 5/04, director of brewing services.

O-79

The Fuel Alcohol Industry: She's Younger, She's Bigger, but Is She Wiser?

W. M. INGLEDEW
University of Saskatchewan

Although the alcohol fermentation industry is mature and has had a long history, the brewing industry has led in technology, education, and the dissemination of the science behind the process. Winery and distillery technology have also advanced. The fuel alcohol industry is not new since it was practiced seriously after the production of the automobile, in times of war, and for industrial alcohol manufacure. The process was not economic, however, since the late 1920s, when low-priced petroleum became available. Since the mid 1970s, production of fermentation alcohol for automobile fuel has steadily increased, and the technology has developed quickly. Because of its youth, the fuel industry has not had the same time to mature through research, education, and technological advances. This presentation will inform brewers and allied industries of the extent of the fuel alcohol industry, its problems and its successes.

Mike Ingledew received his B.Sc. and Ph.D. (1969, microbiology/biochemistry) degrees at the University of British Columbia and completed postdoctoral studies (1970, cellular biology) at CSIC in Madrid. He has conducted research in brewing, winery, distillery, and fuel alcohol technology since 1971 at his University of Saskatchewn laboratory. He received the Eric Kneen Memorial Award (1994) from ASBC, the Award of Recognition (1996) for outstanding services to brewing from MBAA (Western Canada), and the International Biotechnology Medal of Excellence (1999) for work advancing the biochemistry of yeast in alcohol production from Alltech Biotechnology Inc. He has published more than 150 research papers and has had a very long committment to education courses in brewing and fuel alcohol production. He is a past editor-in-chief of the Journal of the ASBC. He consults with the fuel alcohol and distilling industry worldwide.

O-80

Aroma-Active Ester Formation in Brewer's Yeast: What, How, Where, Why, and How to Control It?

KEVIN J. VERSTREPEN (1,2), Jean-Pierre Dufour (3), Isak S. Pretorius (4), Johan M. Thevelein (5), and Freddy R. Delvaux (1)
(1) Centre for Malting and Brewing Science, K.U. Leuven, Belgium; (2) M.I.T. Whitehead Institute, Cambridge, MA; (3) Department of Food Science, University of Otago, New Zealand; (4) The Australian Wine Research Institute, Adelaide, Australia; (5) VIB Department for Molecular Microbiology, K.U. Leuven, Belgium

Fermenting yeast cells produce a wide variety of volatile aroma-active esters that are of great importance for beer flavor. In high-gravity beer fermentations, performed in tall cylindroconical vessels, the beer ester balance is often suboptimal, resulting in a clear decrease in beer quality. The aim of this work was to gain more insight into the biochemical aspects of the formation of aroma-active esters and to investigate how brewers can control ester synthesis. First, the role and relative importance of the known *Saccharomyces cerevisiae* alcohol acetyl transferases, Atf1p, Atf2p, and Lg-Atf1p, were investigated. The respective genes were deleted and overexpressed in a laboratory and a commercial brewing strain. Subsequently, the ester formation of the transformants was monitored using headspace gas chromatography (HS-GC) and gas chromatography combined with mass spectroscopy (GC-MS). It was found that the expression levels of *ATF1* and, to a lesser extent, *ATF2* greatly affect the production of ethyl acetate and isoamyl acetate during small-scale wort fermentations. GC-MS analysis showed that Atf1p and Atf2p are also responsible for the formation of a broad range of less known acetate esters. Northern blot analyses of *ATF1* showed that this gene was rapidly induced by addition of glucose to anaerobically grown, carbon-starved cells. Further investigation showed that the Ras/cAMP/PKA signalling pathway is responsible for this regulation. Furthermore, nitrogen was needed in the growth medium in order to maintain the *ATF1* expression. In addition to nutrient regulation, *ATF1* expression levels were also affected by heat and ethanol stress. These findings explain the effect of medium composition on volatile ester synthesis in industrial fermentations. More specifically, it was shown that the use of high-glucose and high-nitrogen fermentation media enhances the *ATF1* expression levels, which results in higher ester synthase activities and an increased formation of acetate esters. In order to reveal the subcellular localization of Atf1p and unravel the physiological role of this protein, *ATF1::GFP* fusion constructs were overexpressed in brewer's yeast. UV fluorescence microscopy combined with cellular fractionation revealed that Atf1p is localized in lipid particles. This suggests that Atf1p has a specific role in the lipid and/or sterol metabolism that takes place in these particles. Taken together, our study reveals the importance of Atf1p for the synthesis of acetate esters and explains how brewers control the formation of these important flavors by adapting specific fermentation parameters.

Kevin Verstrepen graduated in biological engineering, option gene technology, from the Catholic University of Leuven, Belgium. For his M.Sc. thesis, he joined the group of Prof. Sakkie Pretorius at the University of Stellenbosch to study the use of genetic modification to improve the flocculation behavior of brewer's yeast. A year later, he returned to Belgium to start a Ph.D. program in the group of Prof. Delvaux at the Center for Malting and Brewing Science and the group of Johan Thevelein, Laboratory for Molecular Cell Biology. Between 1999 and 2003, Kevin investigated flavor-active ester formation in brewer's yeast. After earning his Ph.D. degree, Kevin was appointed as a postdoctoral fellow in the laboratory of Prof. Gerald Fink at M.I.T. in Cambridge, MA. He now studies the genetic variability and regulation of the yeast flocculation genes. He also serves as a group leader at the Centre for Malting and Brewing Science, where he coordinates a research project into the synthesis of volatile ethyl esters in yeast. Kevin is author of several publications and regularly serves as a reviewer for different scientific journals and financing institutes. He is a member of the American Society for Microbiology, the EBC fermentation subgroup, and the Royal Belgian Association of Brewing Science Alumni. He was awarded several prizes and was recently named an honorary fellow of the Hoover Foundation.

O-81

Quality Improvement in Continuous Main Fermentation with Immobilized Yeast

ANDREAS LUDWIG and Karl Wackerbauer
University of Technology of Berlin, Chair of Brewing Science, FBM der VLB Berlin

For several years, efforts have been made to define processes for continuous fermentation and maturation with immobilized yeast. Systems for continuous maturation have been introduced and applied at an industrial scale, while applications for continuous main fermentation using immobilization are still in the research stage. One important reason for this fact is that the course of process and the quality of the final product are not stable during reactor operation; constant changes of both are observable. On the other hand, continuous main fermentation with immobilized yeast provides a lot of advantages, such as a considerably increased fermentation performance per volume bioreactor; smaller buffer capacities needed; and due to long-term operation, less expenses for yeast propagation, yeast management, and cleaning compared with batch fermentation. In our investigation, we evaluated different technologies imaginable for an application with immobilized yeast. The main task was to improve the long-term stability of the continuous main fermentation compared with previous experiments. For this purpose, we used three different reactor systems, the defined aeration of the reactors, and a selection of carrier materials that appeared to be promising for our goals in terms of process and product quality. We had the unique chance to evaluate different technological options without being fixed to only one system. Besides the aspects of process technology, we included investigations that refer to the controllability of biological systems using simply measurable or adjustable physical and chemical quantities. We developed a controller software installed on a process control system, which was connected to the pilot reactor. As process quantities, pH value and reactor aeration rate were used and adapted by the controller. The controllability of the continuous process was also investigated, with an emphasis on a constant situation regarding the process as well as the product. It is possible to improve long-term stability significantly by a toolset of technological measures.

Andreas Ludwig had an apprenticeship in brewing (Privatbrauerei A. Rolinck, Steinfurt, Germany; 1990–1992), studied brewing science at the University of Technology of Berlin (TU Berlin; 1992–1997), and was a process engineer for R&D and plant commissioning (EUWA Water Treatment Plants, Gaertringen, Germany; 1997–1999). From 1999 to spring 2004, Andreas was a scientific assistant with teaching duties at the Chair of Brewing Science of TU Berlin, had a research project and Ph.D. thesis on "Main fermentation with immobilized yeast", was head of pilot brewery and pilot plant of TUB/VLB Berlin, was a consultant in brewing technology for VLB Berlin, and was a lecturer in the Brewing School of VLB Berlin for "Energy Technology" and "Process Control Systems". Since June 2004, Andreas has been head of the Central Laboratory, Radeberger Gruppe AG Breweries, Frankfurt, Germany.

O-82

The New Method for Drying Lager Yeasts

TAKAAKI IZUMI, Hideko Yomo, Katsumi Oshita, Hitoshi Matsubara, Nobuyuki Fukui, and Yasutsugu Kawasaki
Suntory Ltd.

Dry yeasts have been widely used for making bread and brewing wine. Dry yeasts for brewing lager beer namely, dry lager yeasts, should be also very available for yeast storage and management of beer production. But there aren't any kinds of dry yeasts on the market employed by our brewery. And even when dry lager yeasts are produced by conventional method, i.e., drying aerobically cultured yeasts, the beers produced by using these dry yeasts have unfavorable qualities. For example, the beers contain few esters and lower sulfur dioxide. So we tried to develop a new method of drying our employing lager yeasts by maintaining their fermentation property. We noticed that intracellular trehalose increases resistance to drying in yeast. Furthermore, we anticipated that sugar alcohols are capable of exerting an effect similar to that of trehalose. From these points of view, we developed our original method to make lager yeasts recovered from the beer fermentation step incorporate extracellular trehalose and sugar alcohols. By using this method, we could give our lager yeasts resistance to drying without changing their fermentation property. As a result, it was found that these dry lager yeasts maintained high activity and exhibited a favorable fermentation property. And we confirmed that the beers produced by using these improved dry lager yeasts showed similar fermentation activity and quality to the beers produced by not using dried yeasts.

Takaaki Izumi received an M.S. degree in biotechnology from Osaka University. He began employment with Suntory Ltd. in 2000 as a researcher in the Institute for Fundamental Research. Since 2002, he has worked at the Institute for Beer Development. He has been studying the development of brewing technology.

O-83

Control of the Yeast Propagation Process—How to Optimize Oxygen Supply and Minimize Stress

OLAU NIELSEN
Alfa Laval Scandi Brew

More than 100 years after its introduction, the yeast propagation process is still not fully understood because of the yeast's facultative nature. In the brewing industry, the desire is to use yeast with good fermenting characteristics but also with the ability to grow fast while maintaining these characteristics during propagation. The problem with growth is that the catabolite repression—the Crabtree effect—limits the yeast's ability to take up oxygen during yeast propagation in wort. Furthermore, in later years, we have seen a growing awareness that certain factors during propagation may stress the yeast and thus influence yeast vitality and beer quality. The stress factors during propagation are closely related to the aeration method. The fundamental questions are, therefore, how and how long to aerate plus how much oxygen to supply? In order to answer these questions, a research study has been carried out. The basis for the study was a newly developed aeration device designed as an off-center agitator with a hollow shaft for air supply. The tests were carried out in a 10-hL test propagator and later in different full-scale propagators in breweries with net volumes ranging from 20 to 160 hL. The intention was to try to detect any signs of stress as a result of the use of the agitator and to find the optimum aeration profile during the propagation. Using a 160-hL net propagator in the most recent experiments, the outlet gas from the propagator was monitored and the oxygen content and gas volume were compared with cell growth and yield factors. As this control is very informative, but also quite complicated, a more simple control was also sought, and some valuable and easily applied methods were developed. The main findings so far are the following. No stress can be detected as a result of the use of the agitator. The benefit of a high concentration of dissolved oxygen during propagation is limited. On the other hand, it seems that oxidative stress is a smaller problem than carbon dioxide stress, so the aeration must be sufficient to assure a low concentration of carbon dioxide in the propagator. By means of monitoring the amount of gas in the outlet from the propagator, it is also possible to determine when the aerobic metabolism stops. A more simple, but equally reliable, way to monitor this is by measuring the yield factor as number of million cells produced per degree Plato consumed. Low yield factor means no aerobic activity. An even more simple, but not so reliable, method is to observe the foam formation. High foam means big amounts of carbon dioxide caused by a high Plato consumption. High Plato consumption means anaerobic metabolism—and no aerobic growth.

Olau Nielsen was born in 1951 and graduated from the Technical University of Denmark with a M.Sc. degree in biochemical engineering. Olau worked for many years in other bioengineering fields before joining Scandi Brew in 1996. In Scandi Brew, Olau holds a position as sales & technology manager for yeast, which is the core product of the company (today Alfa Laval Scandi Brew). The work has concentrated around developing aeration aggregates for yeast propagation plants and mixers for yeast storage plants with a focus on efficiency and low stress conditions. Olau's latest work has involved propagation tests verifying the influence of the Crabtree effect on yeast propagation and investigating measurable stress as a result of mechanical impact on propagated yeast caused by agitation and aeration. Olau's previous work was published at IGB 2003 in Livingstone, EBC 2003 in Dublin, and 4th BYFPC 2003 in Oxford. Planned work involves optimal oxygen supply, oxygen balance and measurable oxidative stress during propagation, and further research into yeast stress conditions during storage.

O-84

Different Physiological Marker to Monitor Yeast Propagation and Fermentation by Flow Cytometry

KARL-JOSEF HUTTER
Eichbaum Brauereien AG, Mannheim, Germany

Flow cytometry provides a rapid and accurate means to monitor the physiological state of yeast cells throughout the fermentation process. This technique allows a near-real time monitoring of the physiological state of yeast populations in industrial fermentations. In the past, we have developed several flow cytometric methods to assess key parameters of the physiological condition of yeast cells, e.g., DNA, glycogen, trehalose,and neutral lipid contents, and proteinase A activity. In common brewing practice, yeast populations are often pitched in the wort in their quiescent (G0) or G1 phase of the cell cycle. These yeast populations need several hours to reach their exponential growth phase with most of the cells in G2 or mitoses and, hence, fermentation to target gravity takes longer. We optimized the propagation of lager yeast by assessing the cell cycle of the yeast population using flow cytometry. This enabled us to establish an improved pitching regime in which the yeast was inoculated in their exponential growth phase, leading to significantly shortened fermentation durations. Furthermore, we monitored the physiological state of lager yeast during fermentation of 18°Plato wort. We found significant variations in the physiological parameters. The increase of the number of exhausted and/or dead yeast cells was indicated by the appearance of yeast subpopulations with different glycogen or trehalose contents. The aim of this contribution is to demonstrate the multiple possibilities of flow cytometric acquisition in industrial processes.

Karl-Josef Hutter was born in 1943 in Dietfurt/Altmühl, Bavaria. Karl-Josef's native country is the Federal Republic of Germany. Karl-Josef studied brewery technology at the TU-Berlin (VLB) from 1965 to 1970 and graduated in 1974. Karl-Josef had vocational training from 1960 to 1962 at Brauerei Frankenheim, Düsseldorf. From 1970 to 1979, Karl-Josef was a scientist at Fraunhofer-Gesellschaft, and since 1979, has been a scientist at the German Cancer Research Center, Heidelberg. Karl-Josef has maintianed lectureships at the University of Heidelberg (1985–1992), University of Hohenheim (1994–1999), Fachhochschule Mannheim (1995–present), and TU-Dresden (1999–present).

O-85

Stress and the Regulation of Brewing Yeast Flocculation

KATHERINE A. SMART, Cheryl L. Jenkins, Steve Davy, Jessica Leclaire, and Stephen Lawrence
Oxford Brookes University

On completion of brewing fermentations, yeast biomass is harvested (cropped) from the fermentation vessel and stored until it is required for use in subsequent fermentations. This recycling process is known as serial repitching. The yeast-harvesting procedure relies on the capacity of the brewing yeast population to aggregate into clumps at the end of fermentation and readily sediment. This process is known as flocculation and is critical for yeast collection and beer clarification. Aberrant flocculation can result in the formation of either an over- or partially fermented product that cannot be processed to final product, leading to significant inefficiencies for the brewer. We have recently demonstrated that the flocculation potential of brewing yeast populations is a function of the number of fermentations the yeast has conducted. Analyses of yeast populations derived from full-scale production fermentation and storage vessels suggest that serial repitching enhances flocculation performance. In part, this is due to inadvertent selection of subpopulations during harvesting; however, serial repitching also results in exposure to a number of stresses that affect the expression of key cell wall mannoproteins that permit flocculation to occur. It has been established that critical stresses occur at distinct stages of the recycling process. Indeed, during fermentation, yeast cells are exposed initially to oxidative stress followed by anaerobiosis ethanol toxicity and low pH. During storage between fermentations, yeast cells additionally become starved and are exposed to cold shock. The impact of three key stresses, the shift from aerobiosis to anaerobiosis, a reduction in pH, and the application of cold shock, on the expression of the CWP gene family that encodes cell wall mannoproteins is considered. The relationship between CWP gene expression and the potential of the yeast cell wall to flocculate and express cell surface physical properties is demonstrated. The functional phenotypes associated with the expression of CWP genes will be discussed and a model describing their potential role in flocculation will be suggested.

Katherine Smart completed a B.Sc. degree (Hons) in biological sciences at Nottingham University and was awarded the Rainbow Research Scholarship to complete a Ph.D. degree in brewing yeast physiology at Bass Brewers, Burton-on-Trent. She then moved to Cambridge University to take up an appointment as research fellow in the Department of Plant Sciences, where she worked on bioactive surfaces, biofouling, and bacterial contamination of beverages. In 1992, Katherine became a lecturer and then senior lecturer in microbiology and fermentation at Oxford Brookes University. Now the Scottish Courage Reader in Brewing Science and a fellow of the Institute and Guild of Brewing, Katherine holds a Royal Society Industrial Fellowship. Katherine is a member of the several societies and has served on society committees and journal editorial boards. She is chair of the Institute and Guild of Brewing International Section and the American Society of Brewing Chemists' international director.

TECHNICAL SESSION XIV: Health and HACCP

Moderator: Rob Maruyama

Robert Maruyama graduated from the University of Colorado in Boulder with a B.A. degree in molecular, cellular developmental biology and received an M.S. degree in environmental science and engineering from the Colorado School of Mines. He joined Coors in 1980. During his tenure at Coors, Rob was responsible for analytical methods development using gas chromatography and high-performance liquid chromatography, development of laboratory automation applications, and analytical project management. In 1994, he was named laboratory supervisor, in which he was responsible for the organic laboratory operations, which supported environmental control and container manufacturing. Rob was promoted to research and quality assurance laboratory manager in 1995, in which he was responsible for managing the analytical laboratory that supports brewing research and development and corporate quality assurance. In 1999, Rob was promoted to the position of director of product quality in the Golden Brewery Business Unit, where he is responsible for the QC functions in malting, brewing, packaging & logistics operations. In addition to his role in quality, Rob assumed the responsibilities for Golden's environmental health and safety in 2000. Rob is a member of the ASBC and ACS and has made presentations and posters to ASBC and AOAC. Rob has served ASBC in many capacities: an active subcommittee participant; chair of a number of technical subcommittees, including the Coordination of New and Alternate Methods, publications chair; and president in 2001. Rob is also the WBC 2004 Planning Committee cochair.

O-86

WITHDRAWN

O-87

Beer and Folates

CAROLINE WALKER, Christopher Booer, Robert Smith, Benn Kerr, and Andrew Faulkner
Brewing Research International

Functional, health-enhancing foods are a hot topic. Consumers are avidly searching for foods that are natural sources of nutrients and vitamins, and nutritionists are encouraging us to improve our diets. One particular area of concern is that folate (vitamin B9) is often lacking in Western diets, which may put the population at an increased risk of chronic disease, including cardiovascular disease and cancer. It is, therefore, a public health issue to find out which foods can make a significant contribution to folate intake in the diet. With this problem in mind, during the last 4 years, we have been funded by the EU and the Home Grown Cereals Authority to look at the folate content of malt and beer. From a survey of commercial samples, we have shown that folate levels in malt range between 2 and 4 mg/kg and are several times higher than those found in barley. Using small-scale and pilot-scale trials, we found that the folate content in the grain was increasing during malting, and this rise was dependent upon conditions. For example, high-diastatic-potential malts had higher folate contents than did ale or lager malts, whereas crystal and roasted malts had much lower levels. However, malting conditions were not the only important factor influencing folate content. Field trials showed that both growth conditions and barley variety influenced the folate content of the finished malt, raising the possibility of directed breeding programs for a 'high-folate' trait. The folate in malt is carried through to the beer during brewing. From our survey of international beers, we found folate contents ranging from 30 to 150 µg/L. In general, beers with higher folate content also had higher alcohol content, probably reflecting malt levels in the grist. Results from pilot commercial brewing trials revealed that folate recovery was poor during mashing but good through the rest of the brewhouse. Laboratory-scale work suggested that folate recovery could be optimized during mashing by adjustment of temperature and liquor/grist ratio. Primary fermentation did not affect folate levels, whereas secondary fermentation, such as that carried out during bottle conditioning, seemed to enhance folate content, possibly due to the physiological condition of the yeast during this process. From our data, we can conclude that, for those who consume moderate amounts of beer regularly, folate intake from beer may be in the order of 10–20% of the daily intake. This is a very high contribution from any one foodstuff and is of dietary significance in beer-drinking populations. Although the levels of folate in beer are significant, our data suggest that, by careful selection of raw materials and some changes in the brewing process, beers with a higher folate content could be produced.

Dr. Caroline Walker holds a degree and doctorate in biochemistry from the University of Bristol. She is manager of the health program at BRi and acts as a consultant on beer and health for BRi's international membership. Along with leading BRi's research in this area, Caroline plays a key role in communication and, as a member of the British Guild of Beer Writers, publishes articles on all aspects of health and brewing. Caroline is also the head of process at BRi, and her group covers research in the areas of microbiology, engineering, molecular biology, and fermentation.

O-88

About Beer and Celiac Disease

MICHAEL J. LEWIS (1) and Charles H. Halsted, M.D. (2)
(1) Department of Food Science and Technology, University of California; (2) Department of Internal Medicine (Gastoenterology and Clinical Nutrition), University of California

Celiac disease, also called celiac sprue, is an auto-immune disease in which a reaction to a sequence of amino acids in prolamines, especially gluten, causes deformation of absorptive villae of the small intestine. As a result, nutrients are poorly absorbed. Children fail to thrive and, in the adult-onset form of the disease, severe weight loss is a characteristic, with malaise, loss of calcium from bones, iron deficiency, dermatitis, potential loss of night vision, and increased chance of diabetes and certain cancers. The disease affects about 1% of people, depending on the population surveyed, but the disease is undoubtedly underdiagnosed in the U.S.A. Although gluten occurs at its highest concentration in wheat-based products, which celiacs must assiduously avoid, other prolamine-containing grains, including barley and malt, must also be excluded. Although beers contain very small amounts of gluten fragments (as currently measured), all beers are banished from the diets of celiacs by the standard that they are not made from gluten-free raw materials. Although there is a possibility that a beerlike drink could be made from grains other than malt, celiacs might prefer to resign themselves to cider, wine, spirits, and RTDs. Considerable progress has been made in identifying the specific amino acid sequence and protein fragments of gluten that trigger the immune reaction, and physicians have begun to consider ways to alleviate the disease other than by strict and life-long dietary control. One potential method (among several target approaches) is to eliminate the offending protein fragments during food manufacture. This is clearly well suited to beer and brewing, because much protein is eliminated during malting and brewing and manipulation of grain proteins is well understood by brewers as a central part of normal processing. This paper will explore these possibilities. Eating "gluten free" is becoming popular among food aficionados and faddists, perhaps as a natural extension of the famous Atkins' diet. As the brewing industry has successfully harnessed the ultra-low carbohydrate content of some beers to this dietary choice, so it may prosper from a developing "eat-gluten-free" movement.

Prof. Michael J. Lewis conducted the program in brewing science at the University of California, Davis for 40 years and is now emeritus professor. He is a fellow of the Institute and Guild of Brewing (London), is a life member of the American Society of Brewing Chemists, and received the prestigious Award of Merit of the Master Brewers Association of the Americas in 1986. The second edition of his book Brewing *has been well received. In 1990, he won the esteemed Distinguished Teaching Award of the University of California. Dr. Lewis teaches several specialized courses through University of California Extension (UNEX), including the accredited 4-month Masterbrewers Program leading to a professional qualification in brewing science and engineering (the Associate Membership Examination of the Institute and Guild of Brewing), and a short (8-week) form of this program called the Professional Brewers Certificate Program. Graduates of Dr. Lewis' programs are well represented in large and small North American breweries as well as abroad. Dr. Lewis earned his Ph.D. degree in microbiology and biochemistry at the University of Birmingham (England) and the British School of Malting and Brewing. Dr. Lewis has also served the University as assistant vice-chancellor of academic affairs and associate dean of the College of Agriculture.*

O-89

HACCP Accreditation at Labatt-Interbrew North America—Corporate and Brewery Perspectives

JESSICA HUDALE (1) and TERRANCE M. DOWHANICK (2)
(1) Latrobe Brewing Company, LLC (Labatt-Interbrew), Latrobe, PA; (2) Labatt-Interbrew North America, London, ON, Canada

In March 2000, the decision was made by senior corporate management at Labatt-Interbrew to have each of its nine breweries in North America HACCP (Hazard Analysis Critical Control Point) accredited before the end of 2004. The first part of this presentation will focus on the challenges faced and strategies employed from a corporate perspective in achieving this goal. The second part of this presentation will focus on HACCP at the brewery level, as experienced by the Latrobe Brewery. Discussion will focus on the internal technical challenges encountered and the overall culture change that led to the successful implementation of HACCP, making Latrobe the first third-party HACCP-accredited brewery in North America in January 2003.

Jessica Hudale received a B.S. degree in microbiology from The Pennsylvania State University in State College, PA. She began her career with Latrobe Brewing Company, LLC in October 2001 as the HACCP coordinator. In January 2003, Latrobe Brewing Company, LLC became the first brewery in North America to achieve HACCP accreditation by a third-party auditing body. Since June 2003, Jessica has functioned as compliance manager, focusing on food safety as well as environmental health and safety. Jessica served the MBAA on the local level as secretary/treasurer from January–December 2003 and is currently serving as the vice president of her local chapter. She has been a guest speaker at a local MBAA meeting and also presented a talk on HACCP at the Northern California Annual MBAA Technical Conference at the Sierra Nevada Brewery in June 2003. Terrance M. Dowhanick, Ph.D. (Carleton University), B.Sc. (York University), began his career at Labatt in 1982 in brewing R&D. From 1984 to 1988, he served as the Labatt visiting scientist for genetic biotechnology at the National Research Council in Ottawa. He holds one patent and has authored/coauthored more than 40 research papers and review articles in the areas of yeast gene expression and microbial diagnostics for the brewing industry. From 1996 to 1998, he was the quality technical manager for the Labatt-Interbrew London Brewery, and from 1998 to 1999, he was science resource manager for technology development as well as quality assurance manager. Since 2000, he has been responsible for quality assurance, product integrity, and food safety for Labatt-Interbrew throughout North America. Terry is an alumnus of the Ivey Executive Business School, member of the Institute and Guild of Brewing, past chair of education for the Master Brewers Association of the Americas, has served on the Board of Directors for the American Society of Brewing Chemists, and is the chair of the Technical Committee for the Brewers of Canada.

O-90

Effective Strategies in Implementing HACCP in San Miguel Breweries

ARNULFO Z. SENIRES (1) and Niceforo V. Alegado (2)
(1) San Miguel Beer Division Quality Assurance; (2) San Miguel Davao Brewery

Two years ago, our technical department saw the need for an enhanced product safety assurance program and chose to implement Hazard Analysis and Critical Control Points (HACCP); it also anticipated possible regulatory requirements in the local and export market San Miguel serves. Strategies were planned to ensure fast and effective implementation of HACCP. It was expected that voluminous documentation and difficulties in writing the HACCP plans, as well as in the implementation, would be encountered since the process of brewing is more complex than in other food industries where HACCP is working well. HACCP-based Malt Beverage Safety and Quality Policies and Guidelines were developed by Beer Division Quality Assurance and endorsed by Beer Division Management. Initial risk assessments of raw materials, process operations, equipment, and machinery were done by Beer Division Quality Assurance. Generic models of brewing-process flowcharts and HACCP plans were also drawn. To gain hands-on experience and expertise, a brewery in southern Philippines, Davao Brewery, was chosen as the model and experimental plant for HACCP and enhanced current Good Manufacturing Practices (cGMP). On-site lectures and workshops on HACCP and cGMP were conducted by Brewing Quality Assurance to the HACCP-cGMP Team of the brewery. During the workshops, the participants were taught how to determine and address noncompliance to cGMP, carefully meld new structures and equipment (which are the requirements of cGMP) with present facilities, conduct risk assessments, make an HACCP plan, identify and confirm the Critical Control Points (CCPs), monitor the CCPs, and conduct an HACCP-cGMP audit. In the course of the workshops, the generic models of flowcharts and HACCP plans were revised in accordance to the brewery's process operations and practices. The participants echoed what they learned to all other employees as well as to the management team of the brewery. Lectures and workshops were then extended to the other breweries, four in the Philippines, one in Hong Kong, and three in China, while those in Indonesia, Vietnam, and Australia have been scheduled for the current year. After a year of preparation and implementation, Davao Brewery has undergone external and third-party HACCP-cGMP audits. Other breweries are scheduled for similar audits. All the breweries where HACCP and cGMP concepts and practices were cascaded are now implementing the systems despite the lean manning.

Arnulfo Z. Senires has been a quality assurance specialist of San Miguel Beer Division Quality Assurance since the latter part of 2000. He holds a B.S. degree in chemistry and a M.Sc. degree in chemistry from the Far Eastern University and the University of Santo Tomas, respectively, both in Manila. In 1974, he started working in San Miguel's Aviles Brewery and then moved to Polo Brewery in 1976, until 1992, when he was assigned to set up San Miguel's Beer Central Analytical Laboratory. making it the first ISO 17025-accredited private manufacturing laboratory in the Philippines.

O-91

Taking Complexity and Cost Out of the Brewing Industry Supply Chain

CHRIS WALLACE (1) and Barbara Roos (2)
(1) Scottish Courage Ltd.; (2) Agilisys

This presentation will look at how the beer industry can drive supply chain performance improvements while being constrained by a unique set of planning and scheduling challenges. Based specifically on the experiences of one of the world's largest beer manufacturers, Scottish Courage, and indirectly on the practices of other known brewers, this presentation will reveal how technology can enable greater supply chain efficiencies in the brewing industry. As beer consumption increases worldwide, brewers are fighting for market share and are challenged to provide a more diversified product line. To stay competitive, brewers must produce the right product in the right quantities at the right time, while minimizing production and distribution costs. This is not an easy task when challenged by some of the most unique supply chain constraints, such as tank scheduling, complex piping networks, buffers, moving bottlenecks, and variable changeovers. To further the complexity, the expansion of contract brewing puts even greater pressure on brewers to more efficiently utilize existing capacity to produce more beer. Some of the largest beer manufacturers in the world rely on Agilisys solutions to enable more efficient beer production. Scottish Courage, leading brewer in the U.K. and one of the largest in Europe, uses Agilisys Advanced Scheduling technology to manage production costs by optimizing their plant and keeping safety stocks in balance. With production lines producing over10 million barrels of beer each year and contract brewing driving more SKUs, Scottish Courage relies on Agilisys for its scheduling success. They now have a clear picture of which beer to produce in which tanks and in which sequence to make best use of their resources to satisfy customer demand at the lowest possible production cost. They have reduced scheduling time and production interruptions, have improved synchronization from brewing to packaging, and now have better visibility of mature beer availability. And, they now benefit from centralized information that allows complete optimization of their multisite U.K. operations. Agilisys Advanced Planning technology also plays a key part in optimizing beer production by balancing supply and demand while considering material and logistical costs, manufacturing capacities, and other constraints to determine the most feasible beer production plan. Other well-known beer manufacturers, such as SAB Miller, Molson, Grolsch, Fosters, and Heineken, are taking advantage of Agilisys brewery-focused solutions. Benefits that Agilisys customers are achieving include reduced production and distribution costs, reduced efforts and time for scheduling and planning a brewery, improved throughput through all processes, "what-if" investment analysis, improved service, increased plant flexibility, and more.

Chris Wallace received his degree in microbiology in 1985. He began his employment with Express Dairies and was later given the position of laboratory analyst. Chris then moved to The Stag Brewery at Mortlake, London, and 2 years later was promoted to process controller, initially as part of the commissioning team for a £22 million lager process block. Chris then moved to become a canning manager, first at Iselworth West London, and then as part of the team that moved and reinstalled the line at The Courage Berkshire Brewery, Reading. He was in charge of the day-to-day running of two high-speed canning lines. Chris then moved to Scottish Courage's Royal Brewery in 1996 as site planning manager, responsible for the day-to-day planning and forecasting of a site producing 3.0 million hL per annum. He moved into a project role in January 2000 within logistics to realign the supply chain to the changing needs of the customer. During this time, he acted as project leader in implementing Agilisys Advanced Scheduling at the five Scottish Courage sites.

O-92

Popular Diets and the Nature of Beer Carbohydrates

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Current popular carbohydrate-focused diets are more sophisticated and complex than simply counting carbohydrates and reducing overall carbohydrate intake. They include nutritional concepts such as the Glycemic Index. They discuss how different carbohydrates behave and are metabolized in the body and how they interact with other dietary components. The nature of the carbohydrate content is now often considered at least as important as the level when choosing food within the context of some of these diets. Carbohydrates and the foods that contain them are ranked and categorized as "good" or "bad" based on these concepts, and many people are making their food and beverage choices, in part, according to advice from these books. Many of these books contain serious technical errors about the nature of the carbohydrates in beer. They are neither brand- nor style-specific and, therefore, the misinformation is applied to all beer. Some carbohydrate-focused diet books incorrectly characterize beer as being high in sugar (particularly maltose); as having a high Glycemic Index, therefore, as being more problematic than other alcoholic beverages of similar calorie levels; and even as specifically causing the deposition of fat in the abdomen due to the presumed nature of beer's carbohydrate profile. This article reviews the errors regarding beer in popular carbohydrate-focused diets and the metabolic concepts that underlie these diets. How beer relates to these concepts and the true nature of carbohydrates in a variety of beer styles is reviewed.

Nathaniel J. Davis is a staff brewmaster of corporate brewing at Anheuser-Busch, Inc. (A-BI), St. Louis, MO. As a staff brewmaster, Nathaniel's primary responsibility is to develop new products. Nathaniel is responsible for developing new product recipes and brewing procedures, planning production processes, and helping to oversee the brewing of new and specialty products at Anheuser-Busch. Nathaniel works closely with A-BI's Brand Marketing group to ensure that new products match both marketplace trends and consumer expectations. In the past year, he oversaw development of the company's new products, including Anheuser World Select, Bare Knuckle Stout, and ZiegenLight. Prior to his current position, Nathaniel served on the brewmaster's staff at Anheuser-Busch's Fort Collins, CO, brewery. Nathaniel is a member of the Master Brewers Association of the Americas and the Institute and Guild of Brewing. Nathaniel was born in Kingston, Ontario, Canada. He is a graduate of the Master Brewers Program at the University of California at Davis. He also holds a bachelor of science degree in microbiology and immunology from McGill University in Montreal, Canada.

O-93

Pilot-Scale Investigations into the Production of Filtered Beers Rich in Xanthohumol

MARTIN BIENDL
Hopsteiner - Hallertauer Hopfenveredelungsgesellschaft

In the past few years, many reports on potential health effects of the hop compound xanthohumol have been published. Especially promising seems to be its cancer chemopreventive activity. Animal studies to investigate its bioavailability and metabolism are currently ongoing. In dried hop cones, xanthohumol is present at a concentration of up to 1%. Its ratio to the alpha-acids is a varietal characteristic and ranges from 0.02 to 0.1. During hop processing, xanthohumol is almost completely recovered in pellets and ethanol extract but not in carbon dioxide extract. During wort boiling, it is converted to isoxanthohumol. This compound also shows positive health effects, although it seems to be less effective than the nonisomerized form. Due to the isomerization process, commercial hopping results in levels of up to about 2.5 mg/L isoxanthohumol in filtered beers, whereas the xanthohumol content is generally lower than 0.2 mg/L. However, during the production of stouts and porters, the isomerization is partly inhibited. By using a commercial ethanol extract of the variety Spalter Select, a concentration of about 1 mg/L xanthohumol could be achieved in a stout after polishing filtration. This concentration was tripled by using a recently developed hop product. This new product is the residue of a secondary extraction of ethanol pure resin extract with supercritical carbon dioxide. It has a ratio of xanthohumol to alpha-acids greater than 1. Other than using the xanthohumol-enriched hop product, no technological changes were necessary for achieving this high concentration of xanthohumol in the stout. As an alternative technology to transfer nonisomerized xanthohumol into beer, addition after fermentation was also investigated. For this application, xanthohumol with a purity above 80% was isolated from ethanol pure resin extract. The purified xanthohumol was added as an ethanolic solution to cold beer before filtration. Depending on the degree of filtration, concentrations in the range of about 1 to 3 mg/L were achieved. Higher concentrations could not be achieved due to the low solubility of xanthohumol in beer.

Martin Biendl received a Ph.D. degree in organic chemistry from Regensburg University in 1990. Since then, he has been employed as head of research and development at the Hopsteiner - Hallertauer Hopfenveredelungsgesellschaft in Mainburg, Germany. Since 1996, he has been section manager of the R&D/Quality Assurance Department of this company. He is a representative of the International Hop Industry Cooperation (IHIC) in the EBC Analysis Committee.

TECHNICAL SESSION XV: Malting/Mashing

Moderator: Rob McCaig

Rob McCaig has more than 22 years of brewing industry experience with Molson Breweries. Starting his career in 1981 with Molson in Quebec, Rob has held a number of positions including research microbiologist, brewer, corporate brewer, and brewmaster. During his time with Molson, he published more than 20 technical papers and was responsible for developing more than 50 new beer brands. In February of 2003, he left Molson to take the position of managing director and director of brewing for the Canadian Malting Barley Technical Centre (CMBTC) in Winnipeg. Rob is a member of the American Society of Brewing Chemists (ASBC), serving as both local chair and as president of the national ASBC. He is also a member of the Master Brewers Association of the Americas and the Institute and Guild of Brewing. He has a master of science degree in applied microbiology from the University of Guelph. He resides in Winnipeg with his wife Louise and two sons, Alec and Ian, where he still plays hockey weekly, flyfishes with his ASBC ROR group, and helps coach both boys in hockey.

O-94

Parameters Influencing the Mash Filterability in the Brewing Process

ROBERT BRAEKELEIRS (1) and Rafael Tigel Gil (2)
(1) MEURA s.a., Belgium; (2) MEURA Technologies, Belgium

The filterability of the mash in a brewhouse equipped with a lauter tun or a thin-bed filter is influenced by different parameters: • Viscosity of the mash enhanced by the variety of malt due to the under- or over-modification, • Viscosity due to high-gravity brewing (density of the first wort over 22°Plato), • Viscosity due to the shear forces forming mostly beta-glucan gels or "Oberteig" (upper dough). It has been noticed that differences in temperature during the brewing process have an influence on the mash filterability. This means, that by mashing-in at lower temperatures, we obtain a better mash filterability. When mashing-in at higher temperatures is required, special precautions have to be taken and/or higher malt quality is required. The influence of oxidation, combined with the factors described above, is playing an important role in the mash filterability. The author describes the various tests that have been done: complete oxygen-free mashing-in, mashing-in under normal circumstances (mash inlet from the bottom of the mash tun), differences in brews at different temperatures, and use of enzymes to determine the reasons of high viscosity in the brewing process. The author describes the filtering system used for comparison.

Robert Braekeleirs received a M.Sc. degree in brewing and food technology from the KAHO University in Gent, Belgium, in 1966. He started his professional activity in 1969 at a local brewing company in Gent as production and service manager. From 1972 to 1978, he worked for Interbrew in Leuven as production manager and also for the R&D Department. From 1979 to 1988, he worked for Alfa Laval Brewing Department in Germany, Belgium, and partly for Sweden as a sales manager. In 1989, he joined the Meura Company as R&D manager and became sales & marketing manager in 1997. He has already given different papers and lectures at IGB conventions, VLB Berlin, and other brewing events in Belgium. He is married and has two children.

O-95

Advantages of Fine Wet Milling with a Rotor/Stator System (RSS) and Lautering with a Thin-Bed Chamber Mash Filter (TCM)

DR. HANS-JÖRG MENGER
ZIEMANN Ludwigsburg GmbH

Technical and technological complexity and interdependence between the brewing process steps (brewing) milling, mashing, and lautering gives the targets for the development of wet milling with rotor/stator systems (RSS) in combination with thin-bed chamber mash filters (TCM). Targets of the milling process (milling) are free starch particles that are out of the cellular structure and high permeability of the endosperm cell walls to get optimum surface conditions for native and/or technical enzymes during the mashing process (mashing). The reached husk structure is responsible for an effective and fast mash filtration during the lautering process (lautering). The described points depend mainly on the particle size distribution (PSD) of the mash. The new development RSS allows a calculation of the PSD by using different mathematical and physical basics. Most important for the mechanical effect of RSS is the shear frequency (SF) and the rate of shear forces (VS). Both values depend on construction details of the RSS, which are circumferential speed (VU), outer diameter of the rotor (DR), rotational speed of the rotor (N), and the number of teeth of the RSS. The experience with different sizes of the RSS shows a highly effective mechanical breakdown of the grains and also of the cell walls. This mechanical effect gives a very homogenous PSD that increases the permeability of endosperm cell walls and also the active surface of substrates, which improves amylolysis, proteolysis, and cytolysis. Milling under water protects the mash against additional oxygen pickup, which means less lipoxygenase (LOX) activity, which gives quality advantages. Technical advantages of RSS can be described as fully automatic system and full integration in the brewhouse cleaning-in- place (CIP) system. Positioning is within the brewhouse beneath the vessels without an additional milling building. The RSS is a very compact construction, which is mill and mash pump in one unit. In case of milling under water, there are no additional explosion and noise emission requirements. After milling and mashing, the lautering step is also important for efficiency and quality. The special design of the TCM chamber plates and the new process technology allow a very homogeneous filling of all chambers within the mash filter. Mathematical and physical basics for the development of the TCM are the filtration laws for porosity cakes, the laws from Darcy and Hagen Poiseuille, and several test simulations in an 8-hL plant. A homogenous filling and a thin-bed spent grains cake are the guarantee for high brew cycles, up to 16 brews per day by high efficiency and best wort quality (low solids/turbidity). Technical advantages are a total automatic system, inclusive of an automatic cloth cleaning device and a low operational/maintenance cost.

Hans-Jörg Menger received the doctor's title for natural science in April 2003 from the University of Stuttgart-Hohenheim, Germany. He began a apprenticeship as brewer and maltster in 1980. In 1985, he started to study food technology at the University of Stuttgart-Hohenheim, Germany. He began employment with Ziemann Ludwigsburg GmbH, Germany, in January 1998 in the technology department. Since April 2000, he is responsible for the patent resort and, since July 2003, he is head of technology department from Ziemann Ludwigsburg, Germany.

O-96

Formation Pathways of Trioxilins During Mashing

LEIF-A. GARBE, Holger Huebke, and Roland Tressl
Technical University of Berlin, Institute for Biotechnology

In contrast to soybean and tomato lipoxygenases, the lipoxygenases from barley and malt (LOX-1 and LOX-2) catalyze the introduction of oxygen into linoleic acid with low regioselectivity. LOX-1 catalyzes the formation of 9-hydroperoxy-10E,12Z-octadecadienoic acid (9-HPODE) and 13-hydroperoxy-9Z,11E-octadecadienoic acid (13-HPODE) in a ratio of 80:20 (9-:13-HPODE) and LOX-2 in a ratio of 31:69 (9-:13-HPODE), respectively. Beside free linoleic and linolenic acids, these enzymes also accept glycerol esterified polar and nonpolar unsaturated fatty acids as substrates. The reactive hydroperoxides are, for example, readily reduced to hydroxides (HODE). In malt 10 ppm free HODE, 109 ppm triacylglycerol esterified HODE and 65 ppm polar esterified HODE were analyzed using isotopic dilution assays (O-18 13-HODE). Further products of the hydroperoxides (HPODEs) are allene oxides that are converted into alpha-ketols, or HPODEs are rearranged to epoxyols that are hydrolyzed to trihydroxyoctadecenoic acids (THOE). The THOE isomers were investigated in detail. The positional regioisomers of THOE are 9,10,13-THOE and 9,12,13-THOE with eight stereoisomers, respectively. Thus, at least 16 isomers of THOE are obtainable and they were assigned in malt by chemo-enzymatic synthesis of eight THOE enantiomers and GC-MS analysis. In malt, various diastereomeric THOE isomers were identified by GC-MS but (9S,12S,13R)- and (9S,12R,13S)-THOE were detected with the highest concentrations. During mashing, a hitherto unknown LOX pathway is activated and only one THOE isomer (9S,12S,13S-THOE) is formed and can be analyzed as free acid in wort and, finally, in beer. This result may indicate a plant defense mechanism throughout the mash process. In contrast to malt lipoxygenases, the new enzyme cascade lipoxygenase-isomerase-hydrolase active during mashing and leading to 9S,12S,13S-THOE is highly regio- and stereoselective and may serve as a plant-signaling compound. The 9S,12S,13S-THOE isomer was formerly described as fungicide in rice blast disease and recently as an antiviral compound. Compared with mono- and dihydroxy fatty acids, the THOE isomers are poorly degraded by yeast and accumulate in beer.

Leif-Alexander Garbe finished his studies of organic and analytical chemistry in 1996 at the Technical University of Berlin (TUB), Germany, with a diploma in chemistry. Afterwards, he worked as an analytical chemist at the Research and Teaching Institute for Brewery 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. degree (Dr. rer. nat.) in April 2002. He performed his Ph.D. thesis at the Department of Biotechnology, Chemical, and Technical Analysis under the supervision of Prof. R. Tressl. During that period, his work as a scientific assistant included the supervision of undergraduate and graduate students of 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 performs new techniques, e.g., LC-MS, to analyze trace compounds especially in malt, wort, and beer by isotopic dilution methods.

O-97

Rheological Studies Simulating the Brewery Mashing Process

DECLAN L. GOODE (1,2), Lisa Rapp (1,3), Tilmann J. Schober (1,2), Helge M. Ulmer (1,2), and Elke K. Arendt (1)
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The brewery mashing process is an enzymatic/time/temperature-dependent degradation process of viscosity creating macromolecules, such as starch and beta-glucan. The measurement of this degradation is gaining interest as both a quality and process control parameter. The aim of this study was to develop a method using a highly sensitive controlled stress rheometer, which could determine viscosity changes in complex systems, such as the brewery mashing process, that contain both dissolved and suspended materials. A controlled stress rheometer, together with a specially designed star-shaped paddle rotor, which enables mash particles to stay in suspension throughout measurement, was used in all experiments. Studies were conducted to simulate an industrial mashing process, taking into account temperature/time, grist loads, adjunct amounts, and enzyme levels. More fundamental studies using pure barley starch and glucan substrates, together with enzyme additions, were also carried out. Four typical viscosity-causing parameters during mashing were assessed in this study: 1) the effects on mash viscosity when increasing the level of unmalted barley in the mash, 2) the effects of malt amylolytic enzyme levels on mash viscosity when using a pure barley starch substrate (pH 5.8), 3) the effects of pH adjustment when using a pure barley starch substrate (pH 4.8), and 4) the effects of glucanolytic enzymes when using a pure glucan substrate. An increase in barley adjunct levels resulted in an increase in start, peak, and end viscosities, together with peak area. These viscosities could be correlated to the endogenous amylolytic and glucanolytic enzymes of the malt and barley. When using a pure barley starch substrate, with an increase in amylolytic enzymes, a resultant decrease in viscosity was observed. A correlation was found between the peak area, peak viscosity, final viscosity, and amount of enzyme added. Using a calibration curve peak area could be directly related to amylolytic activity. Viscosity trends during mashing were found to be greatly altered by the pH of the buffered starch solution. The viscosity readings due to glucans were found to be much less than that caused by starch. The viscosity levels caused by glucans correlated to the amount of added glucanolytic enzymes. It can be concluded from this study that the method developed is a very useful tool for measuring small viscosity changes during the brewery mashing process. It could be used as a screening tool for unmalted and malted grains together with commercial enzymes with regard to their amylolytic and glucanolytic activities. It could also be useful for selecting mash compositions with regard to malt level, adjunct level, pH, enzyme additions, and liquor-to-grist ratios.

Declan L. Goode received a B.Sc. degree in food technology from The National University of Ireland, Cork, Ireland, in 1998. He received his M.Sc. degree in the area of brewing at the National University of Ireland, Cork, in 2001. The title of his thesis was "Brewing with unmalted sorghum and commercial enzymes:. He is currently employed as a senior research scientist at the Research Malting and Brewing Facility of the National University of Ireland, Cork, Ireland, where he takes responsibility for the running of the research brewery. He is also working toward his doctorate degree. His areas of research include enzymes and unmalted cereals. He has previously presented at international conferences and has recently published in the Journal of the Institute of Brewing *and the* Journal of the ASBC.

O-98

The Impact of the Level and Thermostability of Diastatic Power Enzymes on the Hydrolysis of Malt and/or Rice Starch During Wort Production by a Small-Scale Simulated Mashing Procedure

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The conversion of starch into simple sugars that yeast convert into alcohol is arguably the most important process in brewing. Not surprisingly, the quality of barley malt is determined by its extract and the degree of fermentability (apparent attenuation limit, AAL) of that extract. For the commercial malt trading, diastatic power (DP) is often used as an approximation for AAL, since DP is more simply and quantitatively measured, particularly since there is a significant impact of yeast strain/source on alcohol yield. DP is a measure of starch-hydrolyzing enzymes that are the combined activity of beta-amylase, alpha-amylase, limit dextrinase, and alpha-glucosidase. However, the measurement of malt DP does not always accurately predict the level of fermentable sugars generated during mashing or the subsequent fermentability of the resultant wort. We have previously shown that not only the amount of DP activity but also the thermostability of the DP enzymes is critical in determining fermentable sugar yield. This is because the mashing temperature program is a balance between the temperature required for starch gelatinization, to enable efficient hydrolysis, and the rate of thermal inactivation of the DP enzymes. In a recent review of starch in brewing, Bamforth (2003, TQ MBAA 40:89-97) identified that there is a dearth of practical information for brewers on the production of fermentable sugars. In this study, seven commercially sourced malts were used for small-scale simulated mashing trials to investigate the impact of differences in the level and thermostability of malt DP enzymes on the resultant wort fermentability. A modified EBC programmed mashing procedure was employed with mashing-in temperatures ranging between 45 and 76°C. Surprisingly, malt extract yield varied little with mashing temperature for most varieties in this temperature range. However, the fermentability of that extract was considerably affected by mashing temperature, with 65°C achieving the highest fermentability for all malt varieties with or without the addition of rice adjunct. In conventional all-malt mashes, the level of fermentability was determined primarily by beta-amylase thermostability with higher levels of DP, limit dextrinase, and alpha-amylase adjusting AAL higher. Mashes that included 30% gelatinized rice in the grist bill showed a similar pattern, except that the low beta-amylase thermostability type (Sd2L) showed a remarkably higher level of fermentability. It appears that an interaction between the Sd2L beta-amylase and increased limit dextrinase activity is more favorable in fermentability terms than would be expected in rice adjunct mashes. The implications for the selection of malt by brewers to optimally suit different brewing styles and regimes are discussed.

Evan Evans graduated from the University of Melbourne with a B.Agr. Sc. degree (Hons) in 1986. This was followed with a Ph.D. degree in 1990, also at the University of Melbourne, which investigated the merits of pollen selection for oil characteristics in canola. In 1990, he moved to Purdue University (IN, U.S.A.), as a postdoctoral fellow to work on improving soybeans for the production of better-tasting soymilk and tofu by using null variants for lipoxygenase. In 1992, he joined the South Australian Barley Improvement Program, where he developed his interest in malting barley and brewing. Recently, he has relocated to the University of Tasmania, where his brewing research interests continue to be in improving malt quality to improve beer quality and the efficiency of the brewing process. Dr. Evans is currently serving on the IGB Awards Committee and is a member of the editorial board for the Journal of the ASBC.

O-99

Degradation of Beta-Glucan Gel in Model Systems and Unfiltered Beer Due to High Hydrostatic Pressure Treatment

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Lehrstuhl für Energie und Umwelttechnik der Lebensmittelindustrie

In the beverage industry, high hydrostatic pressure is, up to now, predominantly used for the stabilization of fruit juices or milk products. This sparing method conserves valuable nutritious ingredients and flavor compounds much better than thermal treatment. But as shown in former examinations, the high-pressure treatment is not limited to this application. For example, the filterability of beer increases after high-pressure treatment of at least 300 MPa over 300 s. It is already known that this phenomenon depends on the degradation of beta-glucan gel, which has negative influence on the filterability. Beta-glucan can exist in gel and sol states and in the form of solved molecules. The sol state and the solved molecules have no negative influence on the filterability. In this work, the reasons for decreasing the content of beta-glucan gel were investigated. Also, the changes in the state of beta-glucan after high-pressure treatment were examined. The measurements were carried out in model systems with concentrations of 400 and 800 mg of beta-glucan gel per liter. Both in beer and in the model systems, the decreasing contents of beta-glucan gel could not be detected after high-pressure treatment. To identify, whether beta-glucan gel is degraded into beta-glucan or still exists in sol state, viscosity was measured. The influence of the different concentrations of beta-glucan gel is shown in the higher viscosity of the 800-mg sample. Thermal treatment converts beta-glucan gel into sol state. This was approved by detecting a nearly constant viscosity for the 80°C-temperated sample. After high-pressure treatment at 500 MPa, viscosity was clearly decreased. The evidence for the degradation of beta-glucan gel to beta-glucan was supplied. This result was verified by NMR measurements.To analyze the influence of time during high-pressure treatment, online measurements were carried out. These examinations showed that, already during the pressure increasing process, the content of beta-glucan gel is reduced. This effect stops at 200 MPa. Further degradation does not occur until 300 MPa, after 300 s of treatment time, no further degradation could be determined. At 400 MPa, the content of beta-glucan gel is even lower after 300 s of treatment time. There are two different mechanisms for degradation of beta-glucan gel. The first depends on deforming forces during the pressure increasing, the second on the pressure sensitivity of hydrogenous and electrostatic bonds.

Steffen Fischer received a diploma in brewing technologies from Technische Universität München in Weihenstephan, Bavaria. He began his dissertation in 1998 and became a scientific assistant in 2000. Since 2000, he has been giving exercises and lectures in thermodynamics; boiler, power, and refrigeration plants; and high pressure in the food industry.

O-100

Application of Lactic Acid Bacteria in Malting and Brewing

HELGE M. ULMER (1,2), Almudena Soriano (3), Declan L. Goode (1,2), and Elke K. Arendt (1)
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The malting and brewing industry is facing an ever-increasing challenge to be more cost effective, while at the same time improving product quality and safety. The results of this work present the advantages of using lactic acid bacteria (LAB) as a natural way to improve the quality and processability of malt and beer at lower production costs. LAB isolated from grain, malt, and brewing environments were screened for biopolymer degrading enzymatic activities (protease, glucanase, amylase) as well as for the expression of microbial inhibition. A selected number of strains, which either produced high levels of lactic acid, expressed enzymatic activities, or exhibited antimicrobial actions, were used to biologically acidify barley during the malting procedure. The trials were carried out in a micromalting plant. The biologically acidified malt was compared with both a chemically acidified malt and an unacidified control malt. The resulting malt quality was evaluated using EBC Congress mashing analysis procedures. The addition of LAB starter cultures improved viscosity and filterability, increased TSN values, and reduced the microbial load during germination. The LAB, which expressed enzymatic activities, were used for biological acidification of mash and wort in laboratory-scale systems as well as a 10-hL pilot-scale brewery. Wort and beer analyses were carried out according to EBC standard methods. The influence of the enzymatic activities of the strains was clearly seen in the results. The addition of enzymatically active strains led to improved processability (lautering, attenuation), lower beta-glucan levels, and better foam stability, flavor, and shelf life when compared with the controls. The efficiencies of the strains were then challenged in trials in which various levels of unmalted barley (up to 50%) were used. It was found that the brewing samples with LAB performed better than the control samples. The incorporation of LAB enabled the addition of a significant amount of unmalted barley without compromising on processability and final beer quality. Overall, it can be concluded that the selected LAB in this study can be used as a natural way to produce malt and beer of improved quality, processability, and safety while at the same time reducing the production costs.

Helge M. Ulmer received his Diploma Engineer in brewing and beverage technology from the Technical University of Munich-Weihenstephan, Germany, in 1998. He finished his Dr.-Ing. at the Institute of Technical Microbiology, Technical University of Munich-Weihenstephan, Germany, in 2002. The title of his thesis is "Molecular mechanisms of the high pressure inactivation of beer spoiling Lactobacillus plantarum*". He is currently employed as a postdoctoral research scientist at the Research Malting and Brewing Facility of the National University of Ireland, University College Cork, Ireland. His current areas of research include application of starter cultures in malting and brewing, development of alternative functional foods in brewing and baking, and the introduction of immobilized lactic acid bacteria fermentation with additional enzymatic activity into the brewing process.*

NOTES

POSTER PROGRAM

Moderators: Gil Sanchez and John Engel

Gil Sanchez started his brewing career at Miller Brewing Company in 1982 in the Brewing Research & Quality Assurance Division, while advancing to senior research engineer. During his 20 years at Miller, Gil has undertaken various project management and technical support responsibilities in brewing process and product development and improvement, including product flavor and flavor stability, bench and pilot scale-up to plant start-up, filtration and stabilization, adsorption, membrane separations, pasteurization, safety and environmental control, corrosion control, by-products, analytical development, and water and carbon dioxide recovery, treatment, and purification. He also developed and coauthored the patent for Sharp's nonalcoholic beverage and authored the chapter on water for The Practical Brewer. *He is currently director of research & development at the Sierra Nevada Brewing Company in Chico, CA. Gil received his B.S. degree in chemical engineering at the Massachusetts Institute of Technology and his M.S. degree in chemical engineering at the University of California at Berkeley. He has authored several papers for the Master Brewers Association of the Americas and has served as national governor for District Milwaukee and cochair for the 2003 MBAA Convention. He currently is serving on the MBAA Technical Committee. He is also a member of the American Society of Brewing Chemists, the American Institute of Chemical Engineers, and the North American Membrane Society.*

John A. Engel is the director of corporate quality for the Miller Brewing Company. During his 24 years with the Miller Brewing Company, he has held numerous positions within the Company's quality organization at various locations, which includes the Albany, Georgia brewery; Milwaukee, Wisconsin brewery; Trenton, Ohio brewery; and corporate offices. For the past 7 years, he has been responsible for establishing and administering corporate-wide product quality programs. These responsibilities include managing analytical services, process quality, problem solving/troubleshooting, and sensory programs for the corporate headquarters, six domestic breweries, and numerous international licensees. During the past year, his responsibilities were expanded to include packaging materials, packaging, and distribution quality. John obtained a B.S. degree in chemistry from Carroll College in Waukesha, WI. John is a member of ASBC and MBAA.

P-1

Differential Spectroscopy and Beer Oxidation

JAN SAVEL
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Differential spectroscopy is a useful technique recognizing small color changes during beer processing and aging. In our experiments, a 5-cm optical path in a rectangular cuvette offered much greater sensitivity and reproducibility than did a standard 1 cm. The method was able to differentiate between aerated and deaerated beer in the course of laboratory pasteurization. The differential spectra showed the increase of absorbance at 410–420 nm (first differential maximum, FDM) and second differential maximum (SDM) at 500–520 nm. Methylene blue–ascorbic acid system was also shown to be a suitable model for electron transport rate study in beer. The visible light illumination initiated ascorbic acid photooxidation and methylene blue reduction, which could be influenced by other added compounds. The free radicals' reactive species were supposed to take part during this process, speeding up the electron transport. The role of quinones and polyphenols in the beer oxidation was studied by both differential spectroscopy and photobleached methylene blue reoxidation. Quinones, as well as some polyphenols, had a catalytic effect in the course of beer oxidation by air. Oxygen was consumed by beer in a short time, but beer aging continued in the absence of oxygen. A possible anaerobic mechanism of beer aging may involve the oxidative action of quinones or peroxides, anaerobic Fenton reaction, or the additional effect of oxygen ingress through the crown. The oxidative effect of quinones, gallic acid, and tannic acid in the presence of oxygen was also studied with photobleached methylene blue reoxidation. The possible mechanism of action of oxidized polyphenols can comprise 1) catalytic effect in the course of oxygen reduction, 2) direct oxidation of natural beer compounds, and 3) hydrogen peroxide formation. The ratio between quinones/semiquinones/hydroquinones can be changed during beer production, including yeast reduction or beer oxidation. It might explain the contradictory role of the beer reductones: they are both prooxidants and antioxidants.

Dr. J. Savel was born in 1944 in Ceske Budejovice (Budweis) Czech Republic. After grade school, he studied at the Institute of Chemical Technology, Prague, from which he graduated in 1967 with a Ph.D. degree, followed by habilitation in 1966. Currently, Dr. Savel is an external associate professor at the Institute of Chemical Technology, Prague, as well as head of the research department at Budejovicky Budvar Brewery, N.C., Czech Republic. Dr. Savel has been a member of the EBC Brewing Science Group since 1994. He has published more than 100 articles in Czech and foreign professional magazines as well as a monograph dealing with brewing microbiology.

P-2

Potential Ways of Methionine Degradation and Their Impact on Beer Flavor

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While methionine biosynthesis is well-known, only a little information is available about the biochemical degradation of methionine, even though this amino acid is a precursor of diverse organoleptic active molecules such as methional, methionol, and methanethiol. This work aimed to analyze the formation of these compounds during a beer fermentation, trying to see how methionine catabolism influences the final taste of beer. The brewing yeast is able to degrade methionine by at least two different pathways: an Ehrlich-like pathway and a C-S lyase pathway. The first pathway is the so-called Ehrlich pathway that leads to methionol via 4-methylthio-2-oxobutyric acid and methional. Model fermentations pitched with different deletion mutants for the potential genes (*PDC1*, *PDC5*, *PDC6*, YDL080C, and YDL380W) were used. Null mutants do not produce any methional or methionol, so the reaction seems to be only enzymatic. Moreover, the decarboxylase encoded by YDR380W seems to be the main enzyme implicated. The kinetic studies of methional and methionol production also showed that methional is further reduced to methionol. Another significant pathway was also discerned, leading to the synthesis of methanethiol from 4-methylthio-2-oxobutyric acid. Enzymatic studies on cell free extracts of different strains of *S. cerevisiae* demonstrated a biochemical pathway for the formation of methanethiol from 4-methylthio-2-oxobutyric acid produced by transamination of methionine.These three methionine-derived compounds can lead to the formation of products such as methyl thioesters and can have a significative impact on the beer flavor. Fermentations were carried out with and without methionine added in the wort, and a sensory comparison (triangle tests) was done to evaluate the differences.

Olivier Duthoit received an M.Sc. degree in biotechnology from Wageningen University (Netherlands) in 2002. He then began to work for the Université Catholique de Louvain in December 2002 as a Ph.D. student in the group Yeast Biochemistry of the brewing research unit.

P-3

Development of a Biosensor for Monitoring Diacetyl During Beer Fermentation and Maturation

JOHN D. SHEPPARD and Lucas Vann
McGill University

Diacetyl is responsible for the undesirable "buttery" taste in beer and, therefore, should be removed during beer maturation below the taste threshold of approximately 0.1 mg/L or 1.2×10^{-6} M. Current practice requires off-line analysis of diacetyl using gas chromatography. This usually precludes routine monitoring of diacetyl, so the kinetics of production and subsequent reduction are largely unknown in individual batches. Thus, there is a need for a simple and accurate measuring device that can provide regular data on diacetyl levels in the beer. Biosensor technology offers the possibility of being able to measure the concentration of very specific compounds at very low levels. This provided the rationale for developing a biosensor that would be both selective and sensitive for measuring the concentration of diacetyl during beer fermentation and maturation. The biosensor system consists of an enzyme reactor coupled with amperometric detection in a flow injection analysis (FIA) design. The reactor consists of a column packed with diacetyl reductase immobilized onto aminopropyl controlled pore glass (CPG) beads. The amperometric glassy carbon electrode was chemically modified using the organic dye toluidine blue (TB) and was able to monitor the amount of coenzyme NADPH oxidized in the column. The detection limit of the biosensor was 5.8×10^{-6} M (0.5 mg/L) of diacetyl with a percent error of 14%. An alternative optical detection scheme was incorporated into the design using a spectrophotometer at 340 nm. This resulted in lowering the biosensor's detection limit of diacetyl to 2.3×10^{-7} M (0.02 mg/L) with a 4% error at 5.8×10^{-6} M. The immobilized enzyme column provided stable performance for at least 40 days and for at least 30 assays before a significant decrease in activity was measured. Efforts are now underway to improve performance by increasing the purity of the enzyme and testing various procedures for sample pretreatment.

John Sheppard is currently an associate professor at McGill University in Montreal responsible for the Food and Fermentation Engineering program. He joined the university in 1989, leaving the National Research Council of Canada after obtaining his Ph.D. degree in biochemical engineering. His research is focussed on the control and optimization of microbial processes and he has published more than 35 technical papers. He is a registered professional engineer and he regularly consults for the food and beverage industries.

P-4

In situ Optical Rotation Measurement for On-Line Monitoring of Brewery Fermentations

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Fermentation is an important part of brewing with the potential for high variability. Monitoring fermentation progress on-line in real time improves a brewer's ability to control the process and reduce variability. Several techniques have been standardized by ASBQ to measure ethanol content, but all of them are off-line measurements. Our objective was to evaluate a novel, optical rotation instrument that uses a photoelastic modulator to measure sugar consumption on-line during fermentation. The optical system was developed using commercial, low-cost components. A semiconductor laser beam was polarized and modulated at 50 kHz with a photoelastic modulator. The light was then passed through a sample cell followed by another polarizer acting as an analyzer. Transmitted light was collected using a silicon detector and its electric signal was filtered with a lock-in amplifier. Different sucrose solutions at concentrations from 0.01 to 30% (w/v) were used to calibrate the instrument and determine its sensitivity, linearity, and stability. Continuous sampling of a fermentation was accomplished by circulating fermenting wort via a peristaltic pump to the optical cell of the instrument. To verify and correlate results, additional samples were taken off-line to measure ethanol content by gas chromatography and specific gravity using a precision density meter. A significant linear correlation was found between on-line optical rotation measurements and off-line ethanol and density measurements, thus confirming the feasibility of optical rotation as an in-situ measurement technique for monitoring fermentation progress.

Jorge Huerta received a B.S. degree in physics and a Ph.D. degree in electrical engineering from Universidad Autonoma de San Luis Potosi in Mexico. Between degrees, from 1989 to 1992, he worked as a quality assurance manager for a fiber optic-related products company and as a general coordinator to implement and maintain a quality assurance system according to ISO9000 standards. His graduate studies involved developing in situ optical measurement systems to control industrial processes. Currently, he is a visiting scientist and postdoctoral researcher at Oregon State University.

P-5

Comparison of Methods for Assessing Colloidal Stability of Beer

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Numerous methods for assessing colloidal stability of beer have been developed. Some of these, such as forcing tests, are mainly used to ensure that beer has been adequately chillproofed; unfortunately, the results are often only available after the beer has left the brewery. The Chapon alcohol cooling test is much faster but requires special equipment and is ill-suited for use as a routine procedure. Other tests, such as the saturated ammonium sulfate precipitation limit (SASPL) and the sensitive (or haze-active) protein test (based on haze induction with tannic acid, followed by turbidimetry) focus on the protein side of colloidal stability and are mainly used in research studies. It was of interest to compare results of these tests on beer treated with different amounts of silicas of different types and particle sizes. Unchillproofed lager beer of a single brand from a single brewery was treated with a number of different silicas, each at three different addition rates (150, 300, and 1,000 mg/L). Each of the resulting samples was subjected to a battery of analytical methods that are often used to evaluate colloidal stability: SASPL, an elevated temperature forcing test, the Chapon alcohol cooling test, and the haze-active (HA) protein test. The HA protein and forcing tests were slightly more precise (lower coefficients of variation) than were the SASPL and Chapon tests. The results obtained with the different methods showed similar, but not identical, patterns with the different silicas; with each method, the three treatment levels with each silica were readily distinguished from each other and from an untreated control. The silicas of different sizes produced generally similar results. The largest particles had slightly lower SASPL and slightly higher HA protein values (both indicating less stability), but in the forcing test, the differences were negligible, with no apparent pattern. The results of the forcing, alcohol-cooling, and HA protein tests showed comparable patterns within the sample set and essentially linear relationships with each other. The SASPL test, on the other hand, showed differences between the samples, but in a different pattern than the other assays. Its relationships to the other methods were distinctly curved. Since the forcing test is the closest to normal practice, it should be the most relevant result. The alcohol-cooling test and the HA protein results were in good agreement with the forcing test, demonstrating their utility in predicting colloidal stability, at least with a single beer brand. As a result, either test should be useful for making comparisons of silica efficacy. The results call into question the utility of the SASPL test for assessing beer haze potential. The short analysis time needed for the HA protein test would permit product testing prior to packaging.

Karl Siebert received a Ph.D. degree 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 1990, Dr. Siebert joined Cornell University as professor of biochemistry in the Department of Food Science and Technology. He served 5 years as department chair and now has a predominantly research appointment. Dr. Siebert served on ASBC technical subcommittees and was a member and chair of the Technical Committee. He is serving his second stint on the Journal of the ASBC *editorial board (1980–1992; 1996–present). He is active as a consultant in the beverage industry.*

P-6

Measurement of Nonenal Potential by Solid-Phase Microextraction (SPME)

Alexis Bolívar, Julia Franquíz, Mónica Gasparri, and CARSTEN ZUFALL
Cervecería Polar, C.A.

The Nonenal Potential is considered an indicator for the staling characteristics of a sample. Malt extracts, worts, and beers are among the commonly analyzed materials. Its relatively high nonenal figures have made Nonenal Potential analyses easier to carry out than measurements of the free aldehydes. The often-difficult interpretation of free aldehyde concentrations as a measure of flavor stability have also contributed to the widespread use of Nonenal Potential analyses. Since the original presentation of the concept in 1990, many variations of Nonenal Potential measurement have been published, both in terms of variations of the sample digestion procedure as well as different approaches in nonenal analysis itself. Current-published methods include a variety of time-consuming and expensive steps in sample preparation, such as column chromatography and derivatization, which also may decrease reproducibility. To overcome the above-mentioned difficulties, a novel solid-phase microextraction analysis method for 2(E)-nonenal without derivatization or other pretreatment steps has been developed. The activation of 2(E)-nonenal precursors takes place in a headspace vial with 10 mL of acidified sample, pH 4.00, at 100°C for 2 h. The vial is refrigerated at 0°C and opened, Na_2SO_4 added with a magnetic agitator, and sealed. An SPME fiber is placed in the headspace solution for 1 h at 70°C. The 2(E)-nonenal adsorbed on the fiber is analyzed by CG/MS in SIM mode. Besides eliminating derivatization efforts and cost, the new method requires significantly less time compared with previously published ones. The new method has been validated testing linearity, accuracy, precision, specificity/selectivity, range, and ruggedness/reproducibility, as well as detection limit.

Carsten Zufall is corporate manager of quality, innovation and development at Cervecería Polar C.A. He received his doctor in engineering sciences degree (Dr.-Ing.) at Berlin Technical University, Germany, where he also serves as associate professor in brewing science.

P-7

Development of a Headspace Gas Chromatography Method for the Analysis of Vicinal Diketones and Flavor-Active Analytes in Fresh Beer Samples

Joseph A. Palausky, JENNIFER T. HELBER, and Steven Pauwels
Boulevard Brewing Company

Craft breweries are constantly searching for efficient, cost-effective methodologies for quality control. Boulevard Brewing Company recently acquired a gas chromatograph (GC) for measuring free vicinal diketones (VDK) in fermenter samples, with the results used to determine the proper time for cooling. Additionally, the GC has been used to monitor specific flavor-active analytes in finished beer to establish flavor profiles. A method (described below) was modified from one previously developed at Katholieke Universiteit Leuven (Catholic University, Leuven). The instrument selected was a Shimadzu GC-17A with a Tekmar 7050 headspace autosampler. A carousel accessory was added to provide consistent heating of samples. The column used was a Restek Stabilwax 60-meter, 0.32-mm i.d., with a 1-micron film-thickness. The GC was equipped with an electron capture detector (ECD) and a flame ionization detector (FID) connected in series. The GC is temperature-programmed with a run time of 25 min to provide resolution of all target analytes. The nondestructive ECD provides quantification of diacetyl and 2,3-pentanedione to a detection limit of 20 parts per billion (ppb) and is used in both fermenter and finished beer analysis. The FID is used in monitoring the consistency of finished beer at or above the tasting threshold levels in ppb or parts per million (ppm) for five flavor-active analytes including acetaldehyde, dimethyl sulfide (DMS), ethyl acetate, isoamyl acetate, and isoamyl alcohol. Fresh samples are taken and stored at 4°C prior to analysis. Five milliliters (mL) of beer is pipeted into a 21-mL vial and sealed with a silicon-lined crimp cap for loading onto the autosampler. Results are quantified against a five-point calibration curve containing all target analytes and a mid-range standard mixture is run daily along with beer and fermenter samples to verify quantification.

Jennifer Helber graduated with a B.S. degree in biology (minor in chemistry) from Central Missouri State University in 1978. After working several years in industrial laboratories, she returned to school and earned an M.S. degree in microbiology from the University of Missouri—Kansas City in 1985. Following that, her employment was in grant-funded academic research laboratories in the Kansas City area, with a variety of foci—from spontaneous mutations in Neurospora to expression of estrogen receptors in the study of breast cancer. During the course of her research experience, she was asked to propagate yeast for a brewery in Kansas City at its inception. Later, after nearly 15 years in research laboratories, she chose a laboratory QA/QC position with Boulevard Brewing Co. in 1999. She thoroughly enjoys her career switch and also enjoys gardening and activities at the lake where she resides with her family.

P-8

Single-Run Ion Chromatographic Analysis for a Complete Monitoring of Brewery-Related Ions Without Manual Sample Pretreatment

FRANK W. NITZSCHE and Diedrich Harms
Koenig Brauerei GmbH

The spectrum of inorganic and organic ions in beer has enormous effects on taste, foam stability, and pH. Consequently, the monitoring of cations, anions, and organic acids is essential to maintain product quality. Ions such as sulfite concerning oxidation stability; calcium and oxalate concerning haze; nitrite and nitrate concerning contamination; and chloride, sulfate, phosphate, lactate, and ammonium concerning pH are a focus of interest for beer examination. The most effective technique to analyze these and other beer-related ions is ion-exchange chromatography (IEC). Many applications have been published that describe only the separation of single ion groups. This technique is inadequate for brewery laboratories, as long as it requires intensive sample preparation, such as the solid-phase extraction (SPE), and high personnel costs. To increase the effectiveness and acceptance of this technique, we have developed a system with an extremely high level of automation. Therefore, an alternating column regeneration system with software-controlled valves was built for the cation as well as for the anion separation. From a selection of commercially available and self-packed guard columns, the most stable and effective ones were used for the two-valve systems. In the next step, both systems were connected by a two-way 10-port valve, resulting in a system that allows analysis of 16 anions/organic acids and six cations with one injection within 38 min. One anion out of this group is sulfite, which has in recent years been a focus of interest. Sulfite has good antioxidative capacity and indirect protection properties against haze in beer. We aimed to analyze sulfite after stabilization with formalin solution. The newly developed method and classical IEC methods, including SPE sample preparation, exhibit excellent correlation throughout different samples, e.g., beers, wort, water, and wastewater. In addition, the automated system reached better relative standard deviations (RSD) for all ions compared with the reference methods. In conclusion, we established a robust routine system for rapid ion analysis of matrix rich samples to our laboratory. Further development is aiming at increasing the number of sample types applicable to the system.

Dr. Frank Nitzsche was born in 1960. He completed his education to become a brewer and maltster at Veltins Brauerei, Germany, between 1981 and 1983. He received a master's degree in brewing science at TU Muenchen-Weihenstephan in 1988. His Ph.D. work was done with Prof. Dr. Narziss until 1991. Since then, he worked for Koenig Brauerei as head of the R&D department at Koenig Brauerei until 1994 and as head QA until 1997. He currently is responsible for production and QA. In 1999, he founded Easyproof Laborbedarf GmbH, which works mainly on fast microbiological detection methods.

P-9

New Analysis Methods—Detection and Measurement of Carbon Dioxide in Beer Samples with NIR

FRANK W. NITZSCHE, Diedrich Harms, and G. Offer
Koenig Brauerei GmbH

The measurement of carbon dioxide in beer is done either by measuring pressure and temperature or by measuring carbonate that was formed quantitatively by the reaction with NaOH. Both methods are very time-consuming and not suitable for the automated analysis of sample series without the necessity of laboratory personnel. Additionally, the first method is limited to equilibration of carbon dioxide in the fluid. If, for example, nitrogen has been added to the filled bottle or can, the measurement is not accurate due to the additional partial pressure of this additional gas. Due to the nondestructive character of the light-based analysis and the short measuring time, this measuring principle has become more and more common in routine applications. Especially the analysis of nitrogen in barley and wheat during harvesting, the determination of alcohol in beer products, the evaluation of the right composition of cleaning agents, the organic amount in wastewater, and many more applications have been used in brewery laboratories. NIR methods produce predicted results that are based on many single-calibration results. Mathematical models in the back of the software of NIR instruments do the calculation. The analysis of carbonate in fluids based on the NIR spectra of the sample was shown to be possible. A calibration of caustic and carbonate content in cleaning solutions in bottle-washing machines has been reported. This method is transferred to the measurement of carbon dioxide as carbonate in beer. Based on the known sample preparation—the addition of a certain amount of caustic to the beer—the sample is transferred to the measuring chamber. The analysis instrument is an NIR instrument equipped with the Zeiss Optics MCS 511 NIR. Statistical evaluation of repeatability, accuracy, and standard deviation compared with conventional methods will be presented.

Dr. Frank Nitzsche was born in 1960. He completed his education to become a brewer and maltster at Veltins Brauerei, Germany, between 1981 and 1983. He received a master's degree in brewing science at TU Muenchen-Weihenstephan in 1988. His Ph.D. work was done with Prof. Dr. Narziss until 1991. Since then, he worked for Koenig Brauerei as head of the R&D department at Koenig Brauerei until 1994 and as head QA until 1997. He currently is responsible for production and QA. In 1999, he founded Easyproof Laborbedarf GmbH, which works mainly on fast microbiological detection methods.

P-10

New Method for the Determination of Beer Gushing Directly from Barley

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The quality of barley and, consequently, of malt is of basic importance to reach good beer quality. Gushing of beer is a very negative phenomenon so far not completely investigated. So-called "primary gushing" is probably associated with the formation of compounds produced in barley after its attack by *Fusarium* spp., and also by *Aspergillus*, *Rhizopus*, *Penicillium*, and *Nigrospora* spp. The actual compounds that cause gushing are unknown. These compounds are probably a product of plant-pathogen interaction, a result of a preceding stress of an organism. Not all gushing is necessarily related to fungal infection. The elevated content of oxalates (in the form of calcium oxalate) can also significantly contribute to this phenomenon. This so-called "secondary gushing" may be caused by a number of further technological problems (high concentration of some heavy metals, oxidation products, incorrect handling of beer, and many others). Nevertheless, the quality of barley appears to be the most important factor. The subject of this study is an experimental method for the determination of gushing directly in barley. This method enables the precise prediction of primary gushing and, thus, the elimination of barley susceptible to gushing potential before its processing to malt. The results obtained with the help of the new method were compared with the "classical" methods of gushing determination. We also followed the oxalate content in the barley, malt, and during the malting process. We acquired needed information and new experience on an eventual participation of oxalates in the processes, which are in some way connected with overfoaming.

Professor Dr. Josef Havel, D.Sc., graduated in 1962 from Masaryk University in Brno, Czechoslovakia, and studied also at The Royl Institute of Technology, Stockholm, Sweden. He is currently head of the Department of Analytical Chemistry Department at the same University. He has published more than 500 scientific papers and several books. His main interests are separation science, chemometrics, and mass spectrometry.

P-11

5,5-Dithiobis-(2-Nitrobenzoic Acid) as an Alternative to Para-Rosaniline in the Colorometric Determination of Total SO_2 in Beer

ALICIA CARRUTHERS, Rudy Beekman, Stephane Dupire, David Maradyn, Laurent Melotte, and Robert J. Stewart
Interbrew

In the life cycle of a beer, the ultimate goal of the brewer is to produce a beer that is stable from a physical and sensory standpoint. Flavor stability has become an area of tremendous importance in the brewing industry, as such, much time and effort has been devoted to researching compounds responsible for achieving such stability, one such component is sulfur dioxide. Sulfur dioxide (SO_2) is a direct by-product of the fermentation process. Its main role is that of an antioxidant, but it can also bind carbonyl compounds that have been shown to negatively impact flavor (i.e., *trans*-2-nonenal). The significant importance of flavor stability, and the role of sulfur dioxide therein, have made it imperative that the brewer measures SO_2 concentrations in process and finished beer, hence the need for an accurate, precise, and rapid method for the quantification of total SO_2 emerged. The most widely accepted method for analyzing total SO_2 in the brewing industry is the para-rosaniline method. This method has been collaboratively tested and accepted by the AOAC, ASBC, and EBC; however, due to environmental restrictions placed on the use of para-rosaniline hydrochloride, combined with the health risks associated with long-term exposure to formaldehyde and the length of time required for SO_2 analysis by this method, the need for a faster, safer method of analysis emerged. In the EBC *Analytica* (4th edition, 1987), a method is published that describes the determination of SO_2 in beer colorimetrically using 5,5′-dithiobis-(2-nitrobenzoic acid) (DTNB). The main drawback of this method is the length of time each determination takes. In this paper, we report a simplified version of the DTNB method to quantitate SO_2 in beer and the validation of the method against the industry standard para-rosaniline method. In the current DTNB method, a beer sample is treated with a dilute phosphate solution to free all bound SO_2 and then, with a methanolic solution of DTNB, to form the 2-nitro-5-thiobenzoate complex. The measured absorbance at 435 nm, minus the correction for the background color from the blank made with ethanol, is proportional to the total concentration of SO_2 in the sample. In order to compare the DTNB versus para-rosaniline methods, analyses were performed on a series of spiked beer samples containing 0, 5, 10, 15, 20, and 40 mg/L of SO_2. Upon comparison of the results from each method, we obtained an R^2 value of 0.9984. In addition, seven replicates of the same beer were analyzed by each method, resulting in a standard deviation of 3.3% for the para-rosaniline method and 5.8% for the DTNB method. This study demonstrates that the safer, less-time-consuming DTNB method, can be used in lieu of the standard para-rosaniline method.

Alicia Carruthers received a B.S. degree in chemistry from the University of Western Ontario in London, Ontario, Canada. She began her career with Interbrew in March 2003 as a chemist in Global Innovation and Development, Interbrew in London, Ontario, Canada. This past year, she has also served as subcommittee chair for ASBC.

P-12

Electron Paramagnetic Resonance (EPR) Studies Comparing Wort Boiling Temperatures and Various Levels of SO_2 in Packaged Beer

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Coors Brewing Company

In brewing applications of the new technology, namely, electron paramagnetic resonance (EPR), initial investigations using EPR technology have shown promise in wort-boiling studies and packaged-beer samples with various SO_2 levels. In the wort-boiling study, pilot brews were boiled at 95.5, 100.5, and 104.7°C, while wort samples were taken every 20 min, cooled, and frozen for future EPR analyses. EPR profiles did show that high-pressure (temperature) boiling did abuse (scorch) the wort, and they also predicted a reduction in potential flavor stability of the beer with regard to the wort EPR T150 values. Several packaged beers ranging from 2.1 to 10.8 ppm of SO_2 showed a positive trend with EPR lagtime minutes. In looking at the onset of stale flavors for these beers, we noticed that from a sensory perspective, these beers tasted stale at different EPR lagtimes. Therefore, in order to match the sensory stale score with the EPR lagtime scale score, we have incorporated high and low SO_2 fresh beer levels into a predicted staling resistance (PSR) rating.

Bob Foster received his B.S. degree in chemistry in 1972 from Rockhurst College in Kansas City, MO. He joined the Coors Brewing Company in 1974 and has worked in brewing research and quality assurance. Currently, Bob is a manager of flavor stability and chemistry in the Brewing Services Department. During a 2-year absence and a full-time employee, Bob also received a Ph.D. degree in brewing from Heriot-Watt University in Edinburgh, Scotland, in 1997. Bob has been involved in hops, flavor stability, and brewing and packaging oxidation research. He is a member of the American Society of Brewing Chemists, the Institute and Guild of Brewing—Scottish Section, and the Master Brewers Association of the Americas. Bob has published reports on hops and flavor research in the Journal of the ASBC, *the* Technical Quarterly *of the MBAA, and the* Journal of Agricultural and Food Chemistry. *Along with his Ph.D. thesis publication, Bob has a U.S. patent on a process for the isomerization of alpha-acids. Bob has received the 2002 Eric Kneen Award from the American Society of Brewing Chemists for his World Brewing Congress 2000 paper.*

P-13

Use of LC-APCI-MS/MS to Detect *trans*-Resveratrol, a Determinant Nutrition Key for Health, in Hop Pellets

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Nowadays, hop is almost exclusively used in the brewery as a source of bitterness and flavors (Lermusieau et al., JAFC, 49:3867-3874, 2001; Lermusieau and Collin, JASBC, 61:109-113, 2003). Although hop polyphenols have been widely studied in the last decade for their antioxidant activity in the boiling kettle (Lermusieau et al., Food Chem., 72:413-418, 2001), very little is known about its real impact on health. De Keukeleire et al. (EBC, 2001) have isolated very interesting phytostrogenic prenylated flavonoids from hop. The recent discovery of resveratrol in pellets (Callemien et al., EBC 2003) again highlights the key role of hop in improving health on moderate beer consumption. Resveratrol, already identified in wine and other food matrices, seems to be linked to anticarcinogenic, antiviral, antioxidant, antiinflammatory, and estrogenic activities. In the current paper, the *trans*-resveratrol extraction has been optimized in hop pellets, leading to a 99% recovery factor. The so-obtained extract was further analyzed by reverse-phase liquid chromatography hyphenated to atmospheric pressure chemical ionization in tandem mass mode (LC-APCI-MS/MS). The optimized procedure was finally applied on hop pellets from different varieties and origins.

Sonia Collin received a Ph.D. degree in chemical sciences from the University of Namur, Belgium (1988). As professor of malting and brewing sciences at the Université Catholique de Louvain, Louvain-la-Neuve, Belgium, since 1993, she is currently head of the Department of Brewery and Food Industries (INBR). She is a member of the ASBC, the Institute of Brewing, and the EBC Brewing Science Group. She has published around 100 papers, mainly on flavor stability, sulfur aroma, pyrazines, and hops. She will chair the next XIth J. De Clerck Chair "The pH paradox in the brewing process" (2004).

P-14

The Business Case for the Smart Brewhouse

Joel Allin, RENE BECK, and Gary Largesse
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Communication in the control layer of the information hierarchy is experiencing drastic change. Digital fieldbuses are increasing the amount of available data to the brewery from the field devices. What is the value of this additional data? This additional data can remain just that, data, or the data can turn into information to revolutionize maintenance, operations, and many of the brewery work processes. There is a clearly defined and compelling business case for large, continuous processing plants to move toward digital fieldbus technology. The information for those facilities is used to avoid unscheduled shutdowns, increase the time between shutdowns, and in general, predicatively manage the asset base, which equates to millions of dollars of savings and increased revenue. Is there a business case for the brewer for smart devices? The batch and sometimes part-time nature of brewing, as well as the compact footprint of the facility, change the economics of the analysis drastically. Does it only make sense for the large brewer? How large? What factors will weigh heavier than others? Where is the break-even point? This study will look in detail at the business case for the brewer to adopt digital fieldbus technologies. Several aspects will be analyzed: 1) costs, including field devices, wiring, installation, and commissioning; 2) work processes and work flows; and 3) utilizing information flow and their impact on organizational efficiencies. All of these factors will be discussed with respect to digital fieldbuses and the value they bring to the beer-making process.

Rene Beck received a B.S. degree in mechanical engineering from Iowa State University in Ames, IA. She began employment with Hoeschst-Celanese in Clear Lake, TX, and joined Emerson in 1995 in Austin, TX, in technical sales. She is now in business development and based out of the Denver, CO, office.

P-15

New Investigations on Thin-Layer Evaporators for Wort Boiling

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As an accepted recent technology in wort boiling the thin-layer evaporation system with varying heat-transfer areas was tested in laboratory scale and various ranges of industrial scale. This study was initiated to clarify individual material values and verify a number of mathematical and thermodynamic basic theories and the scale-up calculations. The theoretical model for the design was developed for the technical parameters of the system. On the basis of the Nusselt theory of thin trickling film, the heat transfer could be calculated on conical heating surfaces. The results enable one to predict and calculate the heating-up times, boiling times, and optimized recirculation rates during the boiling process. In the scientific approach, theoretical substance properties were used. In practical tests, different product properties at different process parameters were measured and used to prove the obvious performance of the boiling system. The process technology for heating up, evaporation, and boiling phases of the wort preparation process was investigated and compared with the theoretical results. A principle difference of behavior of reaction kinetics could be found between the phases of recirculation and cast-out. It is apparent that the system is working very well with technological product acceptance. Technological results, which could be predicted by the theory, from both laboratory-scale and full industrial-scale installations are shown and discussed. The above work will lead to further technical refinement of different sizing of the technical plant design and optimization of the process engineering.

Jens Voigt received a degree as Diploma Engineer (M.Sc.) in brewing and beverage technology from TU München-Weihenstephan, Germany, in 1985. He started his career with A. Steinecker GmbH, Freising as a technical engineer in brewhouse and fermentation and filtration equipment. He held positions of sales and product and manager with Steinecker until 1995. From 1988 until 1992, he received his doctorate in brewing technology on beer foam from Weihenstephan (Prof. Dr. Narziss). In 1996, he joined Doemens Brewing School in Munich, Germany, as managing director. In late 1997, he joined Heinrich Huppmann GmbH, Kitzingen, Germany, as key account manager for brewery equipment and was managing director of brewmaxx, supplier of software solutions for the brewing industry. Since early 2004, he has been a research associate with Prof. Dr. Karl Sommer at Lehrstuhl für Maschinen- und Apparatekunde (Chair for Mechanical Engineering) at the WZW (Wissenschaftszentrum Weihenstephan) (Center of Life Science, Weihenstephan). He is member of the IGB, member of the editorial board and referee for papers in the Journal of the Institute of Brewing, *London.*

P-16

New Findings on Wort Boiling with Internal Calandrias

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The research in wort boiling during the last few years has shown that wort is very sensitive and does not tolerate excessive temperatures at the heating surface. If the heat transfer, for some reason or other, is insufficient, the thermal stress on the wort is increased. This thermal stress results in problems in wort quality. If the destruction of proteins goes too far, a poor head retention is the result. But this is a visual issue. Much more important are the effects on flavor and flavor stability. Internal calandrias are the most popular boiling system so far. But they have one critical phase—heating up to boiling temperature. In this step, a very good relation between the temperature of the heating media and the natural wort circulation can be found. The wort in the kettle is still too cold to establish a constant natural flow through the calandria tubes. The wort is heated in the tubes until it is pushed out by the thermo-siphon effect—cold wort enters the tubes again and the circulation stops. This phase is called pulsing. During this phase, the biggest damage is done to the wort, the fouling of the calandria tubes takes place here and precursors of aging compounds are formed. The pulsing, together with nonhomogeneity in the kettles, makes it almost impossible to get a constant wort composition. Another advantage is the possibility to get circulation without heating the calandria, a surface is created for the evaporation of undesired flavors. The calandria needs to be cleaned frequently, which is a cost factor regarding the use of chemicals and water as well as a reduction in the productivity of the brewhouse. The more often a calandria needs to be cleaned during the production week, the poorer is the design. In 2003, a new wort boiling system, Stromboli, like the Italian volcano, was developed. The heart of this system is an injector pump above the calandria bundle, which sucks the wort through the tubes during the whole process. The result is almost no fouling in the tubes and a required overall evaporation of about 3–4%. If high evaporation rates are needed to achieve acceptable wort qualities, the reason could be an inhomogeneous wort treatment. For comparison, an existing calandria was retrofitted with the injector pump and the effects are shown.

Matthias Weinzierl was born in 1971 in Aschaffenburg. After finishing school in Lauf, he underwent training as a brewer and maltster from 1991 to 1993 at the Brauhaus Lauf and at the Privatbrauerei Kitzmann, Erlangen. He majored in professional engineering for the brewing and beverage technology at the Technical University Munich-Weihenstephan until 1998. During his studies, Matthias worked with Fischer's Erdinger Stiftungsbrauerei from 1993 to 1994. From 1996 until 1998, he worked with the IT department for network administration at our company. In 1998, Matthias was employed with the commissioning department, including research and development. He is responsible for the organization of the commissioning of new plants all around the world. Today, he is head of the technology department jointly with Mr. Klaus Wasmuht. He participated in the invention of the new wort boiling system "Merlin" in 1998, the new lauter tun "Pegasus" in 2002, and the new wort boiling system "Stromboli" in 2003. Since 1999, Matthias has been a doctoral candidate at the State Testing & Research Institute for Brewing Technology in Munich/Weihenstephan with the subject of wort boiling with Merlin.

P-17

Matching the Benefits of Automation with Brewery Growth

RENE BECK and Gary Silverman
Emerson Process Management, Process Systems and Solutions Division

Many craft- or microbrewers view automation of the brewing process as something for the larger corporate brewers and opt for mostly manual breweries. The larger corporate brewers see automation and manufacturing execution systems (MES) of the enterprise as infrastructure critical to their core business success in producing beer. As a smaller brewer expands their production, there comes a point in time in which automation provides a solid return on investment (ROI) and brings value to the brewer and their beer. This study analyzes the growth cycles of breweries, which are similar to any corporate entity, and defines the point along their growth curve where automating the brewing process provides value. Different trigger points are identified associated with production schedule, labor utilization, and product consistency requirements. Several craft and regional brewers provide input to this study and share their specific experiences and outlook. Once a brewer makes the decision to automate, it is often difficult to define a master plan for the implementation of automation at the brewery. Coming from a manual process operation and resources already spread too thin, it is often difficult to define what to apply automation to and what technology is right for a solid return on investment. This presentation will also present a methodology by which to adopt automation that is consistent with the growth cycle of the brewery and looks at a step-wise implementation of automation and manufacturing automation that allows phases to match with return on investment. A discussion of appropriate infrastructure, technology, and methodology is defined to provide a disciplined approach that will meet the brewers' objectives for a solid return on investment.

Rene Beck received a B.S. degree in mechanical engineering from Iowa State University in Ames, IA. She began employment with Hoeschst-Celanese in Clear Lake, TX, and joined Emerson in 1995 in Austin, TX, in technical sales. She is now in business development and based out of the Denver, CO, office.

P-18

New Formulas for Sharper Calculation

HENNING NIELSEN
The Scandinavian School of Brewing, Copenhagen, Denmark

A brewing chemist or a brewmaster should be able to answer the following type of question. How much beer from tank B will increase the apparent extract in tank A to 2.00%? Tank A: real extract = 3.45%, alcohol by volume = 4.56%, and volume = 1,234 hL. Tank B: original extract = 17.89%, alcohol by mass = 6.54%, and volume = ? hL. To make sharp and quick calculations of this kind, we need improved calculation formulas. Balling's Formula only goes for alcohol by mass! A new formula is presented: Balling by volume. Tabarie's formula is only valid for beer of modest strength! A new formula is presented. The improved Tabarie's Formula valid for strong beer as well. More new formulas are included in this poster, as well as examples of sharp brewing calculations.

Henning Nielsen is a lecturer at The Scandinavian School of Brewing in Copenhagen, Denmark, and an independent brewing consultant. Previously, he has been director of consultation at Alfred Jørgensen Laboratory in Copenhagen; director of production at Bravo International in St. Petersburg, Russia; and technical director at Faxe Brewery in Denmark.

P-19

Purification, Identification, and Properties of Diacetyl Reductase Enzymes in Ale and Lager Brewing Yeasts

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The reduction of diacetyl, and its precursor alpha-acetolactate, remains an important issue in brewing. Reduction to acceptable levels is a slow process, resulting in aging vessels being occupied for long periods of time. Reducing the maturation time could lead to increased production capacity in existing facilities. With direct genetic manipulation being currently unacceptable in brewing, it is important that we obtain a complete understanding of the cellular processes involved in acetolactate and diacetyl metabolism and how these may differ between yeast strains. In order to study diacetyl production and reduction pathways using current molecular and genetic techniques, it is important that enzymes involved in reduction are properly identified and characterized. Currently, it is known that several enzymes are capable of reducing diacetyl to acetoin. It is also known that these enzymes are enantioselective. Yeast samples were taken from industrial ale and lager fermentations being conducted at the Molson Brewery in Montreal. The cells were ruptured, and enzymes showing diacetyl reduction activity were purified using ion exchange and affinity chromatography. The purified enzymes have been characterized kinetically, and N-terminal amino acid sequencing has been performed. The sequencing results have been used to perform protein BLAST (basic local alignment search tool) queries to properly identify the proteins, their corresponding genes, as well as similar proteins that may be capable of reducing diacetyl. The results of the above experiments will be presented here.This work forms part of a larger collaborative project focusing on the production and reduction of diacetyl and its precursor, as well as the development of online measurement systems. The project aims to develop novel methods for improving fermentation performance, leading to better quality control and reduction in maturation times.

Barry van Bergen is currently conducting research toward a Ph.D. degree at McGill University, in Montreal, in the Department of Bioresource Engineering. His area of research is brewing fermentation performance, with a focus on factors surrounding diacetyl production and reduction. He first obtained a B.Sc. degree at the University of Stellenbosch in South Africa before moving to McGill, where he completed an M.Sc. degree before enrolling in a Ph.D. program in 2001.

P-20

Brewing Performance of Lipoxygenase-1-Less Barley

NAOHIKO HIROTA (1), Hisao Kuroda (1), Kiyoshi Takoi (1), Takafumi Kaneko (1), Hirotaka Kaneda (1), Ikuya Yoshida (1), Masachika Takashio (1), Kazutoshi Ito (1), and Kazuyoshi Takeda (2)
(1) Sapporo Breweries Ltd.; (2) Okayama University, Japan

The powdery and papery off-flavor of over-age beer is a common problem in the brewing industry. *trans*-2-Nonenal (T2N) is regarded as the main component of this off-flavor. Barley seed lipoxygenase-1 (LOX-1) catalyzes the initial step of the T2N formation through oxidation of unsaturated fatty acids such as linoleic acid. LOX-1 is also involved in the formation of trihydroxyoctadecenoic acid (THOD), which affects the foam stability and flavor of beer. Therefore, with a barley line lacking LOX-1 (LOX-less barley), it would be possible to produce flavor- and foam-stable beer, although such LOX-less barley has not been discovered previously. Here, we report that the beer made from a newly discovered LOX-less barley showed not only reduced levels of these substances, but also improved flavor and foam stabilities even after aging. We have screened barley germ plasms (Collection of Okayama University, Japan) for LOX-1 activity and discovered barley lines without significant LOX-1 activity and the authentic LOX-1 protein. To evaluate the performance of a LOX-less barley line in brewing, malts were prepared from two F_4 populations derived from the same cross: LOX-plus and LOX-minus. These malts were analyzed for their general malt characteristics, the T2N content and nonenal potential (NP). NP is known as an index to predict the degree of staleness in aged beer. We could not observe any major differences in the general malt characteristics between the malts. However, the LOX-minus wort showed extremely low levels of the T2N content and NP. Trial brewing was carried out with these malts. As we had expected, the THOD content in the LOX-minus beer was reduced to 47% of that in the LOX-plus beer. Moreover, the NIBEM value, an index of beer foam stability, was prolonged for more than 20 s. This result clarified the contribution of LOX-1 to the THOD formation in the brewing process and to the foam stability of the resulting beer, supporting previous reports on the relationship between the THOD content and foam stability. After storage at 37°C for 1 week, the T2N level of the LOX-minus beer was lower than that of the LOX-plus beer by 66%. In the sensory evaluation, well-trained panel members recognized a significant superiority of the LOX-minus beer in terms of 'flavor' and 'total aging' (significant at the 5% probability level). These satisfactory results in the trial brewing indicate that the LOX-less barley will become one of the powerful tools to improve the flavor and foam stabilities of beer.

Naohiko Hirota received a master's degree in plant pathology from Tohoku University, Sendai, Japan, in 1990. He has worked in Bioresources Research and Development Laboratories (formerly Plant Bioengineering Research Laboratories), Sapporo Breweries Ltd., since graduation. His career in Sapporo has concentrated on the improvement of storage substances in barley seeds by means of protein and DNA techniques, transformation, RFLP, and so on. He is currently a lead researcher in the Plant Material Innovation group at Gunma, Japan.

P-21

The Partial Substitution of Hot Filler Sanitation by a Cold Chemical Sanitizer

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The packaging of beer in bottles or cans without pasteurization necessitates that the filler is as near to sterile as possible. In this regard, SIP filler cleaning procedures using a final hot-water (steam) sanitation step at 82°C (180°F) have been very successfully employed to achieve the highest microbial control standards. However, the hot filler sanitation procedure is time-consuming and energy intensive and produces considerable thermal stress to the filler and associated components. A filler sanitation regime using a combination of a cold SIP procedure employing a cold sanitizer, interspersed with a hot filler sanitation procedure, has been tested and found to provide the same microbial control as the sole use of a hot sanitation procedure. This combination has resulted in substantial cost benefits arising from filler cleaning turnaround time gains, reduced energy, and diminished thermal stress on the filler.

George Agius received his master's degree in chemistry and was a lecturer in organic and physical chemistry. An MBAA member since 1987, George has contributed several technical presentations to MBAA meetings. He has held several research positions since 1982, leading to the position of technical director (1990) with JohnsonDiversey, where he was responsible for product development and customer support in North America. During this time, George directed the development of synthetic lubricants, new sanitizers, bottle scuff maskants, low environment impact CIP cleaners, bottlewashing programs, new pasteurizer treatments, and accompanying engineering systems. George is currently the technical director for brewing and beverage applications in North America.

P-22

Optimal Asset Utilization in the 21st Century Brewery

BRUCE SCHMIDT and Brandon Herdt
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Asset utilization is a key component of running a profitable business. It may sound obvious, but the value of your assets goes well beyond the initial investment of capital in your facility. Labor costs, environmental issues, energy costs, and equipment wear all contribute to the overall value of your assets. Judicious selection of your cleaning and sanitation program can add value through lower operational costs, improved efficiency, and increased profitability. Your sanitation practices also provide benefits in the form of the less tangible but far more critical issue of product quality, consistency, and brand protection. This paper reviews historical sanitation practices and their hard and soft costs. It contrasts the pros and cons of those programs to the innovations existing in today's technology. This review contains real-world examples of time, energy, and effluent savings that can be achieved with today's sanitation practices. And it goes further, with analytical data outlining rinsibility of a variety of cleaning chemistries, as well as the impact that these chemistries can have on the physical and organoleptic properties of your beer.

Bruce E. Schmidt is a scientist in the Latin American division of Ecolab Inc. His primary responsibility is to provide technical support to the international operations of Ecolab. The areas supported include cleaning methods, regulatory assistance, product information, program development, corrosion and compatibility, and effluent issues. He is a technical resource for the more than 130 countries in which Ecolab operates. He attended Augsburg College and the University of Minnesota receiving a B.A. degree in chemistry in 1971. He completed an M.S. program in food science at the University of Minnesota in 1975. During his 22-year career with Ecolab Inc., he has held positions in both product development and technical support. He has been involved in the development of several Ecolab sanitation and lubrication product offerings. He is an inventor on six U.S. patents. He has traveled extensively throughout the world in support of Ecolab's global activities. He has also provided technical support for program launches throughout the world. Bruce has been a presenter at numerous technical seminars, including events sponsored by the United States Food & Drug Administration, the International Bottled Water Association, the Master Brewers Association of the Americas, and other industry-sponsored meetings. He is also the author of several articles that have appeared in technical publications.

P-23

Tank Farm CIP Optimization as an Example of Engineering Process Management in the Brewery

PETER KOESTLER, DIPL.-ING.
The Gambrinus Company

The Spoetzl Brewery in Shiner, Texas, underwent an expansion of its fermentation and storage cellars in 1997 and 1998 by installing 18 unitanks. The horizontal discharge piping proved to be difficult to sufficiently clean with the automated CIP system. Visual inspection of the inside revealed a slippery film on the top of the pipe that showed no bioluminescence activity after a regular CIP cycle. Nevertheless, this film could act as breeding ground for microorganisms and a way to securely, repeatedly, and economically remove this deposit had to be found. This small engineering project is used as an example to discuss generally accepted project management practices, which means that these practices "…are applicable to most projects, most of the time, and that there is widespread consensus about their value and usefulness." (A Guide to the Project Management Body of Knowledge, 2000 Edition; Process Management Institute, Newton Square, PA)

Peter Koestler graduated in 1998 as Diplom-Ingenieur for brewing and beverage technology from the Technical University of Munich in Weihenstephan, Germany. He currently works as the brewery engineer for The Gambrinus Company in San Antonio, TX. In his position, he is responsible for engineering projects at the Spoetzl Brewery in Shiner, TX; he provides engineering support for the BridgePort Brewery in Portland, OR; and he leads brewing operations at The Gambrinus Company research and development brewery in San Antonio.

P-24

The Safe Use of Chlorine Dioxide, Benefits to the Brewer

DONALD HOBRO
Halox Technologies, Bridgeport, CT

Chlorine dioxide (ClO_2) has long been recognized as a superior biocide and sanitizing agent. Its unique properties have made it the biocide of choice for such applications as municipal drinking water, large-scale food processing, and pulp and paper production. Approved by the FDA and EPA for most applications, ClO_2 is an environmentally friendly alternative to other oxidizing biocides because it does not form carcinogenic by-products (THMs, HAAs, etc.) and is effective at very low concentrations. However, traditional generation techniques have made ClO_2 unavailable to many users. These methods produce orders of magnitude more ClO_2 than is needed, involve the use of multiple hazardous reactants, and are difficult and dangerous to operate. Halox Technologies has commercialized a single precursor electrochemical method to safely generate up to 5 lb of ClO_2 per day. Case studies are presented that demonstrate the efficacy of ClO_2 in the brewing process: everything from bottle rinsing to CIP to rail car sanitizing.

Donald F. Hobro, product and regulatory affairs manager, is an avid home brewer and joined Halox Technologies in 1998 with a broad background in electrochemical engineering, sales, marketing, chemical technology, and industrial management. Donald has published and copublished numerous papers and presentations on chlorine dioxide, pollution control, and wastewater management. Additionally, he has managed funded projects in the areas of resource recovery and waste minimization. He holds a B.S. degree in chemical engineering from the University of Connecticut.

P-25

Enhancing the 'Craft' in Craft Brewing with Automation

AL MARZI (1), Debi Prickette (2), and Frank Kieser (3)
(1) Harpoon Brewery; (2) Emerson Process Management, Process Systems and Solutions Division; (3) The Huppmann Group

Regarding its brewing operations, the Harpoon Brewery in Boston, MA, has a two-prong vision: 1) to be the most efficient brewery in New England and 2) to be a great place to work. To stay true to those objectives, they installed a new brewhouse from Huppmann in late 2002. They doubled the brewing vessel size in their process and are utilizing Huppmann's low-pressure boiling technology (the first system installed in the U.S.). Their 120-bbl fully automated brewhouse uses Huppmann's alpha.88TM brewhouse application package on Emerson Process Management's DeltaV TM digital automation system. There was concern on the part of some of the Harpoon brewers that automation would prevent them from retaining their craft brewer status. Fortunately, the opposite has proven to be true. Having a fully automated brewhouse enhances Harpoon brewmaster's ability to hand craft the brews. They now have greater control of the process and can replicate any small process improvements that they make in future brews. The automation system has enhanced their control on several fronts. In addition to greater crafting ability for their beer, they can access diagnostic information for process troubleshooting and add new styles to their product line by simply changing the appropriate parameters. The fully integrated system gives them an overall view of the process and a complete brew report at the end of each brew. With the installation of this new brewhouse, Harpoon has been able to decrease their operating schedule from three shifts/day for 6 days down to two shifts/day for 4 days. This significantly increased their productivity as well as helped meet their second corporate objective of making it a great place to work. During production, the automated system keeps things within tight specifications and allows the brewers to focus on incremental value-add tasks. Another benefit of a now more consistent product is that it offers the possibility of distributing to a wider geographic area due to the beers increased shelf stability. The new brewhouse has been a large step for Harpoon to make and had many risks and challenges associated with it. After 1 year, it has proven to be a wise step for the brewery to make in helping to achieve their company objectives.

Al Marzi is the vice president brewing operations for Harpoon Brewery. They have breweries in both Boston, MA, and Windsor, VT. Al joined Harpoon in 1991 and is responsible for overseeing production of the beer from malt to glass in both of Harpoon's breweries. He is the former president of District New England of the Master Brewers Association of the Americas. He received a B.S. degree from Boston University and a brewing certificate from the Siebel Institute of Brewing in Chicago.

P-26

Detergency and Efficacy in Draft Dispense System Cleaning

JAIME JURADO (1), Jeff Gonzales (2), and Peter Takacs (2)
(1) The Gambrinus Company; (2) Spoetzl Brewery, Inc.

Brewers are sometimes challenged to explain mandated cleaning frequencies of draft dispense systems and to list approved detergent products for line cleaning. Results are shared that are germane to these issues. In exploring optimal dispense system hygiene maintenance, formal evaluation of detergency is one component and microbiological study in the field is the second component to ascertain cleaning frequency and appropriate detergents. A description of detergency is presented based on laboratory investigation with an objective to calculate the kinetic constants and project maximum detergency (detergency realized at infinite time under each test set) for a given actual-detergency measurement. A model system that represents a 'mid-level' real-world draft dispense venue is next described in which work has been undertaken to explore implications of cleaning schedules for dispense systems for filtered and unfiltered beer, as well as for a sweetened non-alcoholic beverage. Protocols for cleaning were uniformly applied at each cleaning. Using microbiological tools, the system was subjected to careful, comprehensive swabbing before the beginning and after completion of a number of cycles in the studied cleaning frequencies. A comparison of a commercial detergent system showing good detergency characteristics with a novel formulation developed in the brewery laboratory is presented, and implications of findings of the study are shared that reconcile the need for maintaining clean dispense systems while using detergent solutions that perform well with appropriate protocols to reduce the frequency of cleaning to a (safe) minimum. Anecdotal considerations of expectations extrapolated for high-level (long lines) and low-level (short lines) dispense installations are discussed.

Jaime Jurado serves as director of brewing operations at The Gambrinus Company, the American importer of Moosehead Canadian Lager and beers of Grupo Modelo, as well as its own specialty breweries in Texas, Oregon, and California and its 30-bbl research brewery in Texas. Jaime has been in brewing more than 20 years and has degrees in chemical and electrical engineering, as well as postgraduate work in medical engineering. He is currently second vice president of the MBAA. With approval of company President Carlos Alvarez, The Gambrinus Company focuses its research activity on practical areas beneficial to the industry and supports its managers at its breweries who volunteer to work on MBAA and ASBC projects and committees, as well as in other technical organizations such as ACS and IIAR.

P-27

An Empirical Study of Hydrogen and Methane Two-Stage Production Directly from Brewery Effluent by Anaerobic Fermentation

YUTAKA MITANI (1), Yuji Takamoto (1), Ryo Atsumi (1), Masachika Takashio (1), Tetsuo Hiraga (2), and Naomichi Nishio (3)
(1) Sapporo Breweries Ltd.; (2) Shimadzu Corporation; (3) Hiroshima Univ.

Anaerobic fermentation (methane fermentation) to produce biogas for combustion predominates in the field of technologies for converting food processing wastes into energy. Methane fermentation using an upflow anaerobic sludge blanket (UASB) process has been extensively applied to the treatment of brewery effluents. The UASB process methane fermentation has overcome one of the inherent drawbacks of anaerobic fermentation, i.e., a low fermentation rate, by using granules capable of holding microorganisms at a high density. The advent of this technology has enabled the treatment of effluents with high load concentrations, because of the extremely high rate. However, the UASB process requires precise control of the operating conditions, and the UASB process is not suited to process solid sludge. Therefore, the feed solution requires a pretreatment to remove any suspended solid matter. For example, the pressed filtrate from the spent malt of the lauter tun contains a high density of suspended matter. Physical removal of the suspended matter from this filtrate lowers the load concentration. If it is possible to convert the suspended matter into biogas, more than twice the volume of biogas would be obtainable, which is not possible with the UASB methane fermentation. As is well-known, bacteria found from the anaerobic fermentation produce polysaccharide-degrading enzymes. They decompose high-molecular polysaccharides to low-molecular sugars and organic acids, generating hydrogen as a metabolite. Such organic acids and hydrogen constitute important substrates for methanogens, which produce methane as the final product of anaerobic fermentation. This paper introduces an empirical study of the development of a technology to produce hydrogen and methane gases in a two-stage process of the anaerobic fermentation of brewery effluents containing high solid matter. The first-stage fermentation process produces hydrogen to decompose the solid matter containing high-molecular polysaccharides. The main effective microorganisms are fermenting ones, which produce hydrogen directly from the decomposed organic matters together with acid production. The second-stage fermentation process produces methane from the residual substances of the hydrogen fermentation process. Our technology, when successfully scaled up, can extract energy as biogas from brewery effluents at efficiencies higher than currently possible.

Yutaka Mitani received a Ph.D. degree from Hiroshima University in 1984. He joined Sapporo Breweries, Ltd. in 1984. He was engaged in the research of the biochemicals and the pharmaceutics for 10 years. Since 1994, he has been involved in the R & D of biochemical engineering science at Sapporo's Brewing Research Laboratories (BRL). In Sapporo's BRL, he has been studying the hydrodynamics of the brewing facilities. He has also analyzed the beer foam from the viewpoint of the interfacial chemistry and transport phenomena. Since 2002, he has been working in the field of environmental biochemical engineering at Sapporo's Frontier Laboratories of Value Creation (FLVC). He is now the general manager of the Process Engineering Division of FLVC.

P-28

Efficient Energy Consumption System in a New Suntory Kyushu-Kumamoto Plant

YOSHINORI NISHIWAKI
Suntory Ltd., Kyushu-Kumamoto Plant

The Suntory group is carrying out environmental conservation activities to create a sustainable society. Under the Suntory environmental policy, we reduced the consumption of resources and the emittance of the global warming substance by saving energy. According to this policy, the new Kyushu-Kumamoto Plant was constructed in 2003, where we introduced the production facilities with the concept of less energy consumption by making clear the composition of the loss factor in the existing brewery and the high efficiency of the power plant, making the best use of energy. Through these activities, we have planned to reduce by 30% the specific energy consumption as a target in the plant. In the production system, based on the composition of the loss factor in the existing brewery, two major energy-saving measures were taken. First, in the wort boiling process, the thermal VRC system with energy storage tank was equipped with an internal boiler for quality effect and simplicity. This internal boiler had a specific heating surface area twice as large as the conventional ones. As a result, we recovered almost 100% energy from waste vapor from the wort kettle. Second, in the cooling of fermentation, maturation, and filtration cellars, we changed the temperature of each cellar to about 10°C higher than conventional ones by effectively making each cellar dry without floor drainage and condensation sweat on the surface of the beer lines and cold facilities. In the power plant, we supplied a three-phased refrigerant whose temperature is different corresponding to the temperature in the use point and cooled step by step to minimize energy loss. The refrigerators, with not only a sensible but also latent heat recovery unit, were installed to recover waste latent heat by making hot water for CIP, CO_2 vaporizing, and room heating. These refrigerating systems got the result of 30% higher efficiency than our conventional system. Consequently, the foundation of an efficient energy consumption system to achieve the target was made with the new system that can reduce energy loss in the production process and make the best use of energy in the power plant.

Yoshinori Nishiwaki received a master's degree in chemical engineering from Osaka University in Japan. He joined Suntory in April 1997 as an engineer in the engineering section of Kyoto Brewery. In July2001, he became a member of new Kyushu-Kumamoto Plant Construction Project. In this project, he was in charge of designing the power plant. Since it started production, he has been working with the engineering staff of the plant.

P-29

The Effect of Fermentation Temperature on the Production of Hydrogen Sulfide

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We investigated the impact that fermentation temperature has relative to the production of hydrogen sulfide (H_2S) in beer. Two lager beer formulations (American pilsner and German lager yeast) and two ale beer formulations (Hefeweizen and English ale yeast) were brewed using Bavarian malt. Fermentations were conducted in duplicate in a 2-L plastic container at 20°C for ale and 10°C for lager, which were the normal temperatures, and 5°C lower (15°C) and 5°C (15°C) higher than normal fermentation temperatures for ale and lager, respectively. Fermentation rates were monitored daily by weighing the fermentation containers using a laboratory balance, and the levels of H_2S production were measured daily using sulfide detecting tubes that were then used to determine the H_2S content of the fermenter gas. In general, the yeasts produced the highest amounts of H_2S when they were in the active fermenting stage and this production pattern clearly shows that lager yeasts produce much higher levels of H_2S than do the ale yeasts, regardless of the differences in fermentation temperature. At 10°C, lager yeasts produced 13–28% less H_2S than when fermented at 15°C. Ale yeasts produced fairly low levels of H_2S during fermentation, and Hefeweizen ale yeast produced higher H_2S at 20°C than at 15°C, but the opposite was found from English ale yeast, which produced much higher H_2S levels at a lower temperature (15°C). From the results, we show that continuous monitoring of the H_2S production patterns and the fermentation rate during the fermentation process provides the brewer valuable information in order to control H_2S production in beer fermentation.

Young-Ran Kim received a B.S.degree in food science and technology from Kyung Hee University in Korea in 2003 and continued to work on her M.S. degree at the same University under the supervision of Prof. Seung Park. Her research interests are in brewing chemistry, especially beer flavor stability and off-flavors in beers.

P-30

Prevention of Protein-Polyphenol Haze in Beer Using a Proline-Specific Protease

MICHEL LOPEZ, Jean-Marc Derquenne, Sylvain Delaroche, Gerrit Verschoor, and Luppo Edens
DSM Food Specialties

Haze-forming activity based on protein–polyphenol interactions largely depends on the proline content of the protein fraction present (Siebert, K. J., J. Agric. Food Chem., Vol. 47, No. 2, 1999). It was hypothesized that the addition of a proline-specific protease to the brewing process would prevent, or at least minimize, the association between the protein fraction and polyphenols. Initial results obtained in a model system based on wheat gliadin–catechin precipitation and an available proline-specific oligopeptidase confirmed the hypothesis. To enable large-scale, industrial application of this enzymatic approach, it was necessary to screen for a potentially food-grade, proline-specific protease with an acidic pH optimum. Such an enzyme was found in *Aspergillus niger*. It has been shown that this enzyme effectively prevents colloidal protein–polyphenol precipitations in acidic beverages such as beer. This food-grade enzyme preparation, with the commercial name Brewers Clarex™, represents a promising alternative to current stabilization methods using PVPP, tannic acid, silica gel, or papain.

Michel Lopez has an engineering degree in Agronomical Science and a Ph.D. degree in biochemistry from the University of Lille, France. He joined the Applied Beverages Group of DSM Food Specialties as a scientist in May 1999.

P-31

The Dangers of SASPL in Chillproofing Evaluation

KENNETH A. BERG and Audrey J. Bennett
The PQ Corporation

The SASPL (saturated ammonium sulfate precipitation limit) test is frequently used to evaluate beer chillproofers for their ability to stabilize a beer against the formation of a colloidal haze upon aging. The test has several drawbacks, however. The lack of specificity of the test to haze proteins is demonstrated by comparing dose/response curves when the response is measured by SASPL vs. forced chill haze. The SASPL test clearly responds to many other beer components. The lack of specificity causes the SASPL test to sometimes give false indications of beer colloidal stability, depending on chillproofer and dose. Several factors affecting the test cause it to give an indefinite breakpoint, allowing a degree of subjectivity into the readings. A superior, simpler, alternative test using a single dose of ammonium sulfate is recommended to determine if the beer has been chillproofed or not. Quantitative evaluation of chillproofers, on the other hand, should be made by either forcing or measuring actual shelf life of carefully treated beer samples.

Dr. Berg has a B.A. degree in biology from Cornell University and a Ph.D. degree in biochemistry from Brandeis University. He has been working on beer chillproofing with the PQ Corporation for 18 years and has several papers and patents on the subject. His activities include inventions for other food industries, and other applications of silica-based adsorbents.

P-32

Beer Filtration: Membrane Morphology and Fluid Dynamics

JOHN D. BRANTLEY
Scientific and Laboratory Services, Pall Corporation

The filtration of beer is inherently a balancing act. The filtration system must be tight enough to remove those unwanted components, yet loose enough so the essential qualities of the beer are unaffected. Generally, the goal is to remove the yeast, protein, and polyphenol precipitates, and suspended polysaccharide gels. Since beer and its ingredients are natural products, there can be a wide variation in the proportion of these suspended solids from year to year, if not month to month. Thus, the filtration process must be sufficiently robust to handle these expected variations, as well as any unexpected ones. The situation is complicated by the additional fact that there are many different styles of beer. Proper selection of the membrane is certainly one of the keys to a successful separation. The rating, the material of construction, and the morphology, all affect how efficiently and how economically this process occurs. Less obvious is the role played by the fluid dynamics, which is the actual process of filtration. For example, in direct-flow filtration, the flux of the beer through the filter affects the throughput. Too high a flux will reduce the throughput. In crossflow filtration, the situation is more complex. Inherent in the technique is the contribution provided by the fluid dynamics. Both the flow across the membrane as well as the flow through the membrane are affected by the morphology of the membrane. All of these factors must work together to produce the required separation. This presentation will illustrate how fundamental principles of fluid dynamics and membrane structure and function as well as knowledge of brewing chemistry can work together to produce brilliantly clear, microbially stable beer.

John D. Brantley, Ph.D., grew up in San Antonio, TX, and graduated from the University of Miami (Florida) in 1980 with a B.S. degree in chemistry and math (minor in physics) and an A.S. degree in biology (minor in English) and obtained his Ph.D. degree from The Johns Hopkins University Department of Biophysics in 1989. John had a postdoctoral position in the Department of Agronomy at the University of Kentucky and joined the Scientific and Laboratory Department of the Pall Corporation in 1992. About that time, he began brewing beer at home. In 1996, he attended the 56th Short Course in Brewing Technology at the Siebel Institute in Chicago. John currently lives in Cortland, NY, and primarily supports R&D efforts for the food and beverage market.

P-33

Membrane Filtration and Diafiltration of Mash for Wort Production

JAN SCHNEIDER (1) and Martin Krottenthaler (2)
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Problem: Conventional mash filtration systems, such as the lauter tun and the mash filter, are based on the technique of cake filtration with spent grain as the filter medium. The application of microfiltration membranes for mash separation started in the 1990s with conventional crossflow filtration experiments (1,2). In 1995, a filter with rotating fixtures became the subject of a project of the authors (3). Both attempts did not succeed sufficiently due to a low filtration rate on the one hand and a high power consumption on the other. Further problems, such as the membrane stability against abrasive husks and membrane fouling, had to be named. Now a novel technique, vibrating membrane filtration (VMF), has been studied intensely. New Technique: The VMF generates an impulse in the suspension by the oscillation of the membrane. The mash circulates radially through a gap between membrane discs. The oscillation is maintained in a system of a coupled torsional vibration of two masses close to the resonance frequency. Results: The filtration behavior is different from all described microfiltration models and techniques. Membrane fouling cannot be observed up to a certain solids concentration. The power consumption is low compared with other dynamic filters.The conversion yield is high due to the employment of powder grist. But the sparging efficiency is affected by the dominating backmixing effects in the stirred sparging reactor. The displacement of first wort, which partly can be utilized in cake filter systems, is not possible. The effect of membrane filtration on quality concerns mainly large molecular substances such as beta-glucans and proteins. A correlation of the removal of beta-glucans and the filter resistance could be shown. The influences on wort quality lead to benefits such as a lower viscosity and a better beer filterability as well as to problems such as worse foam stability. Further experiments placed emphasis on the use of poorly modified malt and the application of unmalted adjuncts, which revealed further possibilities. Neither a cereal cooker nor an enzyme additive are necessary anymore and the percentage of raw grain can be increased. Conclusion: Microfiltration of finely ground mash is a promising alternative for conventional lautering systems. Existing problems that are revealed are the removal of valuable high-molecular substances and the sensitivity of polymer membranes to abrasive husk splinters. References: (1) Daoud, I., Crossflow filtration. Brewing and Distilling International (1985) 23(5):31-33. (2) Bühler, T., Burell, K., Eggars, H. U., and Reed, R. J. R. Proc. of the 24th EBC Congress (1993), 691-700. (3) Lotz, M., Schneider, J., Weisser, H., Krottenthaler, M., and Back, W. Proc. of the 26th EBC Congress (1997), 299-305.

Jan Schneider studied in Weihenstephan (1991–1996), was a Ph.D. student and later assistant at the chair of brewery plants and food packaging technology (Prof. Weisser) at the TU München (1997–2001), was a market specialist in beverage industry at Pall Corporation in Dreiech, Germany (2001–2002), and was a technical project manager at Novartis in Kundl, Austria (2002–2003). Since September 2003, Jan has been head of the research institute of plant equipment and packaging technology at the VLB, Berlin.

P-34

Cristobalite-Free Kieselguhr for Beer Filtration

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Heat-treated diatomite filtration aids used for the filtration of beer normally contain crystalline structures of silicon dioxide. Such crystalline structures can release silicosis and are suspected to cause cancer. The configuration of crystalline structures by fluxcalcinating diatomite has been examined. A procedure has been developed that prevents the formation of crystalline structures during heat treatment by using an inhibitor. In order to characterize the phases of silicon dioxide, of which the majority of diatomite consists, x-ray diffraction has been used. In particular, the amorphous silicon dioxide phase and cristobalite were differentiated with this analysis method. For further characterization of the diatomites, particle size analyses have been provided by laser diffraction. The morphology of the diatomite particles has been examined by SEM; furthermore, the "Schenk Water Value" has been determined. Three kinds of diatomites were calcined using the fluxing agents potassium carbonate and sodium carbonate. In the traditional industrial process, sodium carbonate is used. The sodium ion stabilizes cristobalite and similar structures. The potassium ion can prevent the formation of cristobalite or similar structures by its ion size; therefore, potassium carbonate was used.The fluxing agent was added to the diatomite as an aqueous solution. A good distribution of the ions is aimed at by using the fluxing agent as a suspension. Process parameters were the firing temperature, the firing time, and the concentration of the fluxing agent. The raw materials and the sample substances were examined with the above-specified methods. The silicon dioxide is present in the untreated diatomites in an amorphous phase. Samples that were calcined by using sodium carbonate showed a stronger tendency to form cristobalite than did samples that were calcined by using potassium carbonate. Likewise, high temperatures and long calcinating times promoted crystallization. The samples with sodium showed well-ordered structures in the form of cristobalite. The samples that contain potassium showed no crystalline structures and the samples remained amorphous up to 1,000°C. By means of particle size distributions, scanning electron microscopy, and determination of the "Schenk Water Value", it could also be proven that the sintering process was successful.

Dominik Antoni received the degree of Diplom-Engineer in "Technology and Biotechnology of Food" from the Technische Universität München. Since June 2003, he has been working at the Chair of Energy and Environmental Technology of the Food Industry. His application areas are both energy technology and filtration technology. In filtration, he specialized in processing diatomaceous earth.

P-35

Adsorption of Beer Components During Membrane Microfiltration of Beer

PETER RIDDELL
domnick hunter ltd.

Microporous membrane filters, designed to remove spoilage organisms and provide microbiological stability of beer, will also remove any other suspended particles larger than the rated pore size. Additionally, they may be capable of removing colloidal and dissolved beer components, often to the detriment of the product. The described work is a continuation of a study into the effect of membrane microfiltration on the foam stability of beer presented at the 2003 MBAA convention. Dye binding assays were used to monitor changes in the total protein concentration of beer before and after filtration using 0.45- and 0.65-micron retention ratings of two common, commercially available membranes, polyethersulphone (PES) and polyamide (PA). The change in protein fractions was measured using SDS-PAGE with silver staining and densitometry. The total and fractional protein changes were compared with the effect on foam stability of the beer before and after filtration. Using the results, it was possible to identify the molecular-weight range of the proteins that were removed. Volume dependencies, for the effect on beer when using newly installed filters and after cleaning and regenerating the filters, were also established.

Peter Riddell is product manager within the process filtration operation of domnick hunter limited. Based in the U.K., he is responsible for the global development of applications within the food and beverage industry. After graduating with a B.Sc. degree in applied chemistry and chemical process engineering, he spent 7 years in product development at domnick hunter during their diversification into the liquid filtration market. He then moved on to project engineering in the dairy and biopharmaceutical industries. Peter returned to domnick hunter as product development manager with a specific remit to extend and improve the range of products for the beverage industry. After a brief spell looking after all liquid applications, he moved on to his current role of product manager.

P-36

Wet-Mechanical Recycling of Filter Aid in Breweries

ANDREAS TRAMM (1), Tobias Leussner (2), and Günther Hoops (3)
(1) ATM GmbH, Germany; (2) Technical University of Clausthal, Germany; (3) H. Meyer-Weke Breloh GmbH & Co. KG, Germany

The aim of this research project is the development of a plant for the recycling of filter aid (FA). In approximately 20–30 years, the world deposit of kieselguhr could go to slope. This might lead to rising filtration costs in the future. The question, therefore, arose as to what extent is it possible to use FA several times in a circuit. Starting point of this examination is a wet-mechanical procedure for the recycling of the filtercake in breweries. The procedure is based on the following steps. The first step is the alkalization of the filter sludge. This solves organic impurities as yeast and proteins and adherent particles from the FA. The grain size of these components is much smaller than the grain size of the FA. In the second step, the actual separation takes place as physical reverse-flow washing toward water by means of hydrocyclones. An allocation takes place by grain size. Laboratory tests have been accomplished regarding the separation cut, the efficiency, and the components of the product. This research resulted in the development of the first industrial prototype. A plant has been built to process 50 kg of FA per hour, being sufficient for breweries with an annual beer output up to approximately 3 million hL. The dimensions of this plant are approximately 1 × 3 m so that it is easy movable and installable in the brewery. The hydrocyclones are cascade arranged, leading to a very exact separation cut of about 7–10 microns. Different promotion possibilities for the product were examined. The promotion is done by air pressure, because of the abrasive characteristic of kieselguhr. The sedimentation behavior of the FA was tested. A turbulent continuous product flow in the plant is absolutely necessary. In the course of the project, various construction units, valves, designs, measuring technique, etc. have been examined. This plant has been successfully tested in a brewery for FA recycling. The beer filtered with recycled FA reached almost the same quality as beer filtered with fresh FA. The microbiological results, chemical-physical stability, and the sensoric stability complied with the demands. Currently, consumption of fresh FA is approximately 40% of the total mass. The handling is dust free and thus not health endangering. The goal in the near future is to refine a plant with over 80% efficiency. When operating costs and capital outlays are calculated, the amortisation period will be 1–3 years for a brewery (corresponds to 3–1 million hL/a). The recycled FA should not differ in any quality from fresh FA. This research shows that regarding economic and ecological criteria a FA regeneration directly in the brewery makes sense.

Andreas Tramm studied at Technical University Munich at Weihenstephan. In 2002, he received a Dipl.-Ing. diploma for brewery and beverage technology. From June 2002, he worked as a project manager for the construction of brewery plants at Process Network GmbH. Since November 2002, he has worked for ATM Engineering GmbH to develop a filter aid recycling system. Beside this, he works as a quality management representative (QMR).

P-37

CSS Combined Beer Stabilization

AXEL JANY
Handtmann Armaturenfabrik Filtration

The paper describes the Combined Stabilization System (CSS) as an alternative to traditional stabilization procedures. Breweries are enabled to adsorb both haze-forming proteins and tannins in a single step after prefiltration in order to increase the shelf life of beer. The presented data has been created with systems in pilot and production scale. Description of process technology: Base of the CSS is the use of regenerable, high-grade, cross-linked insoluble agarose beads that are permanently retained in an adsorbent chamber. Implemented in an existing filter line, unstabilized beer is pumped through this chamber where both proteins and tannins will be adsorbed within seconds. Finally, the adsorbed substances will be removed by regenerating the agarose by using rock salt and caustic. Results: High flow rates, low pressure drops, and no oxygen uptake have been found, especially in production scale systems, which makes it easy to integrate the CSS into any current or future filtration system. It is shown that the CSS creates much less waste than comparable stabilization methods and that it provides an objective progress under ecological aspects. Analysis of CSS-stabilized beer shows no significant influence on beer quality parameters, such as flavor and head retention, but an extraordinary shelf life. Advanced analysis and results: Detailed protein analysis by SDS-PAGE (electrophoresis) shows no significant difference of the protein profile of CSS-treated and untreated beer, but a certain protein fraction of ~45 kDa has been found concentrated in the regenerate. Further analysis using MALDI–TOF–mass spectrometry indicates that the adsorbed proteins are of a hydrophobic nature and a protein database search has been carried out in order to identify the adsorbed proteins. Relevance for practice: It can be concluded that the CSS stabilizes beer in a very efficient but gentle way by adsorbing haze precursors not on a broad base but very specific. The ecological progress is obvious and will support the global effort to reduce the volume of waste. Economical aspects: Economic data of the CSS from practice will also be presented showing low and competitive costs for a combined beer stabilization making the CSS to an attractive alternative to traditional stabilization methods.

Axel Jany is brewmaster sales manager filtration & stabilization at Albert Handtmann Armaturenfabrik GmbH & Co. KG, Biberach, Germany. Axel started his brewery career in 1987 in Germany, where he served an apprenticeship as a brewer and maltster within the Holsten Brewery Group. After working as a brewer and studying at VLB/Technical University Berlin, he received his brewmaster degree in 1994. He joined the Handtmann Company as a filtration technician and currently holds the position of sales manager filtration & stabilization. Axel has been a member of the MBAA since 1995.

P-38

Ethyl Pyruvate—A New Indicator of Flavor Stability of Beer and Its Controlling Factors

CHIKAKO SHIMIZU, Yasunobu Nara, and Masachika Takashio
Sapporo Breweries Ltd.

Aldehydes and ketones play an important role in the flavor stability of beer. We have measured carbonyl compounds such as Strecker aldehydes to investigate the flavor stability of beer. It was found that an unknown GC/ECD peak of carbonyl compounds after derivatization with 0-(2,3,4,5,6-pentafluorobenzyl)hydroxylamine (PFBHA) was correlated with sensory evaluations of beer. The correlation was higher in low-malt beer such as happou-shu. The GC/MS spectral data of the peak were consistent with that of the PFBHA-derivatized ethyl pyruvate (EP). By means of EP analyses in the very early stages of beer aging (without storage), it was possible to predict the flavor stability of low-malt beer. We found that EP shows an interesting behavior during fermentation and after packaging in spite of the simple structure. The EP behavior showed neither unilateral increase nor decrease. EP increased with increasing pyruvate and ethanol during primary fermentation and then decreased with decreasing pyruvate during secondary fermentation. The decrease in EP during secondary fermentation was affected by pyruvate. From our brewing trials using yeast strains derived from one clone of the bottom-fermenting yeast, the amount of pyruvate reduction during secondary fermentation had a positive correlation with the number of yeast cells at the end of primary fermentation. That is, this contribution of yeast cell density to carbonyl reduction during secondary fermentation was a controlling factor common to pyruvate and 3-methylbutanal, which is an index of flavor stability of low-malt beer, as we previously reported. The formation of EP was accelerated by decreasing the pH, especially under about pH 3.7 in the range of pH 2.7–5.2. Moreover, the topping-up process (Drauflassen) had an influence on the EP formation. After packaging, EP increased with temperature (30°C >20°C >2°C) and storage time. However, at higher temperature and for longer storage times, the increase apparently stopped and EP decreased. There was little difference in the EP formation between pasteurization and nonpasteurization of products. Such behavior appears to be due to the easily hydrolyzed character and the slowness of the esterification of pyruvate (alpha-keto-acid) in a solution such as beer. EP is an indicator affected by both pH and the carbonyl reduction by yeast, which are important factors for flavor stability. In order to improve flavor stability, EP is an excellent index, especially for optimizing the fermentation conditions, e.g., selection of yeast strains, aeration, and topping-up process.

Chikako Shimizu received a Ph.D. degree in medicinal chemistry from the Shizuoka College of Pharmacy in 1990. She joined the Pharmaceutical Research Laboratory of Sapporo Breweries Ltd. in 1990 and moved to the Brewing Research Laboratory in 1993. She researched the effect of proteinase A on beer foam stability, new product development, the relationship between the ploidy of brewing yeast and its metabolism, and the flavor stability of beer with special interest in carbonyl reduction by yeast. She is currently engaged in the planning of research in the Frontier Laboratories of Value Creation of Sapporo Breweries Ltd.

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Application of a New Electronic Nose with Fingerprint Mass Spectrometer to Brewing

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Electronic nose techniques have been used for the aroma discrimination of beers. However, ethanol significantly affects metal-oxide or conducting organic polymer sensors, which leads to a large error in the measurement value. A new fingerprint mass spectrometry-type electronic nose, alpha Kronos (Alpha MOS), can solve this problem. This system is equipped with electron impact ionization, a quadrupole mass filter, and an electron multiplier detector, which enables operators to select any specific ions derived from volatile compounds in the sample headspace. The beer aroma can be discriminated based on artificial neural network recognition with no effect by the ethanol. We investigated the characterization of beer aroma with this system for the application to marketing science and for quality control during brewing. The aroma of 10 Japanese commercial beers could be differentiated by means of principal component analysis (PCA). The ions of m/z = 61, 73, and 88, which are possibly derived from ethyl acetate, mainly contributed to the aroma differentiation. The aroma of beers could be characterized by the ratio of higher alcohols to esters, which is important for the beer aroma balance. It was expected that this new type of electronic nose could characterize beer aromas and could be applied for the development of marketing strategies. This system could detect dimethyl sulfide (DMS) in beer. The intensity of the characteristic ion of DMS showed a good relationship with the DMS concentration in beer. It appeared that this system could detect an abnormal level of DMS in brewing more easily than gas chromatography–mass spectrometry. Based on the results, it was expected that a new fingerprint mass spectrometry-type electronic nose could be applied to the characterization of beer aromas and to quality control during brewing.

Hidetoshi Kojima is a biochemist at the Advanced Technology Laboratory in the Frontier Laboratories of Value Creation, Sapporo Breweries, Ltd. He graduated from Tokyo University in 1999 with an M.S. degree and then joined Sapporo Breweries, Ltd. He has been engaged in the research of antioxidants in barley. He has recently worked on the application of the electronic nose and taste sensor.

P-40

The Impact of Lipid Binding Proteins on the Flavor Stability of Beer

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Brewing Research International

Interactions between flavor compounds and a variety of nonflavor components influence flavor perception in foods, which is a high determinant of food acceptance. Interactions of flavor compounds with proteins are known to have a strong influence on the release of flavor from foods, often having an effect on the volatility of the flavor compound. It has been shown that proteins interact with volatiles reversibly or irreversibly via a number of mechanisms, which include hydrophobic interaction, adsorption, absorption, and by chemical bonds of various strengths. In food systems, where proteins can be added to improve the texture or mouthfeel, aroma is often added back to make the product organoleptically acceptable or to restore the original aroma. Most work of this sort has been carried out using food systems, although there has been some research using wine to look at the impact on sensory perception of the binding of flavor compounds by macromolecules such as proteins. Currently, it is not known to what extent malt barley proteins, especially lipid binding proteins (LBP), can affect the flavor profile of beer by simple interaction with flavor and aroma compounds.The flavor of beer alters with time due to the breakdown of existing components or the synthesis of new flavor compounds. For example, the production of *trans*-2-nonenal occurs due to the breakdown of fatty acids present in beer either via enzymic and/or nonenzymic oxidation. The presence of *trans*-2-nonenal in beer is not desirable because it is said to give the beer a cardboard flavor. The breakdown of fatty acids can occur enzymically during mashing due to the presence of lipoxygenase (LOX) and by auto-oxidation throughout the brewing process and in the final beer. LBPs may influence the formation of *trans*-2-nonenal in the mash by binding the fatty acids and preventing them from being broken down by LOX. LBPs may also prevent auto-oxidation in the final beer by a similar binding mechanism, resulting in the fatty acids being protected from auto-oxidation. The aim of this study was to elucidate the contribution of LBPs to the flavor profile and stability of beer. This has been done using protein extracts purified from various cereals and bovine serum albumin (BSA), a model LBP. Results will be presented showing that 1) LBPs do influence the flavor volatile composition in beer as measured by GC, 2) the interaction between LBPs and flavor volatiles impacts negatively on the aroma profile of beer, 3) LBPs can reduce the activity of LOX, and 4) the presence of LBPs reduces the measured levels of *trans*-2-nonenal in beer.

Daniel Cooper studied brewing and distilling at Heriot-Watt University in Edinburgh. After graduating in 1995, he studied for a Ph.D. degree, also at Heriot-Watt, by looking at high-gravity brewing and its negative effect on foam stability. Thereafter, he worked for 3 years as a postdoctoral scientist at the Institute of Food Research in Norwich, examining the role of lipid binding proteins and their effect on foam and flavor stability. He joined Brewing Research International in May 2002, initially working in the Raw Materials Team and more recently in the Sensory Team.

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Flavor Matching Using a Statistical Experimental Design

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An increasing number of statistical software packages are now available for use as tools to aid biological research. These packages are aimed at the nonstatisticians who have a basic knowledge of statistics and wish to use statistical techniques in their research. Apart from offering rapid and extensive data analysis and graphing tools, it is possible to use some of these software packages to design complex factorial experiments that, as well as being statistically valid, minimize the number of experiments required. The statistical software package MINITAB was used to study two ale yeasts that are known to produce beers that differ considerably. Of particular interest was the study of the influence of wort original gravity, dissolved oxygen, zinc concentration, pitching rate, and fermentation temperature on the production of esters and higher alcohols. The use of MINITAB for experimental design considerably reduced the number of experiments required. The regression equations that resulted from this work provided clues as to whether fermentation conditions could be manipulated in such a way so that the the same volatiles profile could be obtained by both yeast strains. This poster presents the individual and interactive effects that the above-mentioned fermentation conditions have on volatiles production in two ale strains. The implications of some of the regression equations are also discussed.

Behnam Taidi (B.Sc., Ph.D., AMIBREW) is the research and development manager for Scottish Courage Ltd. He is in charge of progressing the strategic research program by initiating and managing process innovation projects. Behnam has more than 10 years of experience in brewing research and, although his expertise is in the area of fermentation and yeast, he manages projects in many diverse areas such as novel raw material usage, yeast management, fermentation control, by-product utilization, rapid microbiology, and beer quality. Behnam serves on the Scottish Section IGB committee and regularly attends scientific and brewing conferences, where he presents aspects of his research.

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Colloidal Stability and Flavan-3-ols

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One of the most important quality characters of beer, the colloidal stability, can only be measured by force test. The main reactants for haze formation are proteins and polyphenols. Besides these substances, there are also other factors influencing the colloidal stability of beer, e.g., storage temperature, oxygen, and metal content. Experiments have been conducted to get new information on haze-active polyphenols and the influence of oxygen, copper, and ferric ions on haze formation. Oxygen in the form of hydrogen peroxide was added to beer. Also copper and ferric ions were inserted to different beers to observe the influences these substances have on the colloidal stability and the flavan-3-ol content of these beers. In this context, the treated beers have been stored at 4, 9, 20, 30, and 40°C. After every day, one bottle of every beer has been cooled to 0°C for 24 h. The formed haze was measured and removed by centrifugation. The supernatant was analyzed for flavan-3-ols by HPLC. A decrease of the flavan-3-ols, catechin, epicatechin, prodelphinidin B_3, and procyanidin B_3 was noticed during storage time. A correlation between these substances and the colloidal stability of the beer could be shown. Also, the effect of oxygen on the haze formation and the decrease of the favan-3-ols was detected. On the other hand, ferric and copper ions did not influence the polyphenol content, even though the colloidal stability was reduced compared with the untreated beer. In summary, we can say that the storage temperature had a strong influence on the colloidal stability of the beer, regardless of the substance added to the beer. Also, the flavan-3-ol content did show a correlation to the haze development rate. Ferric and copper ions did not affect the polyphenols, but the addition of copper ions resulted in a reduced colloidal stability of the beers.

Marc Kusche received a diploma in brewing and beverage technology in 2001 from Technische Universität München, Germany. He began a doctoral thesis in 2001 at the Lehrstuhl für Technologie der Brauerei II, Weihenstephan/ TUM.

P-43

Improving Flavor Panel Performance Using Structured Training and Validation

OLAV VIND LARSEN (1), Bill Simpson (2), Ian Williams (1), and Evelyne Canterranne (2)
(1) Alfred Jorgensen Laboratory/Danbrew PCD; (2) FlavorActiV Ltd.

A problem facing many breweries is the regular supply of sufficient tasters to allow the smooth running of the sensory management function. Flavor panels draw on people occupied with other activities in the organization, and their participation in panel work may be given lower priority than their other daily activities. Using a group of external tasters might be a solution to this problem. The poster presents results of a structured training and validation program put in place for a group of experienced tasters from the expert commercial flavor panel at Alfred Jorgensen Laboratory (AJL) and new tasters, drawn from a group of food technology students at a nearby University. Working as a homogeneous group, these tasters now perform descriptive evaluation of beer samples using a vocabulary of more than 50 flavor attributes. AJL, in cooperation with FlavorActiV, started training external taste panel members as a supplement to the company's own tasters more than 2 years ago. The approach to training and validation developed is now fully integrated into the flavor quality management system of the company. A high level of taster competence was achieved in a short time through use of innovative training and coaching techniques. Use of a rigorous quality management process together with an on-going training program has ensured that the standard initially achieved has been maintained since the initial training. Key learnings in relation to recruitment, selection, screening, training, coaching, use, and maintenance of the specialist taste panel will be described. The results are likely to be of relevance to all those with responsibilities for the brewery taste panel function.

Olav Vind Larsen graduated with an M.Sc. degree in chemical engineering/ brewing technology in 1995 from the Danish Technical University. He holds a diploma master brewers education from the Scandinavian School of Brewing. Olav joined AJL as a brewing engineer/brewing consultant in 1995 and is currently head of the team of brewing consultants at AJL (now integrated into Danbrew Process Consultancy Division).

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Flavor Quality Control

David K. Eaton, LAWRENCE T. NIELSEN, and Donald W. Wright
Microanalytics

The goal of this project is to monitor key flavor components in the brewing process so that the brewer can use this information to control production and produce consistent-flavor beer. This is done by sampling beer at points in its production and analyzing for composition that relates to final product flavor quality. The project initially determined the detailed flavor profile of a commercial beer product from the collaborating brewery. This was obtained by using a multidimensional gas chromatography/olfactometry/mass spectrometry system. Detected flavor compounds were identified and ranked as to their importance to the overall product flavor. Sixteen flavor compounds were initially selected for monitoring by the project's newly developed QC instrument. These target flavors represent different types of expected flavor variations that the brewery's expert flavor panel has identified. After method development, the QC instrument was installed at the brewery and protocols were established for the collection of samples. The first 5 months of production sampling and analysis show the relation between the QC analytical results and the expert flavor panel evaluations. The project is still ongoing and has so far measured 1) flavor differences among different production configurations, 2) flavor differences between beer packaged differently, 3) flavor differences with different aged beer, and 4) differences in beer flavor acceptability ratings related to analysis at the process level. This work is funded by the U.S. Department of Agriculture, project TEXK-2002-03045.

Larry Nielsen works at Microanalytics of Round Rock, TX, a company specializing in aroma, odor, and flavor analysis. During the last 5years there, he has been involved in the development of fast organoleptic analysis methodology for the food, chemical, and packaging industries. Much of this technology is directly applicable to the brewing industry. Larry was previously with corporate R & D of Union Camp Corporation in Princeton, NJ, where he was a senior research scientist for 12 years working in the areas of organoleptic analysis and mass spectrometry. Previous to that, he worked for 15 years in Brazil as an industrial research chemist and university teacher. Larry has B.S. and M.S. degrees in chemistry from Denver University.

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Investigation into Conditions in Steeping and Germination to Improve Beer Flavor Stability

KATSUYA SASAKI (1), Tsutomu Ueda (1), Hiroshi Itagaki (2), Yuka Kakiwaki (2), Kumiko Inomoto (1), Noboru Kagami (1), and Katsuyuki Kawatsura (1)
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The malting process is considered important in producing high-quality beer. However, there have been few studies on the relationship between beer flavor stability and malting conditions, especially conditions in steeping and germination. Therefore, we evaluated conditions in steeping and germination by using two indicators: malt *trans*-2-nonenal potential (M-T2N-P) and lipoxygenase (LOX) activity. In this study, we conducted micromalting trials using different steeping and germination programs in terms of barley water uptake. It was found that spraying water during germination seems to be a key factor in generating LOX. Therefore, we conducted trials in which we increased the steeping degree instead of spraying water during germination. As a result, it enabled a reduction in the M-T2N-P and LOX activity of malt with no significant difference in conventional malt analysis. This phenomenon suggests that spraying water during germination increases the moisture of the germ and acrospire in which LOX mainly exists, and then LOX expression is induced.

Katsuya Sasaki is a research worker at the Brewing Research & Development Laboratory, Asahi Breweries, Ltd. in Ibaraki, Japan. He received his M.S. degree in engineering from Tokyo Institute of Technology in 1998 and joined Asahi Breweries, Ltd. He has researched malt quality and malting technology.

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How to Effectively Identify Flavor Compounds in Beer

David K. Eaton, LAWRENCE T. NIELSEN, and Donald W. Wright
Microanalytics

Recent advances in olfactometry instrumentation and SPME sample collection methodology have permitted the effective detection of beer flavor compounds, in particular, the high-impact, trace-level flavor compounds. Effective detection means obtaining accurate results in a relatively short time even by a single investigator. To illustrate the analytical power of the method, step-by-step procedures are describe for the detection of 2-aminoacetophenone, beta-damascenone, 2,4-dichlorophenol, a substituted dihydronaphthalene, an unreported sulfur compound, and an unreported compound possibly related to karahana ether. The two as-yet-unreported flavor compounds are well characterized by their aromas and mass spectra, but their chemical structures have not been determined. The chosen examples contribute to beer flavor at the trace level and are otherwise challenging to detect by traditional methods. The method indicates that several other important flavor compounds are present in selected beers and that they are accessible to aroma and mass spectral characterization using the stated procedures.

Larry Nielsen works at Microanalytics of Round Rock, TX, a company specializing in aroma, odor, and flavor analysis. During the last 5 years there, he has been involved in the development of fast organoleptic analysis methodology for the food, chemical, and packaging industries. Much of this technology is directly applicable to the brewing industry. Larry was previously with corporate R & D of Union Camp Corporation in Princeton, NJ, where he was a senior research scientist for 12 years working in the areas of organoleptic analysis and mass spectrometry. Previous to that, he worked for 15 years in Brazil as an industrial research chemist and university teacher. Larry has B.S. and M.S. degrees in chemistry from Denver University.

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Developing HACCP Programs in Grain-Based Brewing and Food Ingredient Production Facilities

BRAD A. RUSH
Briess Malt & Ingredients Company

In the 1960s, the Pillsbury Corporation developed the Hazard Analysis and Critical Control Point (HACCP) system with NASA to ensure food safety for the first manned space missions. HACCP involves identifying all points in the manufacturing process where a food hygiene risk could occur, and then controlling and monitoring those risks. Based on its success, HACCP was recognized by the U.S. Department of Agriculture as an effective system in controlling the safety of finished foods. Today, HACCP is mandated for certain segments of the food industry in the United States and in a number of other countries. Fueled by growing threats to the world's food supply, increased concern for food safety by consumers, and possible consequences of failing to provide safe, quality food products, manufacturers in many other segments of the food and beverage industries have begun to voluntarily implement HACCP systems. In fact, a major focus of the new HACCP system is "from farm to table." In short, everyone is responsible for safe foods products. Embracing this concept and recognizing that HACCP is an effective system for controlling both food safety and quality, a number of breweries in all corners of the globe have voluntarily implemented HACCP. And, because security of malt supply is a vital element of HACCP systems in breweries, malting companies have started to voluntarily implement HACCP. This presentation will investigate how a team approach was used to research, develop, and implement HACCP in a production facility that manufactures grain-based ingredients used in the production of both beer and food. The first step of the process was to form the internal HACCP team that was then assigned the task of researching, developing, and implementing the HACCP system. The team was led by an independent, trained HACCP consultant and included personnel from all levels, including production operators, floor supervisors, plant managers, and quality control. The presentation will identify how critical control points, unique to a manufacturing process that begins with raw grain, were identified by the team. It will also present examples of systems that were established to control and monitor those risks.

Brad A. Rush received a B.Sc. degree in environmental analysis from Carroll College, Waukesha, WI, and is a graduate of the quality engineering program at the Milwaukee School of Engineering. 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. He is an active member of the Master Brewers Association of Americas. He is currently president of the MBAA District Milwaukee, and was a member of the 2003 MBAA Convention Committee. Brad is a former member of the American Society of Brewing Chemists and officer of the ASBC Section Milwaukee.

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HACCP Activities Within the Slovenian Hop Industry

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Slovenian Institute for Hop Research and Brewing

Economic situation and long-term trends of development in the hop industry are mainly conditioned by technological and market happenings in the brewing industry. A brewing value thus also has an impact on the market value of hops. Growers, providing hops as a raw material for breweries, are strongly obliged to follow legislation and quality standards that are mostly set by hop consumers—brewers. Only by taking all necessary quality issues into consideration might a hop grower be able to achieve the brewing and market value of hops, a reasonable price, and long-term existence of his hop farm. The brewing value is assessed according to the content of bitter substances (alpha-acids), aromatic substances (essential oil), tannin (polyphenols, anthocyanogens, tannoids), the oxidation state of hops, i.e., the degree of oxidative deterioration of hops during handling and storage, utilization of bitter substances, and the quality of bitterness and aroma. Apart from these issues, new quality requirements are also being set in hop production, such as consumers' health protection, pesticide residues, nitrates, and the presence of heavy metals. The HACCP (Hazard Analysis Critical Control Points) system of quality declaration came into force under the foodstuff hygiene directive EEC 93/43 of 14 June, 1993, and is compulsory for all EU members and exporters to EU. It was passed because of the consumers' health protection since it enables us to prevent the contamination of foodstuffs in the production, storage, and distribution chain from the farm to the consumer. Slovenian hop production in 2003 represented 3% of the world hop area. Introducing the HACCP system into Slovenian hop production should enable very efficient quality control as far as the consumers' health protection is concerned. Research activities carried out at the Slovenian Institute of Hop Research and Brewing Zalec include various topics connected with the HACCP activities such as production technology development, integrated plant protection technology with a computer-aided prognosis, and quality of hop plant material (virus-free hop gardens in Slovenia, biochemical markers use for downy mildew and aphid resistance).The poster presentation presents experiences connected to HACCP quality system research activities within the Slovenian Hop Industry Association.

Majda Virant studied chemical technology at the University of Ljubljana, Faculty of Natural Science and Technology (1971). Majda has been head of the laboratory at the Institute of Hop Research and Brewing Zalec (1972–1990); head of the Department for Brewing at the Institute of Hop Research and Brewing Zalec (1990–present); member of the editorial board of the professional journal Beer Brewing *edited by beer and malt industry, business association (1985–1990); member of Technical Association of the Standards and Metrology Institute at Ministry of Science and Tecnology (1992–present); chair of Technological Commission of the Association of Slovene Brewers (1993–present); member of professional group peparing regulations on beer and raw materials at the Ministry of Agriculture, Forestry and Food, Republic of Slovenia (1993–present); member of the EBC Analysis Committee (1997–present); and member of the EBC Barley & Malt Committee (1997–present).*

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Differences in the UV Spectra of the Hop-Derived *cis*- and *trans*-Iso-Alpha-Acids

PAUL S. HUGHES
Heineken Technical Services

Introduction: Hop-derived iso-alpha-acids are known to be difficult to measure accurately. In 1995, an international standard for analysis of iso-alpha-acids by HPLC became available. This new standard, a significant improvement on previous approaches, contains only *trans*-iso-alpha-acids. A concern, based on the scientific literature, is that the UV spectra of the *trans* isomers are different from the *cis* isomer UV spectra. As most isomerised hop products are *cis*-rich, this suggests potentially significant inaccuracies in the measurement of iso-alpha-acids. Thus, there are two major unanswered questions: 1) scientifically, why do these differences in UV spectra exist, as the *cis* and *trans* isomers are structurally almost identical? and 2) the business question is do these differences have a financial consequence? To address both questions, we applied computational chemistry to computer-generated molecules. Experimental: A computer model of an iso-alpha-acid molecule, with the most relevant iso-alpha-acid functionality, was constructed. This computer molecule was then put into each of its possible 61 stereochemical and tautomeric forms. For each form, the stability was determined by calculating their enthalpies and the Gibbs free energies. This work was done with the Gaussian 98W computational chemistry software, running on a conventional Intel Pentium PC and a Windows 98 operating system. This software is designed to provide accurate thermodynamic information on user-defined computer molecules and is widely used in state-of-the-art industrial and academic research. Results: The following results were obtained. 1) For a given *cis*/*trans*-iso-alpha-acid pairing, the *cis* isomer always had a lower enthalpy and a lower Gibbs free energy than the *trans* isomer. This indicates that the *cis* forms are thermodynamically more stable than the *trans* forms. 2) Of the 61 possible structures, four *cis*/*trans* pairs of tautomers were found to have, by far, the lowest Gibbs free energy, making them the most stable. Thus, we believe that these four *cis*/*trans* pairs are those that exist in beer. 3) The ratios of the four low energy *cis* forms are different from those of the four low-energy *trans* forms, so that that the UV spectra of *cis* isomers vary from those of their *trans* counterparts. 4) Interconversion between the *cis* and *trans* isomers is unlikely since intermediate structures are of too high energy to allow significant interconversion. Relevance: The computer models of the hop-derived iso-alpha-acids have identified four tautomers each of *cis*- and of *trans*-iso-alpha-acids as the most stable. Scientifically, this for the first time rationalizes differences in the UV spectra of *cis*- and *trans*-iso-alpha-acids. Financially, these differences could mean a difference of 1 mg/L for a 20-mg/L beer.

Paul Hughes initially trained as a chemist, gaining a degree first in chemistry and then a Ph.D. degree in organic chemistry at the University of London. In 1988, he joined the Health and Safety Executive, and moved on to the Beer Quality team at BRI in Nutfield in 1990. During his time at BRI, Paul worked on a range of beer quality issues, including bitterness quality and perception, sensory methodology, hop aroma, foam stabilization, flavor encapsulation using cyclodextrins, flavor and physical stability, and chemometric techniques for solving multivariate product quality issues. In 1995, Paul became head of the Product Quality team and, in 1998, assumed responsibility for both raw materials and product quality R&D. In November 1999, Paul crossed the Channel to join the Brewing Science and Technology group at Heineken in Zoeterwoude. His current responsibilities include flavor science and product integrity. Paul passed the Institute of Brewing associate examinations in 1993 and was awarded the IoB Cambridge Prize in 1998. He is currently a member of the EBC Brewing Science group and a member of the editorial board for the Journal of the ASBC. *Paul is the (joint) author of around 40 publications, including a textbook on beer quality that was commissioned by the Royal Society of Chemistry. Paul is both a chartered chemist and a fellow of the Royal Statistical Society.*

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Isomerization Kinetics of Hop Bitter Acids During Wort Boiling

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Although overall hop utilization has been well-defined functionally, there is a pronounced lack of published research pertaining to the actual kinetics of alpha-acid isomerization occurring during kettle boiling and to the effect of varying temperature and pH on the rate of conversion. Furthermore, the impact of alpha-acid solubility limits on hop utilization has not been well defined. This research characterizes the rate of isomerization of alpha-acids to iso-alpha-acids across representative pH and temperature values and also explores hop solubility issues and their impact on utilization. Solubility limits for alpha-acids in a pH-buffered solution were determined spectrophotometrically at 328 nm. Maximum solubility of alpha-acids in a pH 5.2-buffered aqueous solution was found to be 90 ppm. The conversion of alpha-acids to iso-alpha-acids was characterized in a model, laboratory-scale system consisting of purified alpha-acid extract in a pH-buffered aqueous solution. Boiling occurred in multiple 12-mL stainless steel vessels submerged in a temperature-controlled oil bath. Concentrations of humulones and iso-humulones were quantified at discrete points during the boil by HPLC analysis. Hop isomerization kinetics were examined over a temperature range of 70 to 120°C. At 70°C, less than 10% of alpha-acids were converted in a 90-min boil. At 120°C, only 30 min were required for 90% conversion, with subsequent loss of iso-alpha-acids to degradation products following. Activation energy was determined to be 88 kJ per mole. Precise understanding of isomerization kinetics allows improved accuracy in hopping rate calculation to achieve target concentrations of bitter compounds in wort, despite varying temperatures as the kettle approaches boiling, or as wort encounters a lag time prior to entering a heat exchanger for cooling. Also, understanding of kinetics is essential if novel regimes (short duration, high temperature, pressurized boiling) are to be explored for potential energy savings.

Mark Malowicki holds a B.S. degree in mechanical engineering from Cornell University in Ithaca, NY, and an M.S. degree in mechanical engineering from Virginia Tech in Blacksburg, VA. After a 5-year career as a powertrain engineer in the fields of automatic transmission durability and calibration with General Motors, in Ypsilanti and Milford, MI, he escaped the world of corporate engineering in search of brewing knowledge and happiness. Mark is currently pursuing an M.S. degree at Oregon State University in Corvallis, OR, under the guidance of Thomas Shellhammer, with research focusing on hop isomerization kinetics. He is a 2003 recipient of an ASBC Foundation scholarship.

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Analysis of Iso-Alpha-Acids and Reduced Iso-Alpha-Acids in Beer by Direct Injection and LC-UV/LC-MS

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The bitter taste of beer is derived from hops (*Humulus lupulus* L.) or hop extracts added to the wort during brewing. In the boiling process, the alpha-acids are isomerized into the bitter-tasting iso-alpha-acids. Reduced iso-alpha-acids including dihydroiso-alpha-acids (also known as rho-iso-alpha-acids) and tetrahydroiso-alpha-acids are often used in the brewing process to enhance both the light and the foam stability of beer. Therefore, analytical methods for detection and quantitation of both iso-alpha-acids and reduced iso-alpha-acids are of utmost importance. Liquid chromatography (LC) is the current analytical method of choice, but LC methods use involatile buffer additives, such as phosphate and citrate, which are not compatible with mass spectroscopic (MS) detection. Only a few reports have been published on the LC-MS analysis of hop acids and no literature is available on the analysis of iso-alpha-acids and reduced iso-alpha-acids by LC-MS. For the analysis of the iso-alpha-acids in beer, a preconcentration step is normally performed either by liquid-liquid extraction or solid-phase extraction on reversed-phase material. Recently, the application of a new solventless extraction method named stir bar sorptive extraction (SBSE) has been described. SBSE combined with liquid desorption was successfully applied for the analysis of bitter compounds in beer and wort by LC and in beer by micellar electrokinetic chromatography. In this contribution, an LC method is described that enables simultaneous analysis of iso-alpha-acids and reduced iso-alpha-acids in beers without sample preconcentration. Beer is only degassed and filtered prior to injection. Volatile mobile-phase additives were selected to enable hyphenation to MS operated in the atmospheric pressure chemical ionization (APCI) mode. Contrary to common use, an alkaline pH was selected, thereby, improving peak shape and selectivity. Both UV and MS detection are sufficiently sensitive to permit beer analysis without enrichment of the compounds of interest. All major bitter acids are separated within 65 min with the exception of *cis*-dihydroisoadhumulone, which co-elutes with *trans*-isocohumulone. Due to the selectivity of MS, these compounds could be differentiated according to their *m/z* value. The performance in terms of quantification of bitter acids by LC-UV and LC-MS is compared for standard solutions and a selection of 14 beers. The values obtained with LC-MS are similar to those obtained with LC-UV, except for the dihydroiso-alpha-acids. The recovered amounts of dihydroiso-alpha-acids were consistently higher in LC-MS compared with LC-UV. MS detection proved superior to UV detection in view of enhanced sensitivity and selectivity, notwithstanding higher RSDs.

Denis De Keukeleire is full professor associated to the Faculty of Pharmaceutical Sciences at the Ghent University, Belgium, and head of the Laboratory of Pharmacognosy and Phytochemistry. For more than 35 years, he has been involved in research on hops and beer, which resulted in the supervision of 30 Ph.D. students and the publication of numerous papers in the scientific literature and of three books. Denis' current interest is focussed, on the one hand, on hop bitter acids, in particular with respect to the influence of light on beer flavor, and on the other hand, on health-promoting properties of hop polyphenols. Recently, an innovative food supplement, MenoHop, was developed and commercialized to alleviate symptoms and complaints associated to the menopause. The successful application of MenoHop is based on the presence of the hop-derived 8-prenylnaringenin, the most potent phytoestrogen known so far in the plant kingdom.

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Screening of Hop Varieties for Genes Involved in the Formation of Bioactive Prenylated Chalcones

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Hops (*Humulus lupulus* L.) are a very rich source of secondary metabolites that constitute up to 40% (m/m) of the dry weight of a hop cone. Most prevalent are alpha-acids (humulones), which are precursors of iso-alpha-acids (isohumulones), the main beer-bittering agents. Hop varieties differ only quantitatively in the content of alpha-acids, while qualitative variations are located in the composition of hop oils and hop polyphenols. The most interesting features are associated with hop polyphenols. It is, in general, accepted that they contribute to full mouthflavor of beer, although undisputed evidence is lacking so far. On the other hand, increasing information becomes available on the health-associated properties of hop polyphenols. In view of the use of hops as an essential raw material in beer production, polyphenols, when transferred into beer, should account for valuable health features of the beverage. In particular, prenylated flavonoids are extremely interesting, partly because of estrogenic features attributed to 8-prenylnaringenin, and partly because of cancer-chemopreventive activities attributed to xanthohumol. Hops contain appropriate enzymes to biosynthesize prenylated chalcones, mainly xanthohumol and desmethylxanthohumol, a direct precursor of 8-prenylnaringenin. It is striking that the concentration of prenylated chalcones varies widely among hop varieties, hence, a proper choice of a particular hop variety determines the health potential of a specific beer. From this viewpoint, we are interested in screening hop varieties for genes that determine the biosynthesis of prenylated chalcones. In order to collect initial data and to establish appropriate techniques, we selected two hop varieties with quite contrasting compositions of compounds of interest, i.e., Wye Challenger and Admiral. The issue was approached by cDNA-AFLP screening of female inflorescences of both varieties at different developmental stages. High-quality RNA was extracted and reproducible cDNA fingerprints were obtained following detailed investigation of various experimental conditions. The main difficulties encountered were related to specific features of hop materials, including the abundance of secondary metabolites and their accumulation in the sticky lupulin glands. Full cDNA-AFLP analysis (256 primer combinations) should give insight into differential gene expression involved in the biosynthesis of xanthohumol and desmethylxanthohumol. Thus, the method could prove useful, not only to screen other interesting hop varieties but also to provide information to brewers on the potential application of particular hop varieties to add specific health attributes to beers.

Arne Heyerick has obtained a Ph.D. degree in biochemistry from the Ghent University, Belgium (2002) on "Unraveling the mechanism of formation of the lightstruck flavor in beer" (beneficiary of a Ph.D. research grant offered by the Interbrew-Baillet Latour Foundation, Leuven, Belgium). He stayed for research purposes at King's College London and at the University of North Carolina at Chapel Hill. Dr. Heyerick published extensively on various aspects of hop research and is currently involved in collaborative R&D projects on medicinal properties of hop constituents. The aim of the current study (Ph.D. work of Jelle De Keukeleire under the supervision of Prof. Dr. Erik Van Bockstaele and Dr. Isabel Roldán-Ruiz) is to gain insight into the genetic pool of hops that determines the biosynthesis of bioactive prenylated flavonoids. Progress reports on this research topic were presented at the 68th Annual Meeting of the American Society of Brewing Chemists, Santa Ana Pueblo, NM, U.S.A., 7–11 June 2003; at the 1st International Conference on Polyphenols and Health, Vichy, France, 18–21 November 2003; and at the 2004 Hawaii International Conference on Sciences, Honolulu, Hawaii, 15–18 January 2004.

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DNA Typing of Hop Using Sequence-Tagged Microsatellite Site Markers

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The microsatellite DNA or simple sequence repeat (SSR) marker is currently the preferred molecular marker due to its highly desirable properties. We applied this technique to the identification of hop cultivars. Many DNA sequences of hop were analyzed to isolate and characterize new microsatellite DNA, because the number of microsatellite markers currently available in hop is limited. Subsequently, the obtained microsatellite sequences were converted to sequence-tagged microsatellite site markers, which resulted in the reproducible amplification of the region containing identified microsatellites. Using these markers, 37 hop cultivars, including most of the commercially important varieties grown in Europe and U.S.A., were analyzed. As a result, these cultivars were successfully distinguished from one another except for the cases of genetically close individuals. These results indicate that our newly developed DNA-typing system using sequence-tagged microsatellite site markers is useful not only for the identification of hop cultivars but also for quality control purposes.

Daisuke Kanai graduated from the Tokyo Institute of Technology, Department of Life Science, with a master's degree and joined Asahi Breweries Ltd. in 2000. He has been engaged in research and development at the fundamental research laboratory. Since 2002, he has studied alcoholic fermentation with yeast.

P-54

The Influence of Naturally Occurring Hop Acids on the BU Analyses of Dry-Hopped Beers

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Addition of hops (most commonly as leaf hops or pellets) to fermented wort is used by some brewers as a means to impart a "dry-hopped" aroma/flavor to beer, especially to ales. This technique has the secondary effect of increasing the measured bitterness units (BU) of the beer and the question arises as to whether the increase in BU reflects a true increase in the bitterness of the product. HPLC analyses of ales before and after dry hopping revealed changes in the concentrations of certain hop acids. There was typically a marked increase in the concentration of alpha-acids, a slight decrease in iso-alpha-acids, and an increase in the concentration of compounds that elute before the iso-alpha-acids ("pre-iso" compounds). The effect of the minimally bitter alpha-acids on the BU value was determined and can be corrected for by use of a modified BU equation incorporating the absorbance of the trimethylpentane (iso-octane) solution at 325 nm. The major pre-iso compounds found in some dry-hopped beers have been tentatively identified as humulinones, a known oxidation product of alpha-acids when treated with hydrogen peroxide that are actually a hydroxylated, but less bitter, form of iso-alpha-acids. Humulinones share similar UV absorbance characteristics with the iso-alpha-acids and so their contribution to the BU value overestimates the perceived bitterness. Their presence in dry-hopped beers has been noted at levels in the range of about 1–10 ppm and their origin would appear to be due to simple dissolution from the added hops, as we have now observed (via HPLC analysis) the presence of humulinones in both hops and hop pellets, the amount present being in part dependent on the variety of the hops.

Robert Smith has been working at S.S. Steiner, Inc. as a research chemist since 1989. Bob has helped in the development of some of the downstream products from the carbon dioxide extract of hops. Other research interests include the identification of compounds in hop products. In 1978, he received an M.S. degree in chemistry from the University of Oregon. Afterwards, he worked for 11 years at Oregon State University as a research assistant, some of the time spent on the isolation and identification of hop oil compounds.

P-55

The Comprehensive Analysis of Hop Oil Using Two-Dimensional Gas Chromatography Combined with Time-of-Flight Mass Spectrometry

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The selection and quality of hops is a major determinant in beer flavor. Brewers acknowledge that distinctive characteristics of different hop varieties can be traced to the composition of their essential oils. Unlike the compounds responsible for bitterness, which are well characterized, the compounds responsible for the characteristic hop aroma are not yet fully understood. This is mainly attributable to the chemical complexity of hop essential oils, with more than 400 volatile compounds positively or tentatively identified so far. The difficulty in characterizing hop oil is due to the co-elution that occurs when using single-dimension chromatography to separate complex mixtures. In conventional gas chromatography analysis, the separation power of a single column is not sufficient to analyze samples containing more than 150–250 compounds. With the introduction of comprehensive multidimensional capillary gas chromatography (GC×GC), there is a tremendous improvement in the separation power. Recent work using GC×GC with flame ionization detection has suggested that there may be more than 1,000 compounds in hop oil. This work describes the use of GC×GC combined with TOFMS detection (Leco Pegasus 4D instrument) to analyze a sample of target hop oil. The two-stage cryogenic modulator enabled narrow-peak base widths of 0.1–0.2 s preventing co-elution and reducing peak tailing. The TOFMS scanning rate of 60 Hz provided sufficient spectra per peak for identification (340 components were identified with more than 200 previously unreported compounds). When analyzing results, an advantage of GC×GC coupled to TOFMS is that two-dimensional chromatograms can be viewed for individual masses that are characteristic of particular functional groups. This allows the analyst to view the various homologous series of compounds (e.g., alkanes, alkenes, alcohols, ketones, acids, esters) quickly to ascertain their presence in the sample.

Prof. Dr. Ir. Jean-Pierre Dufour has received M.Sc. (1975) and Ph.D. (1979) degrees (Louvain). Jean-Pierre was a research fellow at Johns Hopkins University, School of Medicine, Baltimore, MD, from 1979 to 1981. Jean-Pierre has been professor and head of the Department of Brewery and Food Industries, Catholic University of Louvain (1981–1993); visiting professor, Escola Superior de Biotechnologia (Porto, Portugal) (1989–1994); associated professor, University Senghor (Alexandria, Egypt) (1992–1995); expert for EEC and UNIDO (1994–1996); and professor (1995–present) and chair and head of the Department of Food Science, University of Otago, Dunedin, New Zealand. Jean-Pierre's expertise is in flavor science, fermentation science and technology, malting and brewing sciences, and yeast biochemistry/enzymology. Jean-Pierre is a member of EBC Brewing Science Group, ASBC, IOB, IFT, and ACS. Jean-Pierre is president and fellow of the NZIFST and the New Zealand delegate to IUFoST.

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Evaluation of the Effects of Iso-Alpha-Acids on Seals and Sealing Materials

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Historically, hot wort solutions have proven to be the most difficult brewing applications for valve seats, diaphragms and other static or dynamic sealing applications. During the wort boil, the alpha-acids of hops are transformed into bitter-tasting iso-alpha-acids, which balance the residual sweetness in the fermented beer. This solution, combined with sugars and a modest temperature environment, can dry out ethylene-propylene-diene (EPDM) and fluoroelastomer (FKM) seals. While the exact mechanism is not clear, this phenomenon can have significant effects on sealing in wort applications. If an elastomer swells and softens during exposure to wort solutions, service life and sealability can be greatly affected. In the extreme case, an elastomer that experiences significant softening in a dynamic application will extrude when a valve is actuated and, at some point, a section of the elastomer will break off. An elastomer that undergoes hardening during exposure can pose even greater problems. As the elastomer hardens, cracks begin to form on the seal. Over time the cracks will grow large enough to create crevices where bacteria can form, thus introducing significant cleaning challenges. This paper examines the role iso-alpha-acids play in the chemical and physical aging of select FDA-compliant elastomers used in the brewing industry. The elastomers chosen are initially tested for total organic carbon (TOC) extractables after immersion in purified water for 24 h at reflux. Organic extractables are quantified after immersion in ethanol for 24 h at reflux. The change in tensile properties of the elastomers is compared with several reference wort recipes with varying bitterness indexes to determine if the elastomer is softening or experiencing embrittlement. Elastomer samples are pulled at various times to provide a means to predicting service life. The retention of physical properties is also plotted versus the initial level of organic extractables of the elastomer samples in order to provide a possible mechanical for eventual seal failure. Weight and volume swell changes of the elastomer after immersion in the various wort solutions is also used as a means to evaluate the effects of initial TOC levels on the performance of the elastomers. A full battery of tests will be used to propose an aging mechanism occurring during an elastomer's exposure to specific wort solutions. Finally, a new FDA-compliant elastomer is evaluated versus commercially available formulations.

Timothy Duzick serves as pharmaceutical market manager for Greene, Tweed, a world-class leader in the design and manufacture of high-performance materials and custom-engineered components. Tim is experienced in developing test protocols for polymers requiring Code of Federal Regulations (CFR) and toxicological (USP) approval/compliance. A skilled communicator with a strong knowledge of all aspects of polymer characterization and performance, Tim guides and directs marketing communications, sales, and R&D for Greene, Tweed's expanding pharmaceutical market. Before coming to Greene, Tweed, Tim worked at Asahi Glass, DuPont Dow Elastomers, and E.I. DuPont de Nemours. Tim has presented at both Interphex and ACHEMA and has a patent pending for a novel sealing system created for the pharmaceutical industry. A member of the International Society of Pharmaceutical Engineers, Tim received his M.E. degree from Widener University.

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Freeze Drying for Germination Maintenance of Barley Germ Plasm

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Collections of seed germ plasm (seed banks) provide valuable reservoirs for use in controlled experiments and the selective improvement of species. There are different methods for seed preservation that are of great importance for the malting and brewing industries to protect or maintain the germination energy and germination capacity of the germ plasm. The process of freeze drying has a potential application for the maintenance of the genetic characteristics of malting barley germ plasm. The current study gathers information from tests initiated in 1986 by our esteemed colleague Ing. Guillermo Massieu Olivares and tries to understand the behavior of the germination energy and capacity of malting barley after controlled treatments with the freeze-drying equipment, which was kindly facilitated by the Polytechnic National Institute in Mexico. Results are rather convincing and could open a new technological and practical application for the use of freeze drying in germ plasm centers or in commercial grain storage.

Eugenio de la Mora Miquel received a master's degree in biochemical engineering from the Monterrey Technical Institute (ITESM) and has 11 years of pratical experience in the malting industry for Extractos y Maltas, S.A. in Mexico.

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Reduction of Deoxynivalenol in Contaminated Barley by Malting and Physicochemical Treatment

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The two-row and six-row barleys were pilot malted with the same steeping/germination schedule. The raw barley and germinated barley samples were analyzed for *Fusarium* mycotoxin deoxynivalenol (DON) content and quality parameters. DON content of two-row barley was lower than that of six-row barley. Also, lower concentration of DON was found in the fraction containing the plump kernels than that containing the thin kernels of barley. Steeping and germination reduced the DON contamination of barley. Alkaline condition was more effective than water for solubilization and removal of DON from barley during steeping. Korean barley naturally contaminated with DON at ca. 2 µg/g was treated with a variety of aqueous reagents. Of those reagents investigated, aqueous sodium bicarbonate affected the greatest reduction in DON levels of barley. Soaking barley in a 0.1 M sodium carbonate solution for 8 h caused a 85% reduction in DON concentration.

Won Jong Lee is a professor in the Department of Food Science at Kangnung National University, Korea. He received his B.S. degree in food technology from Seoul National University, his M.S. and Ph.D. degrees in cereal science from North Dakota State University, and had postdoctoral experience at the University of Wisconsin, Madison. He has worked as a visiting scholar at the University of Saskatchewan, Saskatoon, and the University of Nebraska, Lincoln. He also served as dean of the College of Life Sciences, Kangnung National University, Korea. He is a member of ASBC, AACC, and IFT.

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A New Method for Assessing Water Distribution in Steeped Barley

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Brewing Research International

During the malting process, the distribution of water inside steeped barley corns is a key feature that needs to be controlled. Existing tests for assessing the water distribution have a number of disadvantages. They are expensive, time consuming, subjective, and difficult to quantify. As a result, this work was undertaken to develop a new simple method for assessing the water distribution in steeped barley. The new method is called "The Laser Test" and relies on the measurement of laser light transmission through barley grains before and after the grains are heated to gelatinize the starch. The variation in the amount of light passing through the grain can be correlated to the water distribution inside the grains. The correlation produces very good results. The Laser Test is an excellent alternative to currently available methods since it is easy to perform, fast, accurate, objective, and even more importantly, it provides a quantitative measurement of the water distribution inside steeped barley.

Daniel Cooper studied brewing and distilling at Heriot-Watt University in Edinburgh. After graduating in 1995, he studied for a Ph.D. degree, also at Heriot-Watt, by looking at high-gravity brewing and its negative effect on foam stability. Thereafter, he worked for 3 years as a postdoctoral scientist at the Institute of Food Research in Norwich, examining the role of lipid binding proteins and their effect on foam and flavor stability. He joined Brewing Research International in May 2002, initially working in the Raw Materials Team and more recently in the Sensory Team.

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Trends in Production and Supply of Canadian Malting Barley Varieties

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The Canadian Wheat Board

Western Canada is a major supplier of malting barley to the North American and International malt and brewing industries. During the 1990s, the variety Harrington became a dominant standard for two-rowed malt quality and an important ingredient in the raw material blends of many brewers around the world. However, Harrington production has been declining rapidly within Canada in recent years. It is being replaced by a portfolio of newer two-rowed malting barley varieties that have been bred to maintain and improve on the unique malting and brewing attributes of Harrington, while offering growers a much improved yield and agronomic package. Maltsters and brewers worldwide still seek information on availability of Harrington from Canada and what newer varieties are now replacing it. Comprehensive surveys of individual farmer-seeded acres conducted over the past 5 years are graphed to show a very clear picture of the rapidly declining production of Harrington and rapidly increasing production of other newer varieties replacing it, especially varieties such as AC Metcalfe. Further survey information shows the newer two-rowed malting varieties have taken an increasing share of the total Canadian barley acreage with correspondingly decreasing feed and hulless varieties and, to a lesser extent, decreasing six-rowed malting varieties. CWB data is also presented on the relative quantities of varieties marketed as malting barley, indicating increasing domestic and international customer acceptance of these varieties as replacements for the declining Harrington. This information will provide international maltsters and brewers with an understanding of the significant ongoing changes in production and marketing malting barley varieties within Canada, which impacts on the supply of raw material to the malting and brewing industry worldwide.

Michael Brophy holds an M.Sc. degree in agriculture from University College, Dublin, Ireland. He has been working with the Canadian Wheat Board since 1993 and, since 1995, has been responsible for malting barley market development projects, especially focusing on market development for new malting barley varieties. He is an MBAA member and has served on the committee and as chair of the Winnipeg chapter of the MBAA District Western Canada. He is past-chair of the Canadian Malting Barley Technical Centre (CMBTC) and is still a member of its Board of Directors.

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Molecular Characterization of Allelic Variants of Beta-Amylase

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It is well accepted now that beta-amylase (1,4-alpha-D-glucanmaltohydrolase E.C.3.2.1.2) is one of the various enzymes that contributes to the overall malting quality of barley. The enzyme is highly active in the germinating barley seeds and is involved in the mobilization of starch, which ultimately results in good malting quality. Beta-amylase is encoded by multiple genes located on chromosome 2 and 4 of barley. A full-length cDNA encoding for the beta-amylase gene (*bmy1*) is 1,754-bp long and translates to a polypeptide of 535 amino acids. Studies have shown that allelic variation for *bmy1* exists in different barley cultivars. The objective of this study was to identify variants in *bmy-1*at the DNA level at two stages of malting in various barley lines differing in malting quality and phenotypic characteristics. We extracted the beta-amylase messages (mRNA) from eight barley cultivars (four two-row and four six-row cultivars) after 1 and 4 days of germination under micromalting conditions. cDNA libraries were made for all 16 samples. The *bmy1* genes were isolated, sequenced, and compared among the samples. No differences were observed in mRNA sequences between 2 and 4 days of germination within cultivars. However, six single nucleotide polymorphisms (SNPs) were found among cultivars. Three of the SNPs were previously shown to exist between 'Morex', a malting cultivar, and 'Steptoe', a feed barley cultivar (Clark et al. 2003. Plant Physiol. Biochem. 41:798-804). These SNPs were also demonstrated to affect the biochemical properties of the enzyme. Three other SNPs have not been previously identified. These results offer the potential for application in breeding for barley cultivars with desired malting characteristics in a more accurate and precise manner. The cDNA libraries generated in this study are a useful resource for studies of other genes involved in malting.

Dr. Nora Lapitan is professor at the Department of Soil and Crops, Colorado State University (CSU), U.S.A. Dr. Lapitan is leading the wheat and barley genomics laboratory at the Department of Soil and Crops at CSU. She is well-known for her research contributions in the area of wheat and barley genomics, with special reference to genetic mapping and cloning of economically important plant genes.

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Enzymes: The Difference Between Malt and Feed Barley

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Barley has been cultivated as a food source for many thousands of years. During the 20th century, considerable knowledge was gained on producing barley varieties with quality attributes that were more suited to a specific end-use, namely alcoholic beverages. Most countries that produce barley have malt and feed classifications. Typically, barley classified as feed is comprised of either varieties that are not suited biochemically for malting or have failed to meet malting industry delivery specifications. In several countries, including Australia, more barley is used for feeding cattle than in beer production. Anecdotal evidence suggests that malt varieties are best for feeding cattle, but insufficient data has been available to support this generalization. We have undertaken a study comparing detailed malt quality traits with feed quality traits on more than 30 varieties to ascertain a scientific basis to this theory. Results indicate that most of the resting grain components are required at similar levels for each end-use, i.e., high levels of starch, low levels of fiber (thin husk) and nonstarch polysaccharides, and moderate levels of protein. The most significant area of difference is the need for malt varieties to produce moderate to high levels of hydrolytic enzymes that break down endosperm components during malting and mashing. Varieties that performed especially well in both end-uses, i.e., good malt quality and improved animal performance, were current malting varieties. These results demonstrate that barley breeding programs can effectively select breeding lines for both malt and feed quality by focusing on malt quality and selecting lines with high levels of enzymes.

Glen Fox has been associated with the Australian malting industry since 1985. He has a graduate diploma in malting and brewing, an M.Sc. in biotechnology, and is currently undertaking a Ph.D. degree in barley biochemstry and genetics. He is a member of the Institute and Guild of Brewers (Analytical subcommittee), American Society of Brewing Chemists (Wort Color subcommitte), and Royal Australian Chemical Institute (Cereal Chemistry Division - Convenor Dumas Nitrogen subcommitte).

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Improved Assay for Barley Seed and Green Malt Proteases

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Protein hydrolysis and remobilization during malting is a critical process in malt production, ultimately contributing to beer quality. However, the process is complex, involving both storage and other grain proteins as substrates and a large number of protease activities representing all four protease classes (cysteine, serine, aspartic, and metalloproteases) in both cellular (aleurone) and acellular (endosperm) tissues. Many details of protein remobilization are still poorly understood. Further research on these mechanisms would benefit from efficient protease assay systems. Previous assays have involved following disappearance of seed proteins by HPLC or PAGE as well as by protease activity on artificial substrates. Several years ago, Jones et al. (*Anal. Biochem.*, 1998) described an assay system utilizing an artificial substrate (Azogelatin), which provided several improvements over previous assays. However, the Jones Azogelatin protease assay required in-house synthesis of the dye-labeled gelatin substrate, used relatively large volumes (1 mL) of tissue extract, and involved several sample manipulations during the assay (precipitation, centrifugation, and sample transfer) prior to spectrophotometric analysis of azo dye-labeled protein fragments released during protein hydrolysis. Several fluorescently labeled protease substrates are commercially available that offer significant advantages and can be utilized in an improved protease assay. Upon protease activity and protein hydrolysis, a fluorescent signal is generated that can readily be measured and quantified. This assay offers a number of improvements over previous assays in that it can measure protease activity continuously as well as in end-point mode without significant sample handling, it requires microliter rather than milliliter sample volumes, and uses commercially available substrates rather than depending on in-house substrate synthesis. The assay can be routinely run in a microplate-based spectrofluorimeter, reducing reagent volumes and sample requirements while increasing sample throughput capacities. The solution assay is readily quantifiable, shows inhibition by class-specific protease inhibitors, and can be performed over appropriate physiological pH values. It can be adapted for 1- and 2-D PAGE systems. The assay may show utility for in situ analysis of protease localizations in barley and other seeds. Specific assay details and examples will be provided.

Mark Schmitt received his Ph.D. degree in plant physiology and biochemistry from the University of Wisconsin-Madison in 1983 and recently joined the USDA ARS Cereal Crops Research Unit in Madison as a research chemist.

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Effect of Fermentable Sugars and Amino Acids on Fermentability of Malts Made from Four Barley Varieties

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A malting barley variety must be capable of producing a malt that will show good acceptable fermentability if the variety is to be accepted for commercial production. The factors that affect fermentability, though, are poorly understood. The nutrients in malt that are available to yeast, predominantly fermentable sugars and amino acids, are considered to be the most important factors in determining fermentation. The current study investigated the fermentability of malts made from four samples of barley originating in Canada (AC Oxbow and Harrington) and Australia (Schooner and Stirling). Levels of fermentable sugars and amino acids were monitored during fermentation. AC Oxbow and Harrington, the varieties with the highest levels of starch-degrading enzymes, fermented significantly better. These varieties tended to produce worts with higher levels of fermentable sugars, but only glucose and total fermentable sugars correlated significantly with fermentability. Initial levels of amino acids were found to differ significantly among varieties, but this had no significant effect on fermentability. Differences in initial levels of amino acids could, however, have implications on other end-use properties, such as beer flavor.

Dennis Langrell received a diploma in biochemical technology in 1975 from Red River College and a B.Sc. degree in chemistry in 1985 from the University of Winnipeg, both located in Winnipeg, Manitoba, Canada. He began employment with the Canadian Grain Commission's Grain Research Laboratory (GRL) in 1975 and has held several positions involving malting barley quality analysis and research. Since 1993, he has been employed as a malt quality monitoring chemist in the Applied Barley Research Section of the GRL, reporting to Michael J. Edney. He has been a member of ASBC since July of 2000.

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Quality of Buckwheat Malts Germinated at Different Temperatures

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Buckwheat is a pseudocereal that is highly functional and has the potential to be used as an ingredient in the production of beer. It has a high percentage of starch. Buckwheat starch contains 24% amylose and 76% amylopectin, which is a usual composition in true cereal starches. Furthermore, buckwheat is high in protein and essential amino acids. The objective of this study was to evaluate the impact of germination temperature and raw material on the quality of buckwheat malt. Buckwheat (*Fagopyrum esculentum*) with and without hull has been germinated for 3 days at four different germination temperatures: 9.5, 14.9, 16.5, and 20.2°C, while steeping and kilning conditions remained unchanged. Differences between buckwheat with hull and buckwheat without hull were observed in malting loss, alpha-amylase activity, filterability, extract percentage, and mostly, in the level of free amino nitrogen (FAN). In general, it can be said that buckwheat without hull performed better than buckwheat with hull, with special emphasis on the level of FAN. In contrast to that, malting loss of buckwheat without hull was very high and filterability was poor. The best characteristics of buckwheat malt and resulting worts were obtained with buckwheat germinated at 16.5 and 20.2°C. Gelatinization temperature, soluble nitrogen, and FAN showed similar values in barley malt and buckwheat malt, which was germinated at 16.5 and 20.2°C. Total proteolytic activity was approximately 50% of what is present in barley malt. Both alpha- and beta-amylase activity are low in malted buckwheat. Maximum activity of alpha-amylase was 47.79 ± 0.71 units/g in buckwheat without hull germinated at 16.5°C, compared with 105.89 ± 1.92 units/g in malted barley. Maximum activity of beta-amylase was established in buckwheat with and without hull germinated at 20.2°C; 138.56 ± 13.49 and 135.49 ± 2.33 units/g d.w. malted buckwheat, respectively, compared with 533.16 ± 4.38 units/g d.w. malted barley. The highest value of apparent fermentability, 55%, is reached when buckwheat with or without hull is germinated at a temperature of 20.2°C. This is low compared with apparent fermentability of barley malt, which reached a value of 82.7%. Overall, it can be concluded that it is possible to produce buckwheat malt and that the germination temperature, as well as the type of raw material used, has a significant impact on the malt quality.

*Hilde Wijngaard received an M.Sc. degree in food technology in August 2002 from Wageningen University in Wageningen, The Netherlands. As part of her studies, she carried out a master's thesis entitled "New milling and mashing-in techniques in the brewing industry". She also carried out work experiences in a commercial brewery and at the malting and brewing facility of the National University of Ireland, Cork. At the National University of Ireland, Cork, she worked on the use of enzymes in barley brewing. Hilde has been the author of two peer-reviewed papers and several abstracts. In January 2003, she started her Ph.D. thesis in the area of malting and brewing in the pilot research facility of the department of Food and Nutritional Sciences at the National University of Ireland, Cork. The topic of her thesis is malting and brewing with buckwheat (*Fagopyrum esculentum*).*

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Mathematical Models for Predicting the Effect of Electron-Beam Radiation on the Safety and Quality of *Fusarium*-Infected Malting Barley

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The objective of the study was to use mathematical modeling to examine the influence of electron-beam radiation on the safety and quality of *Fusarium*-infected malting barley. Three barley samples (200 g), each with deoxynivalenol (DON) concentrations of 0.10, 0.40, 1.20, and 1.27 µg/g, were irradiated at 0, 2, 4, 6, 8, and 10 kGy at Surebeam Corporation, Chicago. Treated barley was pilot malted. Barley and malt were analyzed for *Fusarium* infection (FI), germinative energy (GE), aerobic plate counts (APC), mold and yeast counts (MYC), and DON. Malt quality parameters included malt extract, soluble protein, wort color, wort viscosity, malt loss, free amino nitrogen (FAN), alpha-amylase, and diastatic power. Response surface regression models were developed with safety and quality attributes as response variables and electron-beam dosage and DON concentration as the predictor variables. The performance of the models was evaluated by examining the correlation coefficient (R-square) for each individual model. The values of R-square for the fitted models ranged from 0.5908 to 0.9578. The fitted models also allowed predicting the optimum DON/dosage concentration that can cause maximum or minimum effect on the safety and quality attributes. For barley with 0.66 ppm of DON, it was predicted that radiation dosages above 2 kGy can significantly cause reduction in FI. APC and MYC were predicted to be minimum at 11.6 and 15.5 kGy for barley with 0.69 and 0.10 ppm of DON, respectively. For barley with 0.10 and 1.27 ppm of DON, dosages below 8 and 3 kGy, respectively, were predicted to cause no significant impact on germination. For barley with 0.1 ppm of DON and treated with 8 kGy, the malt extract was predicted to be minimum. Similarly, for barley with 0.10, 0.60, 0.80, 0.99, 1.06, 1.38, and 1.42 ppm of DON, treated at dosages 9.9, 0.1, 21.9, 9.2, 19.0, 10.5, and 22.8 kGy, the rootlet growth, malt moisture, diastatic power, amylase, FAN, soluble protein, and malt DON were, respectively, predicted to be minimum. Malt weight was resistant to radiation and was predicted to be not affected until dosages of 24 kGy. For barley with 0.40 ppm of DON, dosages above 2 kGy were predicted to cause significant reduction in wort color. For 1.20- and 1.27-ppm barley, at dosages 28.0 and 8.7 kGy, the wort color was predicted to be minimum. The models developed in this study were validated for levels of radiation ranging from 0 to 10 kGy and DON concentrations ranging from 0.10 to 1.27 ppm. Maltsters utilizing mildly *Fusarium*-infected malting barley may use these models to predict the response of safety and quality attributes to electron-beam radiation.

Bala Kottapalli received a bachelor's degree in dairy technology from Osmania University, India, in 1999. Bala received a master's degree in cereal and food sciences from North Dakota State University in 2002. Currently, Bala is working on a Ph.D. degree in food safety at the same university. Bala is working as a research assistant (2000–present) under the supervision of Dr. Charlene Wolf-Hall. Bala's research concentrates on preventing the postharvest Fusarium *growth and mycotoxin production in malting barley. Bala is an active member of the American Society of Brewing Chemists, Institute of Food Technologists, Phi Tau Sigma (honor society for food science), and International Association of Food Protection.*

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Single Malt Kernel Homogeneity Analysis and Processability of Malt

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For a long time, brewers have been looking for methods to describe malt quality. Even if the used methods do not describe malt quality, the classical malt contracts contain a lot of parameters that have to be fulfilled. Looking back to history, every brewer will find years with malt qualities that are not corresponding to the contract, but good beers have been produced. Classical analysis methods describe mean values of certain parameters. A confirmed amount of malt will be brought to analysis for protein, water content, starch amount (extract), and sometimes certain enzyme activities. When this malt is used in the brewery for wort and beer production, other qualities are important for the brewer. If lautering problems occur or the filtration process stops earlier than expected, an intensive review of the analysis results of the malt will be done. Normally, nothing unexpected is seen. It has been the work of the last few years to develop a new analysis method that is based on near infrared light. Dr. Frank Rath, Versuchs und Lehranstalt für Brauerei, Berlin, together with INB Erdmann, developed a single malt kernel homogeneity analysis instrument. New standards have to be set for the quality control of malt. A new evaluation scheme was set up to do the calibration of the new analysis parameters, the behavior of the wort in the brewhouse, and the beer in the fermentation plant and the filtration cellar. The start of the project was set up with an NIR calibration of single malt kernels compared with the Calcofluor staining method to detect unmodified areas within a single kernel. The results describe the homogeneity of a malt batch. Single-kernel protein analysis was done with the Dumas method. Due to the nondestructive NIR measurement of the single kernels, the measured kernels could be taken for calibration with standard methods. During the last few months, a lot of single-malt brews and fermentation were done. The results were correlated with the NIR results of the single malt kernel analysis. The mathematical focus was set on the correlation between a descriptive number of the behavior of the malt in single production steps and the analysis results of the NIR methods. The results of this comparison will be shown. A focus will be set on the mean values, the standard deviation, and the distribution of single values within one batch. Looking into future a optimization of malt batch homogeneity seems to be possible. Plant breeders might have new selection markers due to a nondestructive presorting of single kernels. Together with optimized growing conditions on one single field due to optimized quality control of growing factors, such as nitrogen supply, malt quality might increase. A major step to homogenous and reproducible beer production will be possible.

Dr. Frank Nitzsche was born in 1960. He completed his education to become a brewer and maltster at Veltins Brauerei, Germany, between 1981 and 1983. He received a master's degree in brewing science at TU Muenchen-Weihenstephan in 1988. His Ph.D. work was done with Prof. Dr. Narziss until 1991. Since then, he worked for Koenig Brauerei as head of the R&D department at Koenig Brauerei until 1994 and as head QA until 1997. He currently is responsible for production and QA. In 1999, he founded Easyproof Laborbedarf GmbH, which works mainly on fast microbiological detection methods.

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Optimal Malt Quality and Lautering Problems—Identification of Enzyme Activities to Optimize Processability of Malt

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It is quite common that breweries have detailed specifications for the buying of brewing malt and barley. During the last few years, it sometimes happens that in spite of a "good malt quality", according to the malt analysis results, the malt processability is worse. Especially when the brewer has a closer look at the lautering properties and the filtration capability. Some biotech companies sell specific enzyme combinations to breweries to overcome these unwanted problems. Within these studies, different malt qualities were used for evaluation. The main analysis was the lautering test developed by Weissheimer maltery, Andernach, Germany. Additional analyses, such as sugar composition of the produced worts and classical malt analysis, were done and taken into comparison to the behavior of the wort. It could be shown that there is not necessarily a significant combination of optimized malt quality results and the behavior of the wort in the lauter test. Using different enzyme samples, it was possible to identify significant macromolecules that have a major impact on the filtration behavior of wort. These results show new groups of compounds that have not been mentioned to have major processability influence. Analyzing the processes in a maltery gives a major hint for improving "unvisible" malt quality. Optimized and improved quality estimation within the different stages of malt production conditions have been able to overcome the limitations of enzymatic degradation of these substances. Increasing malt qualities were tested in industrial scale by evaluating lautering quality. The lecture will show test conditions for micro- and industrial-scale malting, used enzyme activities within the malt analysis, and results achieved within the industrial wort production.

Dr. Frank Nitzsche was born in 1960. He completed his education to become a brewer and maltster at Veltins Brauerei, Germany, between 1981 and 1983. He received a master's degree in brewing science at TU Muenchen-Weihenstephan in 1988. His Ph.D. work was done with Prof. Dr. Narziss until 1991. Since then, he worked for Koenig Brauerei as head of the R&D department at Koenig Brauerei until 1994 and as head QA until 1997. He currently is responsible for production and QA. In 1999, he founded Easyproof Laborbedarf GmbH, which works mainly on fast microbiological detection methods.

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Improvement of the Microbiological Analysis by Use of Real-Time PCR

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PIKA Weihenstephan GmbH

One major parameter for beer quality is the microbial stability. Due to ever-shortening production times, the need for fast detection systems is steadily increasing. This study examines the potential of the use of real-time polymerase chain reaction (PCR) analysis for breweries' production monitoring. Comparative data of enrichment and PCR analysis showed that the total analysis time can be reduced about two-thirds when using PCR. The identification of beer-spoiling bacteria and wild yeasts is done within 2 h; the routine analysis including enrichment can be completed within 2 days. Detection limits for different spoiling microorganisms in beer and brewery yeast samples are determined by PCR analysis after spiking with dilution series of bacteria and yeast. The configuration of PCR analysis systems for the routine application in a brewer's laboratory are introduced. The development of a PCR detection system for a new organism is shown considering, for example, a nonidentified isolate from a brewery. After the isolation of the bacterium, a ribosomal gene was sequenced. With DNA alignments, the comparison of the DNA sequence with those from databases, it was possible to develop specific primers for PCR detection. Data from different breweries searching for the source of an infection from the final packaged product upstream to the pitching yeast are demonstrating significant advantages of the PCR analysis against conventional methods. An infection of casked beer with the spoiling yeast *Dekkera*, which was not at all possible to detect in the brewery by standard enrichment methods, was identified and back-traced to its source with step-by-step PCR analysis during the brewing process. Another brewery was detecting Lactobacilli in the storage tank but could not find the source. Only after using PCR analysis, the beer-spoiling bacteria could be traced back to the fermenter. The PCR method that is already state-of-the-art in large breweries gives more detailed information, which was not available with the conventional enrichment methods. The PCR method is already standardized for the detection of beer-spoiling bacteria and wild yeast in the brewery, but its limits are not yet reached. Further applications might soon include the screening for toxin-producing molds or the identification of barley varieties.

Gudrun Vogeser received a master's degree in microbiology from Eberhard Karls University of Tuebingen, Germany. She was writing her doctoral thesis in 1993 at the Brewing Chair of the Technical University of Muenchen-Weihenstephan, Germany, and was working there as a senior scientist afterwards. In 2000, she founded the company PIKA Weihenstephan, a spin-off from the university, working there as general manager. She is member of the EBC subcommittee of microbiology since 1995.

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Detection of *Fusarium* spp. Using the Loop-Mediated Isothermal Amplification (LAMP) Method

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(1) Sapporo Breweries Ltd.; (2) Eiken Chemical Co., Ltd.

The contamination of grains with *Fusarium* adversely affects the quality of the produced beer (gushing). In addition, *Fusarium* spp. are capable of producing mycotoxins (nivalenol, deoxynivalenol, etc.), which are harmful to livestock and humans. The loop-mediated isothermal amplification (LAMP) method developed by Eiken Chemical Co., Ltd., is a nucleic acid amplification procedure that reacts under isothermal conditions and produces large amounts of DNA (10^9–10^{10} times in 15–60 min). The method is characterized by its use of four different primers specifically designed to recognize six distinct regions on the target gene and its process being performed at a constant temperature using a strand displacement reaction. Amplification and detection of the gene can be completed in a single step by incubating the mixture of the gene sample, primers, DNA polymerase with strand displacement activity, and substrates at a constant temperature (in the range of 65°C). The presence or absence of the target gene sequence can easily be detected just by judging presence of the precipitates (magnesium pyrophosphate) in the reaction mixture. Consequently, the LAMP method does not require any sophisticated equipment. The *Fusarium graminearum* group (*F. graminearum*, *F. cerealis*, and *F. culmorum*) is known as a disease agent for Fusarium head blight (or scab). We designed some *F. graminearum* group-specific primer sets with different levels of sensitivity, optimized the conditions for LAMP, and developed a rapid detection and identification method for barely or malt contaminated with the *F. graminearum* group. When the LAMP reaction was carried out using each primer set at 65°C for 1 h, they could distinguish the *F. graminearum* group from other *Fusarium* spp. and fungi belonging to another genus. The ITS primer set, one of the primer sets, was sensitive enough to detect one contaminated barley grain in 20 g of noncontaminated barley in model experiments. Moreover, when the LAMP reaction was carried out with a fluorescence reagent, the positive or negative reaction could be judged by the change in the reaction mixture color. A positive reaction produces a pale green color. In other words, this method is very simple and easy to detect the target without requiring electrophoresis or ELISA. Thus, we think that the LAMP method should significantly contribute to microbial quality assurance in barley production, malt production, and breweries.

Yasukazu Nakakita is a senior microbiologist at the Frontier Laboratories of Value Creation. He graduated from the University of Osaka Prefecture and investigated the bioactive compounds produced by soil microorganisms at the university and obtained a Ph.D. degree in agricultural chemistry. After studying Actinomycete at the Bristol-Myers Research Institute in Tokyo for 5 years, he joined Sapporo Breweries, Ltd., in 1989 and carried out the exploration of microorganisms producing bioactive compounds. Since 1994, he has been studying beer-spoilage bacteria.

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Insect Contamination Hazard in a Brewery

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Insect and other arthropod infestations that often create significant hazards for a portfolio of lager beers were examined in a brewery operating in northern Italy throughout different phases of processing. The rate of solid impurity contamination in raw materials was analyzed by filth test. Results showed low filth levels and emphasized the effectiveness of prevention strategies adopted by the suppliers. Hazards for barley and maize grit during siloing and milling processes were estimated by inspecting and monitoring the presence and frequency of pesting insects. Hazards in the brewhouse, filling, and packaging departments were also evaluated. Results suggest that raw material siloing and milling are relevant critical points due to the presence of barley powders and maize grit rejections, which support high infestation levels of *Ephestia kuehniella*, *Tribolium confusum*, and *Attagenus brunneus*. Relevant presences of Drosophilidae were registered where fermentations occur or exhausted yeast is stored or pressed. As well, Blattodea (*Blatta orientalis* and *Blattella germanica*) were detected in the basement, canteen, and warm-humid and dark vacant structures. Extra care should be taken in improving the levels of hygiene in breweries, especially in those locations where high levels in infestation were found.

Gianluca Donadini obtained a degree in biology in 1994. He began employment with one of the major company that produces and markets beer in Italy in 1998 as a quality assurance staff manager. As HACCP manager, he worked in a collaborative setting, where he established ties with suppliers, university, and the public health service. Since 1997, he has functioned as secretary for A.I.D.A.S.A (Italian Association for Food Defense and Environmental Hygiene), which operates at the Università Cattolica del Sacro Cuore in Piacenza, Italy. He was responsable for articulation, development, and administration of scientific research projects focused on packaging techniques, G.M.O., mycotoxin prevention, and IPM strategies. He has undertaken research that concerns mycotoxin contamination levels in finished beer and liquor mashing.

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Rapid and Automated Inspection System of Beer-Spoilage Bacteria

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Over the past decade, various kinds of microbial identification methods, including physiological identification methods, antibody techniques targeting to the species-specific surface antigen, and molecular biological diagnoses, such as the PCR method, have been markedly developed and made practicable in the food and beverage industries. However, these methods have not only required a cultivation process to grow the target bacteria for detection but also retained several problems with regard to rapidity, specificity, sensitivity, and quantification. In recent years, we have focused on the fluorescence in situ hybridization (FISH) technique, which was successfully applied as a tool to determine the enumeration and population of bacterial communities mainly in an environmental field and developed for the detection of beer-spoilage bacteria. Up until now, we have reported on the noble detection method to detect *Pectinatus*, gram-negative, beer-spoilage bacteria at the single-cell level using specific oligonucleotide probes on a membrane filter. In this study, we newly developed a detection method for the beer-spoilage Lactobacilli, gram-positive bacteria and produced an automated, high-throughput apparatus for the detection and validation of fluorescently labeled microorganisms on a membrane filter. This apparatus is equipped with the following functions: 1) a precise motorized stage that scans the whole surface of a 25-mm-diameter membrane filter and is autofocusing, 2) a high-resolution, highly sensitive CCD camera, and 3) an automated fluorescent filter switching function and algorism to determine whether or not each object is the target bacteria, which is optionally predetermined by the user. Our experiments, in which bacteria were spiked into beer, revealed that the noble bacterial inspection system using the FISH technique and the inspection apparatus had a generally higher sensitivity to detecting the bacteria compared with the conventional culturing method. In addition, it was demonstrated that the FISH technique coupled with the inspection apparatus allowed the species-specific detection of beer-spoilage bacteria within 6 h. We therefore concluded that this microbial inspection system had great potential for the rapid detection and identification of beer-spoilage bacteria without a cultivation step, which requires at least several days.

Takaomi Yasuhara received his M.S. degree in bioengineering from Osaka University, where he majored in yeast genetics directed by Prof. Y. Ohshima and began employment with Asahi Breweries, Ltd. in 1991. From 1991 to 1998, he had been engaged in fundamental research in oncology and allergology. Since 1999, he has been researching for brewing microbiology.

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High-Pressure Inactivation of Beer-Spoiling Lactobacilli

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High-pressure treatment can serve as a mild nonthermal technique for beer preservation. The application of this technique requires data concerning the degree and variation in pressure resistance of beer-spoiling-bacteria. For the description of a "worst case" situation, the most pressure-resistant strain can be determined and used to assess bacterial survival and sublethal injury after pressure treatment. Other levels of pressure resistance may indicate the variability within beer spoilers. For the identification of the most pressure-resistant beer spoiler, 31 isolates, preferably from spoiled beer, were pooled and exposed to a high-pressure treatment at 300 MPa in model beer. The surviving pressure-resistant cells were identified via DNA fingerprints, and *L. plantarum* TMW 1.322 was found as the most pressure-resistant strain. It exhibited a higher resistance to pressure than did other isolates, but the difference in cell counts as compared with less-resistant strains was less than one log after 30 min at 300 MPa. Following sublethal pressure treatments, the ability of these strains to survive in beer and the MDR transport activity involved in hop resistance were determined. A short pressure pulse with 300 MPa inactivated MDR-transport activity in the highly hop-resistant strain of *L. brevis* as described for *L. plantarum* TMW 1460 by Ulmer et al. (1). Accordingly, the addition of hop iso-alpha-acids to a level of 13 mg/L to the growth medium strongly delayed growth of pressure-treated cells of a highly hop-resistant *L. brevis* strain, while the growth of untreated cells remained unaffected. Taken together, the pressure required for a lethal effect is not determined by the degree of hop resistance. Thus, even potent beer spoilers can be inactivated by relatively low pressures. Moreover, mild pressure treatments result in the loss of hop resistance in beer-spoiling lactobacilli and thus prevent their growth and survival during subsequent storage. Therefore, high-pressure treatment is a suitable mild nonthermal technique for beer preservation. (1) Ulmer et al. 2002. Appl. Environ. Microbiol. 68:1088-1095.

Prof. Dr. Rudi F. Vogel was born in 1955 and is a biochemist (Universität Tübingen, Germany) interested in food microbiology and biotechnology. Since his habilitation on the genetics of lactobacilli (Universität Hohenheim, Germany), he is head of the Technische Microbiologie in the Department for Food and Nutrition of the Technische Universität München, Germany. He supervises and coordinates research on lactic starter culture development ranging from ecology and biochemistry to functional genomics, including several projects in brewing science and high pressure in food and biosciences. He is a member of the editorial board of scientific journals, international associations, and advisory comittees on food safety and genetically engineered organisms.

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Monitoring and Controlling Microbiological Contamination in the Beer Filling Area

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This paper presents recommendations on the monitoring and control of microbiological contamination in the packaging area. Microbiological contamination in the environment around the filler causes a number of problems, including slime and odor buildup on conveyors and processing equipment, potential slip hazards due to slime buildup on floors, potential health hazards associated with ingestion of airborne contaminants, and potential contamination of the packaged beer product. Filling and packaging areas in North American breweries typically are not sterile environments. Microbiological contamination can derive from several sources, including beer spillage, pooled water on floors, plant personnel, or airborne contaminants. Microbial contamination includes bacteria, yeast, and mold. Monitoring methods include the following. • Air-sampling devices to monitor airborne contamination. Air samplers can determine levels of bacteria and yeast/mold. Air samplers can be set up in various areas in filling and packaging to determine locations for contamination. Air-sampling test results from a beer-packaging facility will be discussed. • ATP testing to determine overall soil load on hard surfaces and in water. ATP testing provides "real time" results on soil and microbiological contamination. Results of ATP testing in a beer-packaging facility will be discussed. • Standard plate counts to identify and count specific microflora. Results of swab testing in a beer-packaging facility will be discussed. Control of microbiological contamination requires good sanitation practices and routine application of antimicrobial agents. As brewers seek to optimize their packaging equipment, the run times for filling increase and the frequency and time available for sanitation may decrease. Accordingly, the routine application of cleaners and/or antimicrobial agents to processing equipment during production is becoming more important. This paper discusses methods to automate the application of cleaners and sanitizers to processing equipment.

Joe Dirksen has a B.A. degree in chemistry from St. John's University, Collegeville, MN, and an MBA degree from the University of St. Thomas, St. Paul, MN. Joe is recognized as a certified food safety professional from the National Environmental Health Association. Joe has been employed by Ecolab Inc. for 24 years in a variety of positions including product development chemist, international R&D manager, brewery marketing manager, and brewery corporate accounts. Joe is currently senior technical coordinator and is responsible for the implementation of new sanitation technologies for the brewing and beverage markets. Joe has served as president of MBAA District St. Paul/Minneapolis and is currently the BOG representative from District St. Paul/Minneapolis. Joe is also a member of ASBC, International Society of Beverage Technologists (ISBT), and International Bottled Water Association (IBWA). Joe has presented several papers to the MBAA and ASBC on topics related to sanitation, effluent, and product security.

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Enhancing the Performance of Bottlewash Solutions

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The washing of returnable glass bottles continues to be an intergal part of the packaging process in several countries. While the basic bottle-washing chemistry appears to have remained unchanged over the years, packaging operations now face several new environmental and cost constraints that force them to extend the life of the cleaning solution. Increased brewery throughput is also stretching the capacity of the typical label extraction process and solution renovation equipment. Often, this results in an accumulation of insoluble label solids, which have been clearly identified as having a deleterious effect on the bottle appearance by leaving a film deposit on the bottle.These insoluble solids can be settled out; however, plants often lack solution tank capacity and the time to do proper settling and removal. A simple new process has been developed that utilizes existing plant equipment to accelerate the settling of these solids and restore the bottlewash solution. This enables the plant to carry out more frequent settling to keep the bottle-washing solution clean. This process reduces the overall operational costs by eliminating the incidents of quality holds attributed to film deposits and a less frequent wasting and recharging of the bottlewash solution.

George Agius received his master's degree in chemistry and was a lecturer in organic and physical chemistry. An MBAA member since 1987, George has contributed several technical presentations to MBAA meetings. He has held several research positions since 1982, leading to the position of technical director (1990) with JohnsonDiversey, where he was responsible for product development and customer support in North America. During this time, George directed the development of synthethic lubricants, new sanitizers, bottle scuff maskants, low environment impact CIP cleaners, bottlewashing programs, new pasteurizer treatments, and accompanying engineering systems. George is currently the technical director for brewing and beverage applications in North America.

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New Conclusions in Measurements of Permeation Through Plastic Bottles and Closures

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One of the main characteristics of beer flavor stability is the flavor stability threshold. Next to the storage temperature/duration, movement, and light, oxygen has an important influence on the quality properties of the beer. Packaging material, such as glass or metal, are nearly inert against the permeation of oxygen. The chemical properties of plastic materials allow gases to permeate along the partial pressure gradient between the inside to the outside of the package. A new test method to measure the permeation through plastic material will be presented. This new test method combines an oxygen-free bottle filling with an aging process. Every month during the aging process, the oxygen and carbon dioxide of 5 of 30 filled bottles were measured. This aging and the oxygen-free bottling imitate the filling, bottling, and aging process in praxis. Different plastic materials such as PET- and PEN-bottles and closures such as crown corks, plastic caps, etc. were examined. The results show that the oxygen uptake separated for the bottles and closures. Furthermore, the influence of scavenger on the permeation through the different materials was tested. The results of the permeation of one- and two-piece closures with or without scavenger are presented. The oxygen uptake and the reduction of carbon dioxide over a time period of half a year were observed.

Martin Orzinski attended an apprenticeship as industrial sales representative at PolyGram GmbH. In 2003, he received a Diploma Engineer in brewing science from the University of Berlin. In addition, he completed 8 months of industrial placements in breweries. Since January 2003, he began employment with VLB Berlin in the department institute for plant equipment and packaging technology.

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Feasibility Study of DLC-Coated PET Bottles for Beer

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Polyethylene telephthalete (PET) bottles are widely used for beverage containers in the world because of light-weight, unbreakable, and reclosable properties. However, the use of PET bottles for beer products is highly limited because of the property of an insufficient gas barrier, especially against oxygen ingress of PET. Thus, gas barrier enhancement technologies are highly demanded in the world beer market. Kirin Brewery applied diamond-like carbon (DLC), chemically inert amorphous hydrocarbon network, to PET bottles and achieved a unique PET bottle with a high gas barrier property against oxygen and carbon dioxide and an inactive property to flavor ingredients. Based on this special DLC coating technology developed by Kirin Brewery, various tests were performed to show the feasibility of DLC-coated bottles for beer containers. To evaluate the beer quality of DLC-coated PET bottles, a series of beer storage tests was performed. The beer quality was examined regularly based on sensory evaluation and chemical analysis. The result showed a high performance of DLC coating for the preservation of beer flavor and other characteristics. The physical, thermal, and chemical stability of DLC coating were also examined in consideration of the distribution environment. When DLC-coated PET bottles contained high carbon dioxide pressure of beer and they were heated to a high temperature that may occur in warehouses and hot climate areas, it was observed that these bottles maintained a high gas barrier property. Safety issues were confirmed along with FDA criteria, and general physical properties were examined in general surface analyses such as SIMMS, ERD, and RBS. While the performance of DLC coating has the most major impact on the gas barrier enhancement, the performance of the cap of a PET bottle is quite significant for the gas permeation through the whole bottle. Kirin Brewery tested high-gas-barrier caps for PET bottles in order to evaluate the applicability to beer products contained in DLC-coated bottles. These experiments not only established the quality and safety of DLC-coated bottles but also showed the wide applicability of Kirin Brewery's DLC coating technology to the size and shape of bottles. Thus, this technology can provide an innovative container for beer products.

Masaki Nakaya received an M.S. degree in plant biology from Tokyo University in Tokyo, Japan. He began working at Kirin Brewery in April 1997 as a packaging engineer of beer production lines in the Nagoya Plant. In October 2001, he has been a part of the Technology Development Department. From May 2002 to May 2003, he was also a visiting scholar of Michigan State University, taking academic packaging programs.

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New Approach to the Optimization of Filling and Packaging Lines by Efficient IT Applications

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Introduction: Breweries have a substantial interest in attractively packaging their high-quality products at low cost. This can be considerably supported by mechanisms of modern information technology. Yet these have not achieved wide acceptance. Approach: The goal of this study has been the development of innovative applications for the efficient use of information technology in bottling and packaging plants. It was carried out on the basis of a standard interface, specified for the connection of bottling and packaging machines to data acquisition systems. In the course of the project, the related guidelines have been extended in close collaboration to an industrial working party consisting of breweries (Hasseröder, Krombacher, Kulmbacher, Spaten Franziskaner, Warsteiner), system vendors (Proleit, Siemens, Syskron), and machine suppliers (Centro, Heuft, KHS, Krones, Metec, SIG, Stratec) and in coordination with other standardization committees (OMAC, VDMA). Increasing implementations of this standard provided the data required for description and modeling. Results: Fundamental results have been new insights in the downtime behavior of individual machines and complete filling lines. Extensive data analysis allowed the description of different machine types by key figures and to model their stochastic breakdown sensibility by mathematical distributions. Interactions caused by lacks and blocks in plant operation showed that a deteriorating influence on machine caused downtimes. This stop-and-go effect could be quantified for the first time by time-slot analysis. Based on this theoretical knowledge, components for the event discrete simulation of filling lines have been created. They enable the reproduction of industrial plants in virtual models that can be used for layout experiments and optimizations. With their help and by the use of a trainable expert system (ANN), an IT tool for automatic weak point analyses could be developed. Its pilot implementation in a German brewery evinced success. Further implementations are planned. Main development of the project has been a new control concept for bottling and packaging plants, in which a fuzzy controller for machine and conveyer speeds provides user-friendly setup with transparent control characteristics. As simulation studies proved, it increases the efficiency of bottling plants up to 5% and reduces stop-and-go behavior of machines remarkably. Conclusion: The results have been integrated in an overall plan for a higher level IT system. This is capable of initiating an innovative leap in the bottling and packaging branch. It will enable the efficient IT connection between varying machines and IT systems, better evaluation and quality control based on standardised data, and definite cost savings.

Dipl.-Ing. Tobias Voigt (born in 1973) studied at the Faculty Of Brewing And Food Technology in Weihenstephan. After several internships and practical experiences (Gentner Brewery, Wolframseschenbach; SPATEN-Franziskaner Loewenbraeu Brewery, Munich; Gordon Biersch Brewing Company, San Jose, CA, U.S.A.), he graduated as an engineer for brewing science and beverage technology. In April 1999, he was appointed as scientific assistant at the Chair Of Brewery Installations And Food Packaging Technology (Univ.-Prof. Dr.-Ing. Horst Weisser). His main fields of activity are data acquisition, control technology, line simulation, and knowledge-based optimization methods for bottling plants. In December 2003, he finished his doctoral thesis ("New techniques for the implementation of information technology for bottling plants") and he earned a Ph.D. degree in March 2004.

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Cost-Performance Analysis on Plastic Packaging Solutions for Beer

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BP Chemicals

The optimum plastic packaging solution for beer has been a constant debate in the industry. Decision variables that the brewer must consider are numerous and include returnable-refillable (Ret-Ref) versus one-way (OW) system, a wide range of barrier technologies, shelf life requirements, container size, and total systems cost. Although numerous plastic technologies have been offered to the industry, the vast majority of brewers are still waiting for the "perfect" solution. BP Chemicals has been working for several years with a variety of partners to develop competitive packaging technology compatible with the beer industry requirements. This analysis describes several cost-competitive, high-performance solutions based on customer requirements and technology availability. For Ret-Ref containers, the use of polyethylene naphthalate (PEN) is the clear solution of choice. PEN bottles have demonstrated their superior performance capability in Northern Europe for bottles ranging in size from 38- to 125-cL bottles. In South America, 39-cL Ret-Ref PEN bottles have helped a regional brewer to differentiate in a highly competitive environment, without sacrificing beer quality. Among the OW plastic options, there are two basic technologies, monolayer and multilayer. Within each technology, there are many competing variants. Some of these are commercial already, and some are still experimental, but all have as a main objective to be cost-competitive against glass. Multilayer bottles can be found commercially in highly developed markets, such as Europe and the United States. However, broad use of these containers is hindered because of environmental restrictions and/or economic costs. OW monolayer technologies offer the best potential for meeting both environmental and economic criteria. BP has commercially demonstrated that a 350-mL OW monolayer bottle made with a PETN copolymer and an oxygen scavenger (Amosorb) is a preferred solution for small regional distribution systems. For larger more complex distribution systems, which require longer shelf life, BP is working with a variety of partners to develop coated OW PET bottles by combining innovative coating technologies with the Amosorb oxygen barrier. The advantages of these OW monolayer solutions will be presented. BP Chemicals continues to be engaged in the promotion of plastic bottles to the beer industry and is actively participating in expanding the use of Ret-Ref PEN packaging and the development of monolayer technology. BP believes that both of these solutions offer the brewers the best opportunity to achieve market share growth in plastic packaging at the most economical cost.

Aida Aranda received a B.S. degree in chemical engineering from La Salle University and an M.B.A. degree from the Instituto Tecnologico Autonomo de Mexico (ITAM), both in Mexico City, Mexico. She began employment with BP in May 2000 as sales representative for the Specialty Intermediates Business Unit (SIBU), representing PIA, TMA, and NDC product lines. Since August 2001, she has functioned as marketing representative for the Polyester Intermediates North America (PINTA) Business Unit, focusing her efforts in market development for packaging applications and promoting NDC and Amosorb products for their use in beer and food packaging.

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Strategic Training System for Brewery Workers

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In a Japanese intense beer market, breweries are always required to produce beer of high and stable quality at low cost. The workers in a brewery play a key role to meet that demand, so we need to train them effectively and continuously. Therefore, in order to make workers skilled in beer production, we tried to establish a human resource management system, which was mainly composed of a training program for brewery workers. At the beginning, we listed all tasks for beer production and defined necessary skills for doing them in a precise manner. For example, about 70 kinds of skills were defined to be necessary for canning filler operation. And we determined the necessary training contents to acquire those skills. This structuring of tasks, skills, and trainings is the foundation of this whole system. Second, according to that structure, educational plans for each worker were established. Since the skills, which should be acquired by each worker, were very clear, it became possible to carry out a training program systematically. Furthermore, workers could tackle training with high motivation, because individual tasks and goals were very clear. Although training for workers are basically done by OJT, there is a limit to the degree and speed of acquiring skills by only doing OJT. It was thought to be indispensable that each worker knew why these tasks should be done and what was the background for the tasks, especially for highly advanced tasks. Therefore, we founded The Craftsman School, which offered short courses consisting of lectures and practices. The Craftsman School covers brewing, malting, packaging, plant maintenance, microbiological control, quality assurance, and IT, and through these courses, workers can acquire a good knowledge and deep understanding of beer production. With those activities, we got a training system that could promote our human resource management, and all brewery workers can now carry out educational activities as a body. As a consequence, many workers, as members for strategic tasks of the whole beer production activities, are playing an important role in big projects of the existing breweries, in the construction of a new factory, and in overseas breweries.

Hideya Sakamoto received bachelor of law degree from Kyoto University, Japan, in 1998. He began employment with Suntory Limited in April 1998 as an accountant. Since April 2000, he has been assigned to Beer & RTD Production Division, and he has been taking charge of human resource management, cost control, and public relations of breweries.

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The Optimization of Water Consumption in a Beer Brewery by Applying the Water Pinch Technology

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Musashino Brewery, Suntory Ltd.

The natural materials such as malt, hops, and water are the key elements for our beer. So we regard the natural environment as one of the management resources and always try to protect the global environment by saving energy and water consumption. Therefore, along with energy saving, reduction of water consumption has been a key issue in our brewery for years. In order to reduce water consumption, we made an attempt to apply a logical analysis method, which is called Pinch Technology, in one of our breweries. Pinch Technology was originally developed as an optimization technique for heat recovery in the early 1970s. In the same way, Water Pinch Technology makes it possible to find the best solution to optimize water consumption. By applying this method, we attempted to reach a water efficiency rate (fresh water consumption/beer production) of 5.5, which means the top level in Japan. At the beginning, in order to gain an understanding of actual total water consumption properly, the amount of inflow and outflow and the quality of water such as COD_{Mn}, TOC, temperature, pH, and conductivity were measured at each process. Secondly, based on these data, we classified the quality of using water into five levels, such as 1) water for brewing beer, 2) water to have prospects of mixing beer, 3) water to have no prospects of mixing beer, 4) water to flow outside package, and 5) water not to contact the products. As a general rule, fresh water must be used at the stage of levels 1 and 2 and recycling water can be used for the other three levels. Water Pinch Technology was applied to maximize the reuse of clean wastewater for levels 3, 4, and 5 water. Based on this study, we planned to conduct several kinds of improvement for the reduction, reuse, and recycle of water. If all of these measures are taken, approximately 25% of the total amount of water consumption will be reduced. The main parts are as follows. 1) Collecting the clean CIP rinsing wastewater to recycle as cooling water makeup. 2) Collecting the clean CIP wastewater to recycle as CIP prerinsing water after filtration treatment. 3) Reusing the treated water discharged from wastewater plant for level 5 water. 4) Installation of the cooling tower to the power plant equipments and so on. Recycling of CIP wastewater was found to be remarkably useful but that water contained some microorganisms. Therefore, the recycling plant was equipped with the 0.1-micron hollow-fibered membrane for the elimination of microorganisms. By introducing these measures progressively, the water efficiency rate over several years has been steadily improving toward the target. It is suggested that the application of Water Pinch Technology could be a useful tool for the reduction of water consumption in the brewery.

Tetsuji Yano received an M.S. degree in mechanical engineering from Waseda University in Tokyo. He began employment with Suntory Ltd. in April 2001 as an engineer in the Musashino Brewery. He has worked there since, in charge of saving energy and water consumptions.

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On-Line Biomass Monitoring with Scanning Radio-Frequency Impedance Spectroscopy

JOHN P. CARVELL
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Traditional radio-frequency (RF) impedance spectroscopy to measure the concentration of viable biomass is now commonly used in routine on-line monitoring of fermenters and cell culture vessels. Using RF impedance in a fixed radio-frequency mode, the method provides essential information on the live cell concentration and is routinely used in manufacturing systems in both brewing and biotechnology. The fixed radio-frequency mode is carried out at a relatively low frequency (0.3 MHz), and there is sufficient time for the cells to become completely polarized and the capacitance of the yeast suspension is high. In this paper, we present how additional real-time information about the condition of the yeast cell can be estimated by utilizing the full capacitance spectrum over a wide range of frequencies. The concept of measuring a loss in cellular polarization between 0.1 and 10 MHz (referred to as the beta dispersion) is introduced and we explain how shifts in the characteristic frequency (f_c), at which the rate of polarization is one-half complete, can be used to detect changes in cell morphology during fermentation. Future developments of this method could provide brewers with an instantaneous reading of the metabolic state of the yeast and an estimation of the mean cell diameter. Since the method does not require the addition of any reagents or sample pretreatment, it is ideal for on-line applications.

John Carvell is a graduate in biochemistry and he received his Ph.D. degree at Newcastle University, U.K. He gained 4 years of experience in large-scale yeast fermentation as a production manager of the UK Bakers Yeast Division of Gist Brocades, Holland. After 10 years in both the Process Development and Biotechnology Sales Divisions of APV and Alfa Laval, he joined Aber Instruments Ltd. of Wales in 1993 as a director. With the business being more than 90% export and split between both the biotechnology sector and the brewing industry, he spends a large proportion of time visiting key customers involved in diverse range of applications areas where the Aber technology has potential. As a member of the ASBC, MBAA, IOB, and SIM (Society of Industrial Microbiology), John presented posters at the ASBC meetings in Boston and Phoenix and the IOB Symposium in Perth, Singapore, and Adelaide. John also presented papers at the SIM Recent Advances in Fermentation Technology Symposium in Florida in 2001, ACS in 2002, and at both the ASBC and MBBA annual meetings in 2002. When time permits, John enjoys a number of activities including squash, fly fishing, and the occasional drop of quality warm real ale!

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Dry Beer Yeast—New Aspects of Rehydration, Storage, and Shelf Life

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(1) Lallemand Inc.; (2) Maska Laboratories Inc.

In this presentation, we identify parameters that will aid the yeast's activity in the fermentation application by reduction of the lag phase once the rehydrated yeast is added to the wort. This may also include an augmentation of the yeast activity once pitched in the wort that could occur without a reduction in the lag phase. Many parameters will influence the rehydrated yeasts viability and activity. In this presentation, we highlight the importance of the optimum pitching rate, rehydration temperature and medium, as well as the right storage conditions of dry brewer's yeast. This study on dry ale and lager yeast showed that brewer's yeast, in particular lager yeast, requires a lower rehydration temperature than do wine or baker's yeast. These results also demonstrate that dry brewer's yeast becomes more sensitive to temperature with age. The storage temperature of dry brewer's yeast influences the fermentation performance of the yeast. Although the viability of the yeast did not change significantly, the uptake of maltose was affected by the storage temperature. Finally, this study shows that dry brewer's yeast performs at least as well as liquid yeast if applied under the correct conditions.

Tobias Fischborn was appointed project manager for Lallemand Inc. in March 1998. He is now head of the brewing research and development group at Lallemand and is also responsible for quality control and quality assurance of all brewing-related products. With Lallemand's acquisition of the Siebel Institute of Technology in Chicago, Tobias oversees production and quality control of Siebel culture media and brewing yeast collection. He graduated from the Technical University Munich-Weihenstephan in 1993, where he obtained a degree in engineering in brewing and beverage technology. In 1993, Tobias started his Ph.D. degree at TU Munich-Weihenstephan to work with Prof. E. Geiger on research on behavior of lager yeast during drying. Prior to his studies in Weihenstephan, he worked as a brewer at Brewery Ph. & C. Andres in Kirn, Germany.

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Investigation into Genes that are Related to the Insufficient Growth of *Saccharomyces cerevisiae* at Low Temperatures

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Some variants of brewing yeast do not grow well at low temperatures but do so at high temperatures. In view of this trait, variants that do not grow well at low temperatures can be detected by cultivating bottom-fermenting yeast at 32–34°C. Using this method, we were able to detect those variants of brewing yeast that do not grow well at low temperatures, and based on the percentage of the total that these variants accounted for, we estimated the yeast's overall ability to grow at low temperatures. As a result of this experiment, it is now clear that the percentage of variants that do not grow well at low temperatures varies according to yeast cultivating conditions and that isolated strains that grow well at low temperatures frequently mutate into those that do not, but never vice versa. Also, for *S. cerevisiae* laboratory yeast, variants that grew exceptionally well at high temperatures were found to be unable to grow well at low temperatures. Specifically, *S. cerevisiae* variants that grew well at 38–40°C showed insufficient growth at low temperatures. We studied such ability by using *S. cerevisiae* laboratory yeast and cloned the *KEX2* gene. Compared with parent strains, the *KEX2* gene disruption strains did not grow well at low temperatures but did so at high temperatures. We transformed the isolated *S. cerevisiae* variants that did not grow well at low temperatures by introducing the *KEX2* gene into them. As a result of this transformation, some of the variants improved their ability to grow at low temperatures, but others did not. This result confirms that the *KEX2* gene is related to the *S. cerevisiae*'s ability to grow at low temperatures and implies that there might be genes other than *KEX2* that are related to insufficient growth at low temperatures.

Hiromi Yamagishi is a microbiologist at the Brewing Research & Development Laboratory, Asahi Breweries Ltd. She studied pharmaceutical science at Chiba University and joined Asahi Breweries Ltd. in 1985. She has been devoted to the research and development in brewing science, specializing in fundamental research of yeast physiology.

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Temporal Production of a Platelet-Activating Factor by Yeast (*Saccharomyces cerevisiae* and *Saccharomyces uvarum*) at Different Temperatures

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Reproductive Biology Associates

The biochemical performance of yeast during the fermentation process will significantly influence beer quality. Yeast produces a number of biochemical compounds, including platelet-activating factor (PAF; 1-O-alkyl-2-O-acetyl-sn-glycero-3-phosphocholine). PAF is a potent signaling phospholipid with pleiotropic physio-biochemical properties in addition to activating platelets. Since its discovery more than 30 years ago, PAF has been reported to be present in a variety of cellular systems. PAF appears to be of critical importance for many cellular events, including division and metabolism. Additionally, it has been suggested that PAF can be used as a biomarker for quality control. Yeast (*Saccharomyces cerevisiae*) cells produce PAF, and this unique biochemical controls the cell cycle phase in budding yeast. The study objective was to determine temporal PAF production by two yeast strains (*Saccharomyces cerevisiae*, ale; *Saccharomyces uvarum*, lager) at different culture temperatures (4, 14, 23, 37, and 37°C). Yeast cells (Wyeast Laboratories, Odell, OR; provided in kind by Beer Necessities, Alpharetta, GA) were cultured in 10% DME in water medium for 100 h. At different culture times (30 min to 100 h), an aliquot (100 µL) of medium was removed for PAF analysis by a specific radio-immunoassay [^{125}I] according to manufacturer's instructions (NEN Research Products, DuPont, Boston, MA). Data were analyzed by Student's t-test, analysis of variance and the Tukey test. A total of 120 yeast cultures were analyzed for PAF content as described. The overall mean (±SEM) PAF level was 40.99 (±2.54) pM/10^6 cells, the range was 67.1 pM/10^6 cells, with maximum and minimum levels of 68.8 pM/10^6 cells and 1.70 pM/10^6 cells, respectively. There was a significant difference ($P < 0.001$) between ale (16.35 ± 1.28 pM/10^6 cells) and lager (26.68 ± 2.15 pM/10^6 cells) yeast in PAF levels. Both culture temperature and time had significant ($P < 0.001$) effects on PAF production. There was a cyclic pattern to PAF production in both yeast varieties; however, this was most evident in the lager strain. The data confirm that brewer's yeast produces PAF and production levels are cyclic in nature and are strain and temperature dependent. Additional studies are warranted to determine the significance of PAF in yeast cell physiology and its impact on beer quality.

William E. Roudebush received a B.S. degree in agricultural science from Morehead State University, Morehead, KY, an M.S. degree in physiology from Ohio State University, Columbus, OH, and a Ph.D. degree in developmental biology from Michigan State University, East Lansing, MI. He began employment (2000) with Reproductive Biology Associates as director of the clinical laboratory, prior to that he was a professor at the Medical University of South Carolina, Charleston, SC. Dr. Roudebush has published more than 60 papers and book chapters plus presented more than 100 abstracts at national and international meetings in the field and is a leading expert on platelet-activating factor.

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Anaerobiosis Stress Response in Brewing Yeast Strains

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(1) Oxford Brookes University; (2) Scottish Courage Brewing Ltd.

Brewing yeast strains are propagated in aerobic conditions in wort. The resulting biomass is then inoculated into fresh wort and a fermentation occurs that involves the transition from aerobic to anaerobic conditions. The impact of the down-regulation of "aerobic" and the up-regulation of "anaerobic" mannoproteins on brewing yeast cell wall composition and functionality has not been previously studied but is highly relevant to the process of flocculation (cellular aggregation), which occurs toward the end of fermentation. In haploid laboratory strains, it has been reported that the transition from aerobiosis to N_2-induced anaerobiosis results in the down-regulation of *CWP1* and *CWP2*, which encode cell wall mannoproteins. Furthermore, this is accompanied by an up-regulation of *DAN1*, *DAN2*, *DAN3*, and *DAN4*, which putatively encode wall mannoproteins, although their functionality has not been established. The *DAN* genes have been detected in ale and lager brewing yeast strains using PCR, and the sequences of these genes have been established. Their expression in the wild-type *Saccharomyces cerevisiae* haploid laboratory strain S288C and brewing strains has been investigated during aerobiosis and N_2/CO_2-induced anaerobiosis using real-time quantitative PCR. Furthermore, the expression of the *DAN* proteins has been assessed using 2D-gel electrophoresis during the transition from aerobiosis and N_2/CO_2-induced anaerobiosis.The function of the *DAN* genes has been investigated and their potential role in fermentation will be discussed.

Stephen Lawrence received a 2:1 honours degree from the University of Sheffield in 2002 with specializations in molecular biology and microbiology. It is due to his study of fungi molecular biology that led him into yeast biology. Stephen started a Ph.D. program in October 2002 at Oxford Brookes University, studying the brewing yeast responses to anaerobiosis. Stephen is supervised by Dr. Katherine Smart at Oxford Brookes. His Ph.D. study is funded by the Morrison-Inches Educational trust and cosupervised by Dr. Jeff Hodgson from Scottish Courage Brewing Ltd.

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Yeast Handling and Cold Shock Stress

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Yeast brewing strains are exposed to low temperatures throughout fermentation and yeast handling. It is suggested that exposure to these cold temperatures is detrimental to yeast quality and may, therefore, adversely affect subsequent fermentation performance. Tolerance to cold is strain dependent with ale strains exhibiting a lower resistance than lager strains. Furthermore, cold storage results in a loss in cell viability, implying that cold temperatures represent a stress to brewing yeast. Despite this, the temperatures used to store yeast between fermentations has not previously been considered to be stressful. Exposure of brewing yeast to stress is typified by the expression of the global stress response, which represents a nonspecific defense that is activated following exposure to several types of stress. The response involves the up-regulation of genes involved in the synthesis of glycogen, trehalose, heat shock proteins, ubiquitin, DNA repair proteins, and enzymes such as catalase. The activation of the global stress response during exposure to cold shock has been investigated using the representative biomarkers glycogen, trehalose, catalase activity, and the expression of the heat shock protein HSP104. The response was observed to be strain dependent. The impact of cold shock stress on yeast quality is discussed.

Jessica Leclaire graduated from the University of Wales, Cardiff, in 2001, with a B.Sc. degree (Hons) in biotechnology. She is currently with the Yeast Research Group at Oxford Brookes University in the third year of her Ph.D. work. The title of her project is "The cold shock response of Saccharomyces cerevisiae*". Jessica has presented her research at several brewing and yeast congresses.*

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Genome-Wide Analysis of Gene Expression for Hydrogen Sulfide Production in the Bottom-Fermenting Yeast *Saccharomyces pastorianus*

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The amount of hydrogen sulfide (H_2S) produced by yeast during fermentation has a significant effect on beer flavor. Control of H_2S production is important in brewing due to its very low threshold for detection. H_2S is formed as an intermediate during reductive sulfate assimilation, which leads to formation of the sulfur-containing amino acids methionine and cysteine. Typically, a cropped yeast from one fermentation is continuously reused to pitch subsequent lager fermentations. The physiologic state of the cropped yeast is thought to influence the quality of the subsequent fermentations. DNA microarray analysis has recently been used to compare genome-wide patterns of gene expression in the bottom-fermenting yeast *Saccharomyces pastorianus*. Here, we investigated the relationship between the physiological state of the cropped yeast and its ability to produce H_2S. A strain of *S. pastorianus* was used to ferment wort at a normal and at an elevated temperature and was then cropped and subjected to microarray analysis. The ability of the cropped yeast to produce H_2S during the subsequent fermentation was also analyzed. H_2S production by the yeast cropped from the fermentation conducted at the higher temperature was greater than that at the normal temperature. Expression of genes involved in reductive sulfate assimilation was found to have increased in the yeast cropped from the fermentation conducted at the higher temperature, suggesting elevated consumption of methionine. Therefore, we examined the effect of adding methionine to the wort. H_2S production by the yeast cropped from the fermentation supplemented with methionine was found to be lower. DNA microarray analysis indicated that the addition of methionine resulted in a decrease in the expression of genes involved in the sulfate assimilation pathway. These data suggest that H_2S production can be controlled by alteration of fermentation conditions and wort composition.

Toshiko Minato graduated from Tokyo University of Agriculture and Technology in 1992. She works for Central Laboratories for Key Technology, Kirin Brewery Co., Ltd.

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Measuring Oxidative Stress in Yeast Cells—A New Approach to Look into Yeast Cells

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During the last few years, new analysis methods have been implemented in the evaluation of yeast quality. Besides sum parameters, such as acidification power test or glycogen content in a yeast population, fluorescence-based methods give a more detailed view on the statistical distribution of the amount of certain classes of substances within one yeast population. Flow cytometric-based methods, such as the discrimination of live or dead cells, the lipid content in cell walls, or the glycogen content in every single cell, allow a more detailed view into the cell. This work describes the first steps in the measurement of the intracellular oxygen content in yeast cells during fermentation with flow cytometric methods. Focus is set on oxygen molecules that are available in a "free" state in the cell. The detection of radical or singlet oxygen molecules will give information on major changes within a fermentation, especially within the first hours of fermentation. As it is known, yeast has to undergo the change of the aerobic metabolic pathways to the anaerobic pathways. Measuring oxygen in the cells will first give detailed information about oxygen accumulation in the cells and the differentiation of different oxygen molecules, such as singlet oxygen or bound oxygen. During secondary fermentation, one of the major reactions is the conversion of 2-acetolactate to diacetyl. As published, this reaction is catalyzed by the presence of oxygen.

Dr. Frank Nitzsche was born in 1960. He completed his education to become a brewer and maltster at Veltins Brauerei, Germany, between 1981 and 1983. He received a master's degree in brewing science at TU Muenchen-Weihenstephan in 1988. His Ph.D. work was done with Prof. Dr. Narziss until 1991. Since then, he worked for Koenig Brauerei as head of the R&D department at Koenig Brauerei until 1994 and as head QA until 1997. He currently is responsible for production and QA. In 1999, he founded Easyproof Laborbedarf GmbH, which works mainly on fast microbiological detection methods.

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Key Enzyme Activities and the Physiological State of Brewing Yeast During Propagation and Fermentation

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Despite the fact that yeast is considered by some to be the most important raw material in the brewery, there is still no exact, reliable method to describe the physiological state of yeast accurately. Current methods of analysis are time-intensive, resulting in the inability to take corrective action during the actual process. With the help of enzyme kinetics, we have developed a new, rapid (90 min), and accurate method to define the physiological state of brewing yeast. In the process of making medical diagnoses, measurement of enzyme activity is essential for detecting changes in metabolism and its connection to disease. This knowledge can be applied in the detection of changes in yeast metabolism, as well, in order to make predictions about the physiological state of the yeast during propagation and fermentation. Currently, we have sucessfully measured the activity of four enzymes (alcohol dehydrogenase, alpha-glucosidase, pyruvate decarboxylase, and pyruvate dehydrogenase) that play a key role in yeast metabolism. One yeast strain from the Hefebank Weihenstephan was investigated during propagation and fermentation and the behavior of the enzymes were observed. We found a relationship between enzyme activity and the physiological state of the yeast. Using the ratio of pyruvate dehydrogenase and pyruvate decarboxylase enzyme activity, we can track typical behavior during propagation. Later in our research, we were able to determine that a high level of activity of several enzymes at the beginning of the fermentation leads to a faster fermentation. Currently, we are investigating the influence of oxygen at the beginning of fermentation. Due to the known negative effects of oxygen on the flavor, the antioxidants, and the colloidal stability of beer, we are attempting to establish whether or not oxygen is necessary when using yeast in an optimal physiological state. Based on the results of this research project, we have developed a simple, low-cost method to determine the physiological state of yeast. The implications of this research would be applicable not only in larger breweries but in smaller breweries as well. This method offers new ways to improve the structure of yeast management, resulting in shorter fermentation times and improvement of beer quality. Another application of this research is to compare the behavior of a single yeast strain being used in different breweries. As use of this method becomes more widespread, it will then be possible to compare different yeast strains with each other.

Urs Wellhoener was born in 1972 in Bonn, Germany. Urs is a technical graduate as brewer and maltster (1991–1993), received the degree of Diplom-Engineer at the Faculty of Brewing and Food Technology of the Technische Universität München (TUM) (1993–1999), and was a cooperator on a yeast project at Veltins, Meschede-Grevenstein (1999–2000). Since 2000, Urs has been a scientific assistant and doctorate at the Chair of Brewing Technology II at the Weihenstephan Center of Food and Life Sciences, Technische Universität München (TUM). Urs focuses on analyses of the physiology of yeast during fermentation and propagation.

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Filtration Characteristics of Fermented Wort Mediated by Yeast Strain Selection

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Optical clarity is an important consumer expectation for many fermented beverages, such as beer and wine. The well-documented causes of haze are largely concerned with the raw materials, such as the levels of such compounds as beta glucan in malt and pectin in wine, and process parameters, such as shear stress during mashing. Little attention has been given to the contribution of the yeast strain to this important criterion. Filtration is often required in the processing of these products to achieve suitable clarity. However, filtration not only contributes to production costs and results in production losses, but product quality may also be adversely affected. Previous work by this laboratory revealed the widespread occurrence of the secretion of invertase and other proteins into the medium by yeast strains. Importantly, variation in this trait prompted an evaluation of the extent to which the choice of yeast strain affected the filterability of the fermented product and the haze in the filtered product. Beer was made under laboratory conditions using hopped malt extract and was fermented using a number of strains of brewers', bakers', distillers', and laboratory yeast. After a period of maturation, the beer was filtered according to standard methods to determine the filterability (V_{max}). The filtered beer was also evaluated for initial haze and haze shelf life according to EBC procedures. Marked differences were seen between the beers in these measured parameters depending on the yeast strain used in the fermentation. An investigation of the secreted proteins by SDS polyacrylamide gel electrophoresis and a variety of staining methods has allowed quantification and broad characterization of the proteins and glycoproteins secreted by individual strains. The ability of a protein concentrate to influence filtration characteristics in beer was also investigated.

Philip Douglas has a B.Sc. degree in microbiology from Aberdeen University (1980) and an M.Sc. degree in malting and brewing from Heriot Watt University (1983). After working in breweries in the U.K., Australia, and Bolivia, he is now undertaking Ph.D. studies in the School of Agriculture and Wine at the University of Adelaide.

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Improving the Prediction and Monitoring of Brewing Yeast Performance Using Flow Cytometry

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Using flow cytometry, we measured intracellular proteinase A (PrA) activity, trehalose, glycogen, and DNA content of yeast during high gravity (20°Plato) and sales gravity (12°Plato) fermentations. Flow cytometry is a low invasive and near real-time method of assessing the physiological state of a large number of individual cells within a yeast population and can be applied in an industrial environment. In addition, recognized brewing parameters (yeast viability, pH, attenuation rate, external PrA activity, amino acid and sugar spectra) were monitored throughout the fermentations.The proteinases of *Saccharomyces* yeast are located in the vacuole but, due to missorting during the transport from the cytoplasm to the vacuole, PrA or its proform is excreted into the surrounding media instead of being delivered to the vacuole. Previous research suggests that foam-positive hydrophobic polypeptides are degraded by PrA, leaving beer with reduced foaming potential. Yeast proteinases also play an important role in the apoptosis (cell death) and autolysis of yeast cells. PrA thus leaks into the fermenting wort and exerts a negative impact on beer foam stability. Stress factors, such as high osmotic pressure and ethanol, during high-gravity brewing may impact these mechanisms. The aim of this presentation is to correlate the physiological state of yeast with PrA excretion and foam stability. Furthermore, we sought to gain a greater insight into how other fermentation parameters influence the physiological state of yeast cells and, hence, the concentration of intracellular and excreted PrA. Our work suggests that intracellular accumulation of PrA indicates the onset of the apoptosis of yeast cells. In this context, a fraction of cells in 20°Plato fermentations appear to accumulate more PrA than does the rest of the yeast cell population. Although glycogen was found to accumulate during replication, a significant number of cells during the 20°Plato fermentation were depleted of glycogen. Monitoring physiological markers in yeast with flow cytometry, in addition to conventional brewing parameters, is an effective means of assessing the physiological state of pitching yeast and its subsequent fermentation performance. The holistic approach of our work will assist our understanding of the mechanisms leading to PrA excretion and cell death. This knowledge will help the brewing industry to optimize the fermentation process and the selection of yeast by minimizing yeast cell autolysis with all its negative consequences for beer quality and by enhancing foam stability through minimizing PrA excretion.

Michaela Miedl studied the brewing science and technology of beverages at the Centre of Life and Food Sciences, Technische Universitaet Muenchen-Weihenstephan, Germany (1998–2003). After projects in the fields of functional drinks and alternative fermentation beverages, she concluded her studies with a diploma thesis entitled "Haze formation in beer and in a protein-polyphenol model system" to obtain the degree of a Dipl.-Ing. This thesis was conducted during a 6-month exchange at the Department of Food Science and Technology, University of California, Davis (in the laboratory of Prof. Charles W. Bamforth), and with the Chair of Technologie der Brauerei II, Technische Universitaet Muenchen-Weihenstephan (Prof. Eberhard Geiger). Since October 2003, she has been working toward her Ph.D. degree at the International Centre for Brewing and Distilling, Heriot-Watt University, Edinburgh, Scotland, in the field of high-gravity brewing, foam stability, and yeast stress.

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The Novel Yeast Propagation Method for the Appropriate Fermentation of Beer

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Asahi Breweries, Ltd.

The efficient propagation of brewing yeast for the appropriate fermentation is important in breweries, and this paper is about the establishment of efficient propagation. The test plant for yeast propagation was designed and built in the laboratory. The capacity of the propagation tank is 250–300 L, and the tank has a circulation line with aeration equipment. *Saccharomyces cervisiae* from our stock culture was used. All experiments of propagation were carried out using 250 L of about 12°Plato adjunct wort in the tank and incubated at 12.5°C for 72 h with circulation and aeration. Dissolved oxygen (DO) was controlled by the aeration rate. All experiments of fermentation were carried out using about 12°Plato adjunct wort at 10–12°C in 2- or 200-L fermentation vessels. The velocity of fermentation and the maximum value of VDK released by yeast during fermentation were used for evaluation of fermentation by the cultivated yeast. The maltose uptake ability and DNA microarray analysis were used for evaluation of yeast cell metabolism. Once a yeast propagation tank has been topped up with wort, the process starts immediately. The yeast/wort suspension is taken out from the bottom of the tank by a sine pump. After pumping, the air is directly added and mixed in a line, and its mixture is pumped back into the tank. The pump frequency is adjusted to control the circulation volume, and it also allows control of the agitation in the tank. The DO value meter constantly measure the DO values in order to control optimum air dosing. In this condition, the yeast count increased from an initial value of about 3 million cells/mL to about 180 million cells/mL after approximately 72 h. During the propagation, the DO value was controlled at 6 ppm constantly. We investigated the influence of the yeast crop timing in the propagation on fermentation. The cultivated yeast of the early logarithmic phase (ca. 24 h) fermented rapidly, but the maximum value of VDK was very high. To the contrary, the cultivated yeast of the stationary phase (ca. 72 h) fermented dull, but the maximum value of VDK was low. We found that the cultivated yeast in the latter logrithmic phase (ca. 60 h), the yeast count is about 110 million cells/mL, was the best timing for yeast crop from the propagation in this condition. Meanwhile, the DO value was gradually controlled from 6 to 1.5 ppm during the propagation, and the cultivated yeast in the latter logrithmic phase performed better than the noncontrolled condition on the fermentation. The result of the maltose uptake ability indicated the same as the result of our experiments. In addition, we report that we investigated metabolism of the yeast during the propagation and fermentation using DNA microarray analysis.

Takeshi Kurashige received a B.E. degree in chemistry from Tohoku University in Sendai, Japan. He began employment with Asahi Breweries, Ltd. in April 1992 as an engineer in the brewery. He has worked for about 10 years as an engineer (brewing, packaging, and so on). Since September 2001, he has researched the propagation of brewing yeast with Takayuki Masuda and Takashi Kimura in the engineering and technology development laboratory of Asahi Breweries, Ltd.

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Yeast Quality and Quantity Management System

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An appropriate and precise control of the fermentation process is the most important issue to consistently brew high-quality beer. Yeast has a major role in the fermentation process and its quality and quantity influence finished beer quality. Therefore, it is critical to optimize yeast quality and quantity. Based on this philosophy, we have developed a new yeast quality and quantity control system. As previously reported, we developed methods to evaluate yeast vitality and various physiological conditions. For example, the ICP (intracellular pH) method, one of the most effective and practical techniques, enables us to know the quantitative effect of the major stress factors, such as temperature, alcoholic content, and hot/cold break, during the yeast storage period, and this technique realizes the standardization of the optimized yeast handling procedure. As a result, yeast having good vitality can be used constantly and this provides us with important knowledge on consistent fermentation. On the other hand, the investigation of fermentation processes from the view of quantitative control of yeast has revealed that the yeast cells in suspension at the beginning stages of primary/secondary fermentation vary to some extent among fermentation batches. The number of the pitched yeast cells affect the attenuation and ester formation and, under certain circumstances, results in inconsistency of young beer quality. Also, the reduction speed of acetaldehyde is closely regulated through the number of cells in suspension in secondary fermentation. It is suggested that the yeast slurry concentration homogeneity in the yeast storage/pitching vessel is important for accurate control of cells in suspension in the primary fermenter under the condition of wet spin volume-based pitching. To maintain a homogeneous yeast slurry in the yeast vessel, it is shown to be effective to reduce the yeast concentration to a certain level with cold water. Including these results, we have started to set a target range of yeast cell numbers in suspension as well as yeast vitality management by ICP index. By developing this system, which manages both the quantity and quality of yeast, we have constructed an important basis to brew high-quality beer consistently.

Shigehiro Yoshizaki graduated from Hokkaido University in 1997 with a master's degree in agricultural chemistry and joined Kirin Brewery Company Ltd. the same year. He worked in the Brewing Section of the Kyoto Plant in 1997, and of the Chitose Plant from 1998 to 2002. Since April 2002, he worked in the Production Division, the Technology Development Department, and the Research Laboratory for Brewing Technology. He is now engaged in the research and development of the fermentation process.

P-95

Uptake and Utilization of Zinc by Brewing Yeasts

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Several divalent metal cations are known to influence yeast fermentation performance, including zinc. This essential trace element is especially important for fermenting yeast cells in maintaining high activities of ethanol dehydrogenase (which is a Zn-metalloprotein). In the brewing process, Zn levels may decrease during mashing, lautering, and wort boiling since the metal ion beomes complexed in precipitated trub. Consequently, Zn bioavailability in malt wort may occasionally be compromised, leading to slow and incomplete fermentations. The current study has focused on the uptake of Zn by industrial strains of *Saccharomyces cerevisiae*, including brewing strains, and the subsequent utilization of this key metal by yeast cells during fermentation. Experimental fermentations simulated brewing practice in which preaerated hopped malt wort was pitched at 10×10^6 cells/mL. Total Zn in yeast cells and wort was determined by atomic absorption spectrophotometery and intracellular free Zn in yeast was visualized using Zn-specific fluorescent dyes. The effect of varying initial wort Zn levels and of Zn-supplemention salts once fermentation had commenced was also investigated. Research findings provide valuable new insight into the interactions of Zn with industrial yeasts. For example, both ale and lager brewing yeast strains take up most of the available Zn very quickly following pitching—sometimes within the first 2 to 3 h, with some yeast strains increasing their cellular Zn 10-fold at the onset of fermentation. Interactions of yeast with wort calcium and magnesium revealed completely different patterns of cellular uptake of these cations compared with Zn. Zn content of yeast cell walls (prepared following mechanical homogenization of cells) was found to remain constant during fermentation (at around 30% of total cell Zn). These findings, together with results from work using specific membrane transport inhibitors, suggest that most of the initial Zn uptake was metabolism dependent, rather than via a cell surface biosorption phenomenon. After initial periods of cellular Zn accumulation, and during the course of the subsequent fermentation, Zn becomes virtually undetectable in wort. As yeast cells grow during this period, Zn becomes distributed to daughter cells at cell division and this effectively lowers their individual cellular Zn concentration. Depending on the extent of yeast growth during fermentation, this may result in the generation of Zn-depleted biomass at the time of yeast cropping. The consequences of this for efficient industrial processes will be discussed, including implications for brewing fermentation optimization based on control of wort Zn bioavailability.

Graeme Walker graduated with a B.Sc. degree in brewing and biochemistry in 1975 and completed his Ph.D. degree in yeast physiology in 1978, both from Heriot-Watt University in Edinburgh. Dr. Walker's professional career has included a Royal Society postdoctoral fellowship at the Carlsberg Foundation in Copenhagen, Denmark, and university lectureships in New Zealand, Ireland, and Scotland. He is currently reader and divisional leader in biotechnology at Abertay University in Dundee, Scotland, where he directs a yeast research group investigating cell physiology and biotechnology in industrial yeasts. He is an active member of the Institute and Guild of Brewing and the American Society of Brewing Chemists. He acts as consultant to the brewing industry. Dr. Walker has published widely in the yeast field and has authored the textbook Yeast Physiology & Biotechnology, *published by John Wiley & Sons in 1998. Raffaele De Nicola graduated in agriculture from the University of Perugia, Italy, in 2000. He has worked as a winemaker in an Italian winery and as an associated researcher in the fermentation laboratory of a biotechnology company producing biopesticides. He is currently undertaking a Ph.D. program in yeast physiology at the University of Abertay of Dundee, Scotland. His work is related to the investigations of zinc interactions with industrial yeasts and particularly lager brewing yeast strains. He is an active member of the Institute and Guild of Brewing (Scottish Section) and ASBC.*

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Measurement of Yeast Vitality—A Comparison of Methods

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The consistency and quality of fermentations can be directly influenced by the physiological state of yeast. The ability to control yeast quality and predict fermentation performance is important to ensure a uniform and stable product. Several methods for assessing yeast vitality have been developed to achieve this goal. These methods are usually based on the measurement of different metabolic activities or intracellular compounds of yeast. All of these tests have been tested for their significance to measure yeast vitality in quite different ways, but there have hardly been comparative trials between methods. In this study, seven tests for yeast vitality have been compared directly. These methods have been chosen by selecting promising tests from literature and the performance of preliminary tests using these methods. Finally, the acidification power test, diacetyl reduction, CO_2 pressure test, vitaltitration, formazan-formation, ICP method (measurement of the intracellular pH), and a short version of the ICP method have been compared. In order to test if the methods are able to detect differences in the physiological state of the yeast cells, batches of yeast were propagated to obtain yeast in good physiological condition. Four kinds of stresses in varying intensities were applied on the resulting yeast to acquire yeast populations in different physiological states. The vitality tests were carried out with these yeast populations and fermentations in a 10-L scale were executed to demonstrate the impacts on the subsequent fermentation performance. The complex ICP method, as well as the short ICP method, was able to reliably detect differences in the physiological state of yeast populations, which result in differences in fermentation performance. CO_2 pressure test, diacetyl reduction and formazan-formation were also able to indicate the differences in yeast conditions, but the latter two have shown fluctuations in reproducibility.

Frithjof Thiele obtained a technical degree as brewer at the brewery Binding, Frankfurt (1993–1996). Frithjof studied brewing and beverage technology at Technische Universität München-Weihenstephan (1996–2002). Frithjof became a graduate engineer in 2002, and the topic of the diploma thesis was "Optimization of an assimilation plant in the Damm Brewery, Barcelona". Since 2002, Frithjof has worked on a doctoral thesis at Lehrstuhl für Technologie der Brauerei 1 (Prof. Back) in Freising, Weihenstephan, on "Formation of fermentation by-products in dependency on yeast vitality and fermentation parameters". Frithjof is a member of the ASBC subcommittee Yeast Viability by Fluorescent Staining.

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Modelling of Yeast Growth and Physiology

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Propagation of *Saccharomyces* sp. yeast represents a central step of beer production. Yeast propagation in breweries aims at the provision of an adequate inoculum for subsequent fermentations concerning amount and physiology of the propagated biomass. Referring to this, the current work introduces a deterministic model supplemented by a modelling approach for yeast physiology as a basis for an active process control. The developed deterministic model includes different propagation strategies, such as batch, sequencing batch, fed batch, or continuous propagations. Included are features such as temperature and oxygen dependency of growth as well as limitation or inhibition effects due to applied growth media (beer wort). Experiments were made in a 150-L continuously aerated fermenter system for model identification and extraction of relevant parameters. Temperatures between 5 and 35°C and oxygen contents between 0.0 and 1.0 ppm were applied. Model validation was realized by experiments in the above-mentioned system as well as in industrial plants up to 200 hL. In order to fit model-based simulations on experimental data, only two parameters, which were extracted in a sensitivity analysis, were adapted for each data set. These two parameters, a temperature coefficient describing the rate of sugar uptake and a parameter describing the oxidative capacity of the yeast population (Crabtree effect), could be replaced by temperature functions. So, parameters no longer needed to be fitted, but a predictive simulation was possible. During model validation simulations and measurement, data for biomass and substrate concentrations deviated below 8% for the regarded laboratory and industrial applications. In addition, the first time physiological data (flow cytometric analysis of trehalose, glycogen, and cell cycle) could be implemented in a process model. In particular, relations between the specific growth rates calculated by the process model and the behavior of the physiological parameters could be demonstrated. With this work, a modelling approach is introduced that shows a high accuracy and, on the other hand, includes not only standard growth data as biomass, sugar, or ethanol concentration but also delivers information about the physiological state of the yeast population. So, a reasonable basis for an active process control of yeast propagation could be created.

Tomas Kurz received a Dipl.-Ing. degree in brewing and beverage sciences from TU München, Life Science Center Weihenstephan. He began employment with TU München, Chair of Fluid Mechanics and Process Automation, in April 1997. In 2002, he became head of the working group Process Automation of the Chair of Fluid Mechanics and Process Automation. In November 2002, he finished his Ph.D. thesis "Mathematically based management of Saccharomyces *sp. batch propagations and fermentations". In September 2003, he was announced a junior professor for food process engineering at the University of Technology Berlin.*

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Effect of the Storage of Surplus Yeast on the Quality of Recoverable Yeast Beer

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The amount of accumulated surplus yeast after fermentation and maturation is about 3% of the total beer production volume. Therefore, it is a major beer extract loss within the brewing process. Up to 75% out of these 3% could be extracted as yeast beer by using recovery systems. The quality of yeast beer is mainly influenced by the physiological condition of the yeast population. Within this study, the influence of surplus yeast storage time and temperature on the quality of the recovered yeast beer was investigated. It could be shown that, with extension of storage time and higher temperatures, yeast vitality and viability declines. Due to a worse physiological condition, the flavor profile of the yeast beer was changed negatively. The flavor profile was studied by aroma extract dilution analysis (AEDA) followed by quantitation by GC/FID. It could be demonstrated that extended storage times in addition to higher temperatures came along with an excessive loss of esters. In contrast, the amounts of medium-chain fatty acids (MCFA) and higher alcohols did increase. The vitality of yeast cells is directly related to the excretion of proteinase A (PrA). PrA is reported to have a negative impact on foam stability of beer by degrading foam-active polypeptides. Higher activity of PrA was caused by yeast storage at higher temperatures. In addition, the effect of blending pitching wort with 10% recovered yeast beer on the quality of the final beer was studied. Due to the high activity of PrA and higher contents of MCFA, beer foam stability was decreased. Yeast beers that were recovered from warm-stored yeast suspensions had a more negative influence on sensory evaluation of the final beers than did yeast beers recovered from cold-stored yeast suspensions. These final beers showed an unattractive bitter taste in combination with a cheesy flavor.

Mark Schneeberger received a technical degree as a brewer at brewery Beck & Co., Bremen (1993–1995). Mark studied brewing and beverage technology at Technische Universität München-Weihenstephan (1996–2001) and was a graduate engineer in 2001, with a diploma thesis topic of "Influence of malt and grist treatment on lipid oxidation in the brewing process". Mark was a commissioning engineer at Filtrox AG, St. Gallen, Switzerland (2001–2002). Since 2002, Mark has worked on his doctoral thesis at Lehrstuhl für Technologie der Brauerei I (Prof. Back) in Freising, Weihenstephan, with a topic of "Treatment of waste beers in the brewing process".

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Cross Flow Microfiltration of Yeast—Detection of Proteinase A Activity in Recovered Beer and Estimation of Enzyme Inactivation Conditions

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Foam stability is one of the major quality properties for German pilsner beer. A lot of work was done to describe the impact of proteinase A activity on foam stability. A detailed investigation of the foam-positive protein LPT1 and the destructive nature of the enzyme has been published (2003, Leisegang). A fluorescent substrate-based method from Nakatani et al. has been used to determine the proteinase A activity in beer recovered from yeast with a cross flow microfiltration plant. As a reference, commercial-available proteinase A was used for setting up the best analysis parameters. Is was obvious that the low-activity detection of proteinase A has its limitations due to the fluorescence background signal of the beer. Due to the standard tests, it can be shown that proteinase A is a very stable enzyme. Different temperatures and times were used to find a reproducible inactivation time and temperature. Furthermore, the method was used for the detection of proteinase A activity in the recovered beer. Under normal production conditions, no significant Proteinase A activity could be found in the beer. If the amount of activity was found on a higher level, it could be shown that the cleaning of the plant was not sufficient and single yeast cells were in the plant for more than 48 h. It has to be noted that only yeasts with a high live/dead ratio were used for beer recovery. The analysis of different commercially available beers showed low proteinase A activities in general. Those beers that had higher activities showed lower foam points measured with the method according to NIBEM.

Dr. Diedrich Harms was born in 1968. Diedrich was in undergraduate studies in Marburg and Münster in 1994, took the Staatsexamen in Food Chemistry at the University of Münster in 1995, and took the Staatsexamen in Food Chemistry for Dr. rer. nat. in 1998 (Münster, fellowship by the Stiftung Industrieforschung). Since 1999, Diedrich has been a chemist in the R&D department of the Koenig Brewery, Germany, and since 2001, Diedrich has been leader quality control.

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Polar Lipids of *Saccharomyces cerevisiae*

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DNA methods cannot distinguish between certain strains of commercially important brewer's yeasts. The aim of this study was to differentiate between these strains by comparing their polar lipid composition—particularly strain 34/70—one of the most commonly used brewer's yeast for lager beer production in Germany. Six isolates of *Saccharomyces cerevisiae* were studied after growth under pilot-plant beer fermentation conditions. Polar lipids were then extracted from freeze-dried cultures and analyzed by thin-layer chromatography (TLC) in order to observe the presence of individual phospholipid families. Fatty acid distributions, in both whole cells and lipid families, were investigated using capillary column gas chromatography (GLC) of fatty acid methyl esters. TLC results showed that the major phospholipid classes present in all strains were phosphatidylcholine < phosphatidylethanolamine < phosphatidylglycerol. Phosphatidylinositol, phosphatidylserine, and phosphatidic acid were found to be minor components. Quantitative differences between different phospholipid families were detected. Two unidentified phospholipids were found, one only in strain 34/70. Repeat cultures and extractions showed that 1 µL of lipid extract was enough to clearly detect this lipid in strain 34/70, whereas with extracts of all other yeast isolates, the same volume of lipid extract did not lead to detection of this unknown lipid. The major peaks by GLC, as expected, were identified as methyl esters of palmitic acid and palmitoleic acid. However, novel data were observed for the whole cell fatty acids and fatty acids of phosphatidylcholine using GLC. The *trans*-isomers of dioneic acids of n-C_{18} and of polyenoic fatty acids of n-C_{18} were found. Novel data were observed for lecithin using GLC, when *iso*-$C_{14:0}$, -$C_{17:1}$, -$C_{16:2}$, -$C_{18:3(n-6)}$, and -$C_{22:1}$ were identified. Several unidentified peaks with carbon chain length above $C_{24:0}$ were detected. All our strains have these novel fatty acids. It appeared that growth conditions for pilot-plant beer fermentation are not ideal for chemotaxonomy using GLC analysis of fatty acids. However, TLC proved to be a useful tool for polar lipid identification of *Saccharomyces cerevisiae* isolates. It is concluded that it is possible to differentiate *Saccharomyces cerevisiae* strain 34/70 from other bottom-fermenting and top-fermenting yeasts investigated, and it may be possible to differentiate between other strains on the basis of their lipid chemistry.

Wolfgang Tosch holds a degree in brewing science (Diplom-Braumeister) from the Technische Universität München, Center of Life Science Weihenstephan, Germany. In 2003, he completed a master's degree (M.Phil.) in microbiology from the School of Biological Sciences, University of Manchester, Manchester, U.K. Currently, he is researching on a Ph.D.
program at the Oral Microbiology Laboratory of the University of Manchester in collaboration with the Chair of Brewing Technology II, Technische Universität München, Center of Life Science Weihenstephan, Germany.

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An Examination of the Relationship Between Yeast and Beer Style

CHRISTOPHER WHITE
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We spend a lot of time classifying beer into certain styles, such as American lager, British pale ale, or European dark lager. Why do we do this? With wine, the answer is clear. The main ingredient—grapes—determines most wine styles. The grape variety, or sometimes the region where the wine is produced, are used to classify the wine. But with beer, the malt and hops we use can come from the same or different regions, and rarely dictate the style. Beer styles have been developed over time by breweries, creating a tradition of different products. Beers that caught on and sold well most likely became styles of beer. Beer can easily be divided into ale and lager, but there are many types of each. The ale and lager separation alone was born from the difference in the yeast. This seminar will divide yeast into four types—lager, ale, wheat, and Belgian. The flavor impact of yeast from each category will be discussed, as well as fermentation do's and don'ts for different yeast strains. Other issues addressed will be how to manage these different yeast strains in one brewery, propagation tips for different yeast strains, and the versatility of various types of yeast strains.

Chris White holds a doctorate degree in biochemistry from the University of California, San Diego. He is the president of White Labs Inc., headquartered in San Diego, CA. White Labs is a yeast and fermentation laboratory for the brewing and wine industry. Chris is a member of the American Society for Brewing Chemists and the Master Brewers Association of America and serves on the board of directors for the Association of Brewers, Boulder, CO. He is also a lecturer in the Chemistry and Biochemistry Department at the University of California, San Diego, and a faculty member of the Siebel Institute, Chicago, IL.

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Subcellular Localization of the Acetate Ester Synthase Atf1

K. J. VERSTREPEN (1,2), S. D. M. Van Laere (1), J. Vercammen (3), G. Derdelinckx (1), I. S. Pretorius (4), J. Winderickx (5), J. M. Thevelein (6), F. R. Delvaux (1), and J.-P. Dufour (7)
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The yeast alcohol acetyl transferase I, Atf1p, is responsible for the major part of volatile acetate ester production in fermenting *Saccharomyces cerevisiae* cells. Some of these esters, such as ethyl acetate and isoamyl acetate, are important for the fruity flavors of wine, beer, and other fermented beverages. In order to reveal the subcellular localization of Atf1p and further unravel the possible physiological role of this protein, ATF1::GFP fusion constructs were overexpressed in brewer's yeast. The transformant strain showed a significant increase in acetate ester formation similar to that of a *ATF1* overexpression strain, indicating that the Atf1p-GFP fusion protein was active. UV fluorescence microscopy revealed that the fusion protein was localized in small, spherelike organelles. These organelles could be selectively stained by the fluorescent dye nile red, indicating that they contained high amounts of neutral lipids and/or sterols, a specific characteristic of yeast lipid particles. Purification of lipid particles from wild-type and mutant cells confirmed that the Atf1p-GFP fusion protein was located in these organelles. Furthermore, a clear alcohol acetyl transferase activity could be measured in the purified lipid particles of both wild-type and transformed cells. The localization of Atf1p in lipid particles may indicate that Atf1p has a specific role in the lipid and/or sterol metabolism that takes place in these particles.

Kevin Verstrepen graduated in biological engineering, option gene technology, from the Catholic University of Leuven, Belgium. For his M.Sc. thesis, he joined the group of Prof. Sakkie Pretorius at the University of Stellenbosch to study the use of genetic modification to improve the flocculation behavior of brewer's yeast. A year later, he returned to Belgium to start a Ph.D. program in the group of Prof. Delvaux at the Center for Malting and Brewing Science and the group of Johan Thevelein, Laboratory for Molecular Cell Biology. Between 1999 and 2003, Kevin investigated flavor-active ester formation in brewer's yeast. After earning his Ph.D. degree, Kevin was appointed as a postdoctoral fellow in the laboratory of Prof. Gerald Fink at M.I.T. in Cambridge, U.S.A. He now studies the genetic variability and regulation of the yeast flocculation genes. He also serves as a group leader at the Centre for Malting and Brewing Science, where he coordinates a research project into the synthesis of volatile ethyl esters in yeast. Kevin is author of several publications and regularly serves as a reviewer for different scientific journals and financing institutes. He is a member of the American Society for Microbiology, the EBC fermentation subgroup and the Royal Belgian Association of Brewing Science Alumni. He was awarded several prizes and was recently named an honorary fellow of the Hoover Foundation.

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Waste Yeast, an Energy Commodity

Chris McCombs, Dennis Shippee, and FLORIS DELEE
New Belgium Brewing Company Inc.

At the New Belgium Brewing Company in Fort Collins, CO, U.S.A., all process water gets treated at the brewery's own process water treatment facility. Some of the major process steps include aerobic as well as anaerobic treatment basins. The anaerobic basin reduces most of the bioload of the process water (up to 80% reduction). During this process step, methane gas is produced that is pumped back to the brewery and used as a primary energy source in a gas engine. This poster reviews some of the steps taken by the brewery to increase the volume of methane produced out of the digestion of some of the breweries waste flows, e.g., waste yeast.

Floris Delee, technical director, Board of Directors, Compass, has been associated with NBB since September of 1993, working at other business for periods during his tenure. He has more than 10 years of international experience in brewery design, brewery operations, and brewery construction management. At New Belgium Brewing, he has worked his way up from entry-level engineer to being the head of the Design and Engineering department.
His education is in biochemical engineering from the Catholic Institute of Technology, Antwerp, Belgium.

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CO_2 Brewery Self Sufficiency and Best in Quality

JOS SLOESEN (1) and Dan Gruber (2)
(1) Haffmans B.V., Venlo, The Netherlands; (2) Sudmo North America, Rockford, IL

The recovery and use of CO_2 is getting more and more attention within breweries worldwide. This is because CO_2 is added to the final product during its total processing for carbonation, counter pressure, push gas, and final packaging. Being that CO_2 is the fifth ingredient, quality requirements are becoming more stringent and the added CO_2 must, therefore, be as pure as possible in order to avoid the risk of undesirable contamination. This is especially true in order to avoid the addition of harmful impurities and substances that can have a negative impact on the final quality of the product, such as oxygen and/or sulfur components. This applies especially when dilution occurs after high-gravity brewing. Therefore, a higher-quality CO_2 in greater volumes is now a necessity within the brewing industry. CO_2 gas recovery systems have been designed and are available for recovery and reclaiming CO_2 in sufficient quantity and quality within the brewery for on-site use. Breweries can yield up to 40% more CO_2 and easily become self-supporting or are even able to produce a surplus of high-quality, food-grade CO_2. With the excess of purified fermentation CO_2, breweries can consider CO_2 gas for sale to soft drink producers since its acceptance is nowadays proven for use for soft drinks and even mineral water. Soft drink producers are more acceptable to gas from fermentation sources since the gas is derived from natural food products and there is no danger of contamination with undesired impurities, such as benzene or toluene. Haffmans' intention is to present a poster that will give brewers worldwide the ammunition to effectively study and implement technologies they can add to their breweries to improve their own CO_2 quantities to achieve self sufficiency and quality, which can have a positive impact on their final product quality.

Jos Sloesen has an M.Sc. degree in engineering from the Technical University Eindhoven, The Netherlands. After many years of engineering both at Haffmans and other worldwide locations, Jos has become senior product manager and is responsible for the sale of Haffmans CO_2 systems, which include CO_2 recovery plants and units for water-deaeration, blending, and carbonation.

NOTES

AUTHOR INDEX

The number following an author's name refers to the number of the author's abstract and indicates the order of that presentation in the program and in the printed abstracts. The "O" preceding the number refers to an oral presentation. The "P" preceding the number refers to a poster presentation.

MANCHESTER GRAND HYATT FLOOR PLANS

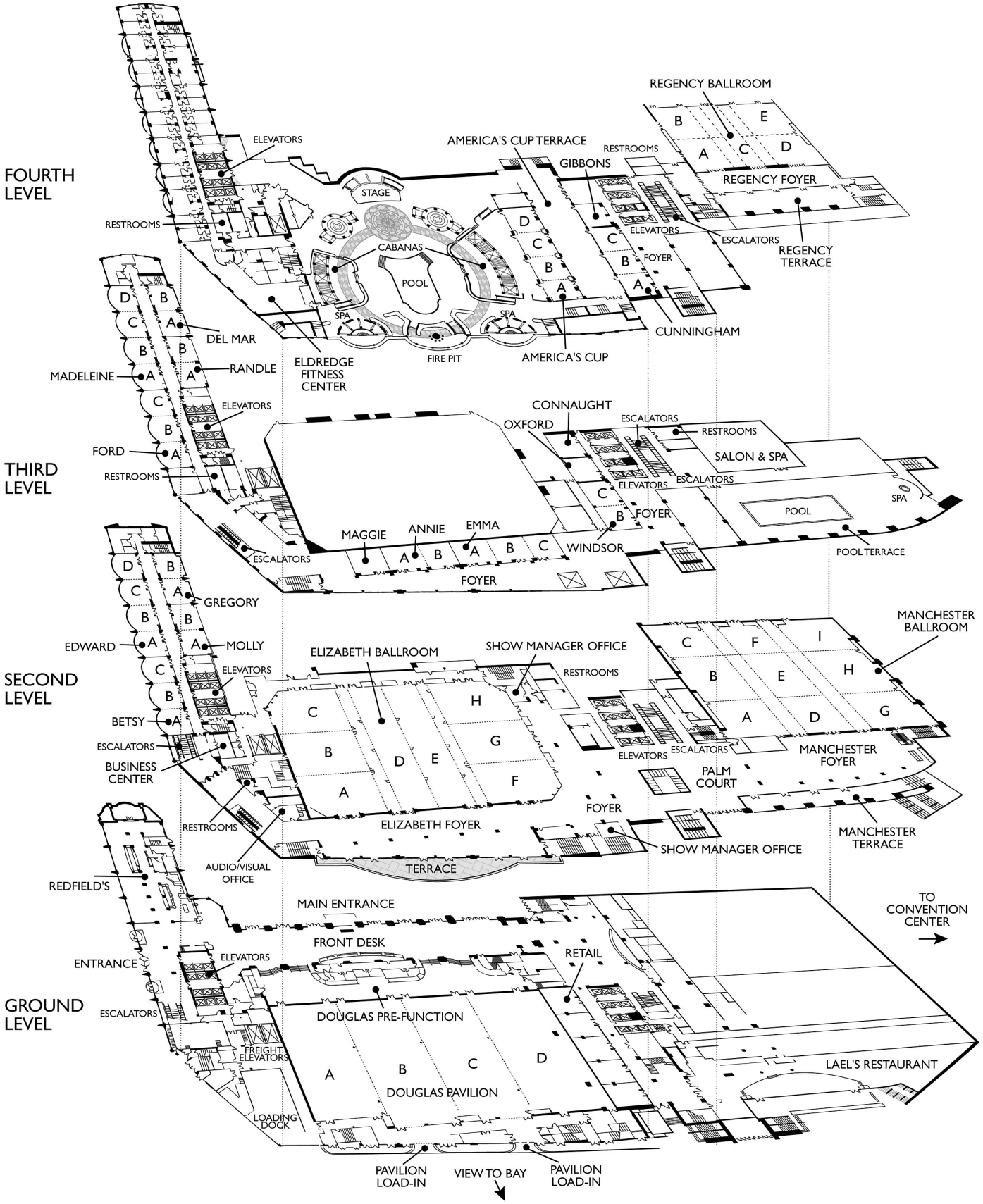
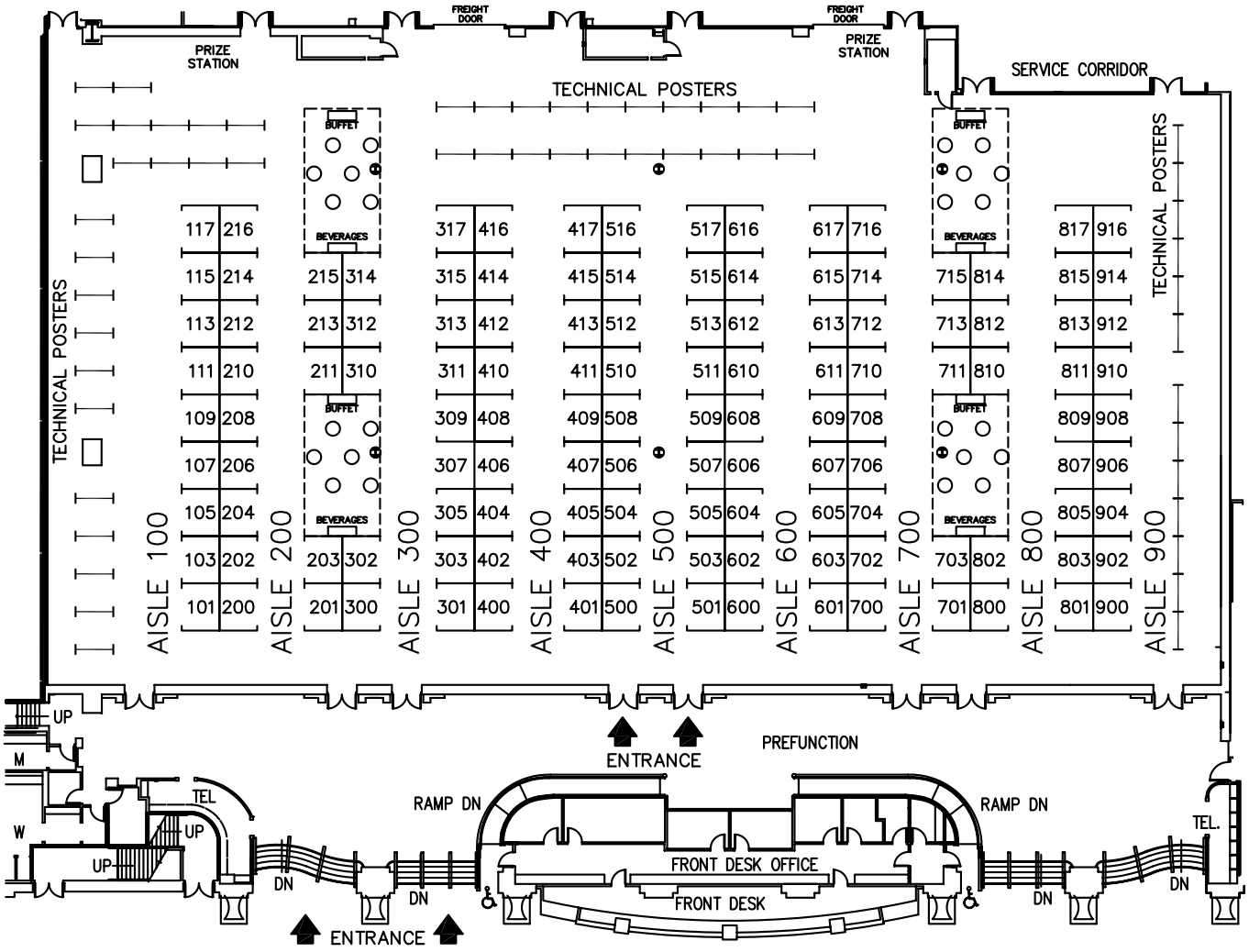


EXHIBIT FLOOR MAP



WELCOME TO THE WBC 2004 TABLE-TOP EXHIBITS

EXHIBIT HALL HOURS

Sunday, July 25	11:30 a.m. – 2:00 p.m.
Monday, July 26	11:30 a.m. – 2:00 p.m.
Tuesday, July 27	11:30 a.m. – 2:00 p.m.

The table-top exhibits feature the latest resources for the brewing industry. The following list shows participating companies and the descriptions they supplied of their products and services. Exhibitors reserving space after this section had gone to press are listed in the Program Addendum.

Please show your support for their valuable contributions to the meeting and the industry by visiting the exhibits in the Douglas Pavilion at every opportunity during the Congress. Come each day to learn of industry resources, review the Technical Posters, enjoy a buffet luncheon and beer hospitality, and register to win prizes.

EF = Elizabeth Foyer

† *Participants in WBC Supplier Sessions. See daily schedule for presentation times.*

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406 **Aber Instruments Ltd.,** Science Park, Aberystwyth SY23 3AH, United Kingdom; Phone: +44 1970 636300, Fax: +44 1970 615455, Website: www.aber-instruments.co.uk.

413 **AcquiData, Inc.,** 45 Executive Dr., Plainview, NY 10803; Phone: +1.516.349.7786, Fax: +1.516.349.7785, Website: www.acquidata.com. *Products or Services:* Testream®/CS, AcquiData Inc.'s premier product quality information system, has expanded its capabilities to include web-enabled programs for the automatic acquisition of test measurements directly from lab instruments as well as other online information systems. Testream®/CS' new Interface Application program joins AcquiData's browser-based real-time data displays to deliver the best in quality data collection and management. Also announcing 'ChartWriter': browser-based tool for easy creation of graphs and charts of all of your quality data.

614 **Adaptive Analyzer Technologies, Inc.,** 115 W. 30th St., Room 1213, New York, NY 10001; Phone: +1.212.393.9540, Fax: +1.212.393.9538, Website: www.analyze.com. *Products or Services:* ATech specializes in process analysis solutions using fiber optic-based spectroscopy. Our 25 years of experience spans virtually all application areas. We also provide applications development services, support, chemometric calibration assistance, and consulting. We offer off-the-shelf, guaranteed, and validated UV, Vis, NIR, and FT-NIR analyzer systems for multicomponent analysis to measure properties and chemical composition of solids and liquids. Moisture, color, extract content, and malt variability are available as standard analyses for the brewing industry. Many other applications are available either as a standard or special analysis.

516 **Albert Handtmann Armaturenfabrik GmbH + Co. KG,** Arthur-Handtmann-Strasse 13 + 23, 88400 Biberach, Germany; Phone: +49 7351 3424542, Fax: +49 7351 3424465, Website: www.handtmann.de. *Products or Services:* Handtmann Armaturenfabrik, a leading supplier of valves, fittings, and complete process equipment for the beverage industry. The patented deep-bed filter MultiMicroSystem for fine and sterile filtration of beer and the new CSS (Combined Stabilizing System) for beer stabilization demonstrate our innovative expertise to realize new ideas.

305 **Alfa Laval Inc.,** 5400 International Trade Dr., Richmond, VA 23231; Phone: +1.804.222.5300, Fax: +1.804.236.3276, Website: www.alfalaval.us. *Products or Services:* Leading global supplier of centrifugal separators, heat exchangers, flow and tank components, process modules, and yeast systems for the brewing industry. From design planning to production, Alfa Laval is committed to world-class service throughout the lifetime of your brewing processes. With worldwide installations and more than 400 employees dedicated to the industry, Alfa Laval brewery technology has the engineering experience and process expertise to keep your brewery running at the height of efficiency.

714 † **AMC Technologies, Inc.,** Suite 201, 6617 Clayton Rd., St. Louis, MO 63117; Phone: +1.314.726.9969, Fax: +1.314.726.9989, Website: www.amctechnologies.net. *Products or Services:* AMC Technologies, Inc. specializes in portable and inline analyzers for dissolved oxygen down to 1 ppb (±0.4 ppb), gas phase oxygen in acid gases, pH/ORP, turbidity, cleaning validation, cell growth fermentation, interface detection, vorlaughing, filter aid detection, and fluorescence detection. Complete engineering solutions for difficult applications in the food and beverage industry.

EF **American Society of Brewing Chemists (ASBC),** 3340 Pilot Knob Rd., St. Paul, MN 55121; Phone: +1.651.454.7250, Fax: +1.651.454.0766, Website: www.asbcnet.org. *Products or Services:* ASBC is your global authority for excellence in the science and technology of brewing. We can provide you with analytical, scientific process control methods to ensure high quality and safety standards as well as scientific support to evaluate raw materials for optimum performance. ASBC will display membership and check sample information, ASBC clothing, and our scientific resource materials.

504 **Anton PAAR USA,** 10215 Timber Ridge Dr., Ashland, VA 23005; Phone: +1.804.550.1051, Fax: +1.804.550.9074, Website: www.apaarusa.com. *Products or Services:* Anton PAAR USA will be featuring its new laboratory carbon dioxide monitor, the Carbo QC. The instrument automatically pierces cans and bottles and measures the CO_2 content of the beer without influence from other gases. We will also show our Beer Alcolyzers, lab density meters, and our complete line of online Beer Analyzers.

701 **Anton Steinecker Maschinenfabrik GmbH,** Raiffeisenstr. 30, 85356 Freising, Germany; Phone: +49 8161 9530, Fax: +49 8161 953150, Website: www.steinecker.com. *Products or Services:* The firm Anton Steinecker Maschinenfabrik GmbH, a subsidiary of the firm Krones AG, is among the world's leading suppliers of brewing plants. The scope of services encompasses the planning, brewing technology, manufacturing, and commissioning of plant components as well as turnkey projects. The range of products includes brewhouse and filter plants, fermenting and storage cellars, pasteurizing and CIP plants, and also CO_2 recovery systems. Our newest innovations are Merlin®, Pegasus®, our Twin-Flow-Filter system, and Stromboli.

802 **Applied Biosystems,** 850 Lincoln Centre Dr., Foster City, CA 94404; Phone: +1.650.638.6995, Fax: +1.650.638.6393, Website: www.appliedbiosystems.com.

314 **APV,** 3280 Langstaff Rd., Concord, ON L4K 4Z8, Canada; Phone: +1.905.760.1852, Fax: +1.905.760.1863, Website: www.apv.com. *Products or Services:* APV is a world-class supplier of high-quality process engineering solutions, components, automation, asset management, performance optimization, and other value-added services to the brewing markets. Leaders in wort cooling technology, unitized beer processing systems, and fluid handling products designed to meet the demands of brewing applications while offering unrivaled cleanability and user-friendly benefits.

212 **Astoria-Pacific International,** P.O. Box 830, Clackamas, OR 97015-0830; Phone: +1.503.657.3010, Fax: +1.503.655.7367, Website: www.astoria-pacific. com. *Products or Services:* Astoria-Pacific International is pleased to present the Astoria®2 for the analysis of alpha-amylase, beta-glucan, diastatic power, free amino nitrogen, bitterness, and other tests in the beer and malt industries. With various domestic and international customers in the brewing industry, our analyzer offers fast sample throughput and low operation costs.

501 **BASF Corporation,** 3000 Continental Dr. N., Mount Olive, NJ 07828-1234; Phone: 1.800.527.9881 or +1.815.357.1778, Fax: +1.973.426.5399, Website: www.humannutrition.basf-corp.com. *Products or Services:* BASF's Divergan® PVPP Stabilizer helps make beer clearer and provides exceptional stability for longer shelf life and consumer appeal. BASF's Divergan HM Polymer is an excellent adsorber of heavy metal ions, removing substances that cause turbidity or bitterness. To learn how Divergan PVPP Stabilizer and Divergan HM Polymer can help make your products better, call 1.800.527.9881, or e-mail divergan@basf-corp.com, or visit us at our booth at the WBC.

904 **Beckman Coulter Inc.,** 11800 S.W. 147th Ave., M/C 32-B13, Miami, FL 33196; Phone: +1.305.380.2564, Fax: +1.305.883.6877, Website: www.beckmancoulter.com.

200 **Bio-Chem Laboratories, Inc.,** 1049 28th St. S.E., Grand Rapids, MI 49508; Phone: +1.616.248.4900, Fax: +1.616.248.4904. *Products or Services:* 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 and outstanding customer service.

800 **BIRKO Corporation,** 9152 Yosemite St., Henderson, CO 80640; Phone: +1.303.289.1090 or 1.800.525.0476, Fax: +1.303.289.1090, Website: www.birkocorp.com. *Products or Services:* BIRKO Corporation is a leading supplier of environmentally and worker-friendly sanitation chemicals, process aids, antifoaming agents, and equipment to the brewing industry. We can custom blend both liquid and powdered products. BIRKO has warehouses in principal cities across the country. We solve tough problems; Call BIRKO!

415 **Brewers Digest,** 831 Anthony Rd., Canutillo, TX 79835; Phone: +1.915.877.3319, Fax: +1.915.877.3319. *Products or Services:* Copies of the March/April and May/June issues, which will cover the WBC program exhibitors; copies of the annual Buyers Guide and Brewery Directory; subscription information.

EF **Brewery Convention of Japan (BCOJ),** 2-8-18 Kyobashi, Chuo-ku, 104-0031 Tokyo, Japan; Phone: +81 3 3561 8386, Fax: +81 3 3561 8380, Website: www.brewers.or.jp/english/bcoj-en.htm.

702 **Brewing Research International,** Lyttel Hall, Nutfield, Redhill, Surrey RH1 4HY, United Kingdom; Phone: +44 1737 822272, Fax: +44 1737 822747, Website: www.brewingresearch.co.uk. *Products or Services:* BRi is the premier technology and information organization providing consultancy, market research, auditing, brand development, analysis, and knowledge management services to the global brewing, malting, and drinks industries. We've been at the forefront of beer research for more than 50 years and our knowledge and expertise is recognized by all major international brewers. BRi is a member organization but it provides consultancy and contract services to members and nonmembers anywhere in the world.

503 **brewmaxx,** Einsteinstr. 8, D-91074 Herzogenaurach, Germany; Phone: +49 9132 777411, Fax: +49 9132 777150, Website: www.brewmaxx.de. *Products or Services:* brewmaxx is an open, component-based process control system, especially developed for the technological requirements of breweries. It consists of high-performance modules regarding process control, recipe generating (according to ISA S88), and process data acquisition. Additional important features are available by compatible modules regarding MES/ERP.

510 **Briess Malt & Ingredients Company,** 625 S. Irish Rd., P.O. Box 226, Chilton, WI 53014; Phone: +1.920.849.7711, Fax: +1.920.849.4277, Website: www.briess. com. *Products or Services:* Briess produces more than 50 styles of malts: base, wheat, Carapils®, caramel, rye, special processed, dark roasted, and black. Briess offers one-stop shopping for malt, roasted barley, pure malt extract, colorants, brewers flakes, torrified grain, and filtering aids plus personal support and technical service. Your partner in brewing since 1876.

201 **Briggs of Burton, Inc.,** 5 Marway Cir., Rochester, NY 14624; Phone: +1.585.426.2460, Fax: +1.585.426.0250, Website: www.briggsplc.co.uk. *Products or Services*: Briggs excels in mash conversion and separation, wort boiling, yeast management, dry goods, and the process block. The 1998 acquisition of Burnett & Rolfe allows us to help anywhere in the brewing process from dry goods to keg racking. Experienced engineering support, great products and ideas, dedicated service, and in-house automation.

208 **Bruker BioSpin Corporation, EPR Division,** 19 Fortune Dr., Billerica, MA 01821; Phone: +1.978.663.7406, Fax: +1.978.670.8851, Website: www.bruker-biospin.com. *Products or Services:* 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.

300 **Buhler Inc.,** P.O. Box 9497, Minneapolis, MN 55440; Phone: +1.763.847.9900, Fax: +1.763.847.9911, Website: www.buhlergroup.com. *Products or Services:* Complete solutions for grain handling and processing in the brewing and malting industry including raw material handling and storage, conveying, cleaning, grinding, weighing, and process automation. Buhler's Maltomat® gristmill has revolutionized malt grinding, setting new standards for mill performance and grist quality. Buhler also offers complete tower malting technology and equipment. Buhler is committed to helping its customers succeed by providing them with equipment and systems offering superior performance, quality, and value.

815 **Cambridge Wire Cloth Company,** 105 B Goodwill Rd., P.O. Box 219, Cambridge, MD 21613; Phone: 1.877.226.9473, Fax: +1.410.228.2617, Website: www.camwire.com. *Products or Services:* Premium brews deserve our premium leaf. Cambridge Continuweld 360 filter leaves represent innovation in pressure filtration technology. These leaves feature continuous nonporous welding of filter cloth to solid bar frame for the ultimate in sanitary leak-proof performance. Cambridge can easily repair your 360s to like-new condition.

608 **Canadian Malting Barley Technical Centre,** 1365-303 Main St., Winnipeg, MB R3C 3G7, Canada; Phone: +1.204.984.4399, Fax: +1.204.984.5843, Website: www.cmbtc.com. *Products or Services:* The Canadian Malting Barley Technical Centre (CMBTC) is a nonprofit, independent organization that was set up to provide technical assistance to the malting barley and brewing industries. We are funded primarily by our member companies, which include barley breeders, seed companies, grain handling companies, maltsters, and brewers, but we also do fee-for-service work for nonmembers. Canada produces the best malting barley in the world, and our job is to assist users of Canadian barley to fully utilize its potential. Our mandate includes the evaluation of new varieties of malting barley, providing technical marketing support to our member companies who market malting barley and malt around the world, applied malting and brewing research, and providing educational opportunities for customers of Canadian malting barley and malt.

517 **Canongate Technology Inc.,** 2045 S. Arlington Hts. Rd., #109, Arlington Hts., IL 60005; Phone: +1.847.593.1832, Fax: +1.847.593.1629, Website: www.canongatetechnology.com. *Products or Services:* Canongate Technology manufactures a range of instruments for the brewing and beverage industries. Best known for the CarboCheck inline dissolved CO_2 analyzer, the company also offers instruments to monitor dissolved CO_2,
%alcohol, Plato, calories, and Brix. Cost- effective multisensor instruments are now manufactured—choose from any of the above!

500 **Cargill Sweeteners North America & Malt,** 15407 McGinty Rd. W., Wayzata, MN 55391; Phone: +1.937.237.1236, Fax: +1.937.237.1238, Website: www.cargill.com. *Products or Services:* Cargill's Sweeteners North America, SNA, and Malt America's, MA, business units are leading providers of brewing adjuncts, malt, and innovative brewing solutions to the world wide brewing industry. Products featured from SNA include the world's most complete line of Satin Sweet High Maltose and Clearbrew liquid adjunct brewing syrups, IsoClear 42% and 55% High Fructose Corn Syrups, and highly fermentable dextrose syrups. Malt America will feature a complete line of 2- and 6-row pale and specialty malts. All products can be shipped almost anywhere beer is made. Let the Cargill team help you create great products for your customers.

617 **CE Elantech, Inc.,** Suite 5, 170 Oberlin Ave., Lakewood, NJ 08701; Phone: 1.888.232.4676, Fax: +1.732.370.3888, Website: www.ceelantech.com.

706 **Centec LLC,** P.O. Box 820, Germantown, WI 53022; Phone: +1.262.251.8209, Fax: +1.262.251.8376, Website: www.centec.de. *Products or Services:* Centec manufactures systems for water deaeration, blending, carbonation, nitrogenation, flash pasteurization, product deaeration, and instruments to measure on-line alcohol, OG, Brix, CO_2, extract, and product/product/water interfaces, and it represents Keofitt sampling valves and equipment.

708 **ChemTreat, Inc.,** 4461 Cox Rd., Glen Allen, VA 23060; Phone: +1.804.935.2182, Fax: +1.804.965.6974, Website: www.chemtreat.com. *Products or Services:* ChemTreat, Inc. is the largest U.S. company dedicated solely to industrial water treatment. Offering a complete line of boiler, cooling water, and process water treatment chemicals, ChemTreat also provides influent clarification and wastewater products and services to North, Central, and South America, the Caribbean, Mexico, and the Asia-Pacific region.

401 **Cool-System Bev. GmbH,** Schwabacher Strasse 106, 90763 Fuerth, Germany; Phone: +49 911 9776754, Fax: +49 911 9776755, Website: www.coolsystem.de. *Products or Services:* Cool-System Bev. GmbH produces CoolKeg —the world's first self-chilling Keg. Founded as a private company in 1999, Cool-System has been developing the CoolKeg along with the dispensing equipment, the CoolKeg Charger, and the CoolKeg Sleever. With this equipment the CoolKeg is regenerated, refilled and relabeled after each use.

301 **Crispmalt/Brewers,** 312 Connell Hwy., Newport, RI 02840; Phone: +1.401.845.2072, Fax: +1.401.845. 2073, Website: www.brewerswholesale.com.

210 **Danbrew Ltd. A/S,** Rahbeks Allë 21, DK-1801 Frederiksberg C, Denmark; Phone: +45 33 21 09 18, Fax: +45 33 21 15 18, Website: www.danbrew.com. *Products or Services:* Danbrew is a consulting and main contracting company providing worldwide services to the brewing, malting, and beverage industry with regard to process know-how, quality assurance, process engineering, logistics & economics, new plants, renovation, contract management, and turnkey.

900 **DIAGNOSTIX,** 400 Matheson Blvd. E., Suite 15, Mississauga, ON L4Z 1N8, Canada; Phone: +1.905.890.6023, Fax: +1.905.890.6024, Website: www.diagnostix.ca. *Products or Services:* DIAGNOSTIX remains committed to simplifying analytical solutions for brewers, maltsters, millers, and grain handlers. Our EZ-Quant line of mycotoxin test kits is the most repeatable and accurate rapid test method available for identifying contamination from DON, aflatoxin, fumonesin, zearalenone, and T2. Information is quickly available at www.diagnostix.ca/don or by calling 1.800.282.4075 from anywhere in North America.

607 † **domnick hunter inc.–Gas Purification Division,** 5900-B Northwoods Pkwy., Charlotte, NC 28269; Phone: 1.800.345.8462, Fax: +1.704.921.1960, Website: www.domnickhunter.com. *Products or Services:* Manufacturer of PCO_2 range of carbon dioxide purifiers and MAXIGAS nitrogen gas generators. PCO_2 range of carbon dioxide purifiers will remove harmful contaminants from CO_2 supplies. The MAXIGAS range of nitrogen gas generators operate from compressed air and deliver a continuous, uninterrupted supply of nitrogen gas at purity from 97–99.999%.

609 **domnick hunter inc.–Process Division,** 5900-B Northwoods Pkwy., Charlotte, NC 28269; Phone: 1.800.345.8462, Fax: +1.704.921.1960, Website: www.domnickhunter.com. *Products or Services:* Manufacturer of complete range of cartridge filter products used for filtration of beer, process water, steam, and sterile air and CO_2. Applications include trap filtration, final stabilization, and process water pretreatment.

807 **DSM Food Specialties,** P.O. Box 1, 2600 MA Delft, The Netherlands; Phone: +31 15 2793474, Fax: +31 15 2793540, Website: www.dsm-foodspecialties.com. *Products or Services:* Brewers Clarex prevents chill haze formation in beer. It is a highly specific enzyme that can be added at mashing or during fermentation. It denatures the proline-rich protein fraction responsible for complexing with polypenols that would have precipitated to cause the haze. Polyphenols are not removed from the beer.

713 † **EaglePicher Filtration & Minerals,** 9785 Gateway Dr., Suite 1000, Reno, NV 89521; Phone: +1.775.824.7600, Fax: +1.775.824.7601, Website: www.eaglepicher.com. *Products or Services:* EaglePicher Filtration & Minerals is a leading global filtration company specializing in the production of low beer soluble iron filter aids, with 20 years of experience in the brewing industry. Our products are accompanied by optimization services where we reduce filter aid usage and increase throughput while meeting all your quality standards.

502 **Ecolab Inc.,** 370 Wabasha St. N., St. Paul, MN 55102; Phone: +1.651.293.2233, Fax: +1.651.293.2260, Website: www.ecolab.com. *Products or Services:* Ecolab is the industry-leading provider of sanitation products, systems, and services for the brewing industry, including CIP and automated control systems, specialty conveyor lubricants, cleaners, sanitizers, and service expertise.

512 **Emerson Process Management,** Suite 250, 350 Indiana St., Golden, CO 80401; Phone: +1.720.497.1500, Fax: +1.720.497.1501, Website: www.emersonprocess.com. *Products or Services:* Emerson Process Management (www.emersonprocess.com), an Emerson business, is a leader in helping businesses automate and integrate their production, processing, and distribution in many different industries including food and beverage and pharmaceutical. The company combines superior products and technology with industry-specific engineering, consulting, project management, and maintenance services.

810 **Endress + Hauser Inc.,** 2350 Endress Place, Greenwood, IN 46143; Phone: +1.317.535.7138, Fax: +1.317.535.1498, Website: www.us.endress.com/ foodinfo. *Products or Services:* Endress+Hauser—Full line supplier of innovative, sanitary measurement solutions for the brewing and beverage industry. Dedicated to high-performance, quality instrumentation designed to meet the stringent requirements for safety and reliability. Endress+Hauser provides global support to satisfy local application and service needs. Measurement solutions for the entire brewing process from malting to filling.

507 **ENERFAB, Inc.,** 4955 Spring Grove Ave., Cincinnati, OH 45232; Phone: +1.513.641.0500, Fax: +1.513.242.6833, Website: www.enerfab.com. *Products or Services:* Design/build brewing process system installations, shop- and field-fabricated brewing process equipment, brewhouse maintenance and renovation services, LASTIGLAS/MUNKADUR tank lining services, piping systems fabrication and installation, and process maintenance components.

703 **Enzyme Development Corporation,** 21 Penn Plaza, Suite 1102, 360 W. 31st St., New York, NY 10001-2727; Phone: +1.212.736.1580, Fax: +1.212.279.0056, Website: www.enzymedevelopment.com. *Products or Services:* Enzyme Development Corporation is a producer and supplier of brewing enzymes. These include the chill proofing enzyme Papain, (liquids and powders), as well as other brewing enzymes such as betaglucanase and glucoamylase.

EF **European Brewery Convention (EBC),** P.O. Box 510, NL-2380 BB Zoeterwoude, The Netherlands; Phone: +31 71 5456047, Fax: +31 71 5410013, Website: www.ebc-nl.com. *Products or Services:* EBC, a not-for-profit organization founded in 1947. Information on the objectives, organization, and primary activities of the Convention, including details on its committees & groups, congresses, symposia, and publications, and cooperation with affiliated organizations.

203 **Filtrox North America Co./Filtrox AG,** 2585 S. Sarah Ave., Fresno, CA 93706-5034; Phone: +1.707.696.6133, Fax: +1.508.348.0185, Website: www.filtrox.ch. *Products or Services:* A complete line of filtration equipment for beer filtration, beer/yeast recovery, filter media, and engineering.

202 **FOSS,** 7682 Executive Dr., Eden Prairie, MN 55344; Phone: +1.952.974.9892, Fax: +1.952.974.9823, Website: www.foss.dk. *Products or Services:* FOSS offers the most complete line of analytical solutions for beer/malt production. Products include laboratory and process control beer analysis instruments, image analysis of rice and barley, extraction of fat in grains, protein analysis, sprout damage, at-line grain analysis, and analysis of raw materials, intermediates, and finished products.

700 **Frings America Inc.,** 1413 Sherman Rd., #30, Romeoville, IL 60046; Phone: +1.630.783.1407, Fax: +1.630.783.1410, Website: www.fringsamerica.com. *Products or Services:* Equipment and systems for biotechnology and chemical technology, yeast propagators for pilot- to production-scale yeast growth, mechanical defoamers, alcohol probe for real-time in-line measurement, and control of alcohol concentration. Alkosens alcohol probe and lab-scale yeast propagator on display.

602 **GE Water Technologies,** 4636 Somerton Rd., Trevose, PA 19053; Phone: +1.215.953.2396, Fax: +1.215.953.5524, Website: www.gewater.com. *Products or Services:* From boiler to the bottle, GE Infrastructure Water & Process Technologies is the leader in protecting the brand image and equipment of the world's largest beverage makers. We set the industry standard in water treatment systems, drawing from more than 50 years of beverage industry water history. Our innovative and cost-saving chemical treatment programs for pasteurizers and bottle processing earned GEWT the reputation as the company that delivers proof, not promises, at the world's leading breweries. The largest RO manufacturer in the world, we bring our filtration expertise to enable beverage producers to achieve global product consistency as well as product enhancements that lead to new markets and squeeze cost out of waste products.

313 **Genencor International, Inc.,** 200 Meridian Centre, Suite 300, Rochester, NY 14618; Phone: +1.585.256. 5200, Fax: +1.585.256.5286, Website: www.genencor. com. *Products or Services:* With more than two decades of expertise in the brewing and alcohol industries, Genencor offers a complete line of high-quality enzymes and processing aids that offer solutions for filtration, chill-haze prevention, adjunct liquefaction, and mash optimization; provide technology for low-carbohydrate beer production; improve manufacturing processes and reduce costs by reducing wort viscosity and eliminating barley β-glucans. To find out more, please visit us online at www.genencor.com. Cheers!

107 **Gerstel, Inc.,** Suite H, 1510 Caton Center Dr., Baltimore, MD 21227; Phone: +1.410.247.5885, Fax: +1.410.247.5887, Website: www.gerstelus.com. *Products or Services:* Gerstel provides integrated GC/MS-based sample introduction, separation, and detection systems that significantly improve the detection of compounds important to beer quality. SPME, SBSE, voice recognition olfactory detection, multidimensional GC, preparative fraction collectors, and MSD-based ChemSensors provide unsurpassed tools for product development and quality control.

117 **GKD–USA, Inc.,** 5469 Moose Lodge Rd., Cambridge, MD 21613-3424; Phone: 1.800.453.8616, Fax: +1.410.221.0544, Website: www.gkdusa.com. *Products or Services:* One of the largest metal weaving plants in the world. Woven solutions include fabricated elements, rescreening services, filter media cloth, and technical filtration assistance. NeverLeak filter leaf design and precision woven KPZ filter media cloth will be displayed.

403/405 **Gusmer*Cellulo*,** 1165 Globe Ave., Mountainside, NJ 07092; Phone: +1.908.301.1811, Fax: +1.908.301.1812, Website: www.gusmercellulo.com. *Products or Services:* For eighty years Gusmer*Cellulo* has been dedicated to providing service with knowledge to the brewing industry. Gusmer*Cellulo* 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 make up a portion of our product line.

310 **HACH Company,** 5600 Lindbergh Dr., Loveland, CO 80539; Phone: +1.970.207.1077, Fax: +1.970.207.1088, Website: www.hach.com. *Products or Services:* HACH Company manufactures and distributes analytical instruments and reagents used to test the quality of water and other aqueous solutions. Our systems are designed to simplify analysis and include easy-to-follow methods.

407 **Haffmans,** 1330 Anvil Dr., Rockford, IL 61115; Phone: +1.815.639.0322, Fax: +1.815.639.1135, Website: www.haffmans.nl. *Products or Services:* Haffmans, a member of the NORIT Group, is a leading supplier of CO_2 management systems and offers CO_2 recovery plants, CO_2 audits, CO_2 instrumentation, water deaeration, and blending and carbonation units.

711 **Hanna Instruments,** 584 Park E. Dr., Woonsocket, RI 02895; Phone: +1.401.765.7500, Fax: +1.401.762.5064, Website: www.hannainst.com. *Products or Services:* Hanna Instruments produces a wide variety of instruments for the brewer. Precisely monitor the most important parameters in the brewing process including temperature, pH, turbidity, dissolved oxygen and ORP. Products include a popular line of testers, portable and laboratory bench meters, magnetic stirrers, and testing accessories. For more information, contact Hanna Instruments at 1.877.694.2662 or e-mail food@hannainst.com.

613 **HDP-NERB,** 200 Avenue Rd., Cambridge, ON N1R 8H5, Canada; Phone: +1.519.740.9399, Fax: +1.519.740.3686, Website: www.hdpcanada.com or www.nerb.de. *Products or Services:* A unique partnership of European and North American engineering and manufacturing with advantages in price, technology, and quality. Brewhouse and tank fabrication, brewhouse and cellar automation, thin film vacuum wort production, process piping, malt mills, malt-grist-spent grain conveyance, and plants for CIP, yeast, pilot brewing and malting, and packaging.

404 **Headmaster Limited,** Moor Place Farm Estate, Plough Ln., Bramshill, Hampshire RG27 0RF, United Kingdom; Phone: +44 1189 326670, Fax: +44 1189 326660. *Products or Services:* Calibrators to instantly verify dissolved gas analyzers ($CO_2/N_2/O_2$). These systems produce a constant water stream containing exact amounts of dissolved gas. Simply connect the analyzer to calibrator and compare their displays, if both give the same value, then the analyzer is working correctly. Use for both routine and emergency verification.

505 **Huppmann Group**, Heinrich-Huppmann-Str. 1, 97318 Kitzingen, Germany; Phone: +49 9321 303104, Fax: +49 9321 303254, Website: www.huppmann.com.

817 **Hygiena,** 941 Avenida Acaso, Camarillo, CA 93012; Phone: +1.805.388.8007, Fax: +1.805.388.5531, Website: www.hygienausa.com. *Products or Services:* Hygiena's new SystemSURE II luminometer and Ultrasnap ATP swab are revolutionizing the food hygiene industry. Designed to be robust, easy to use, and low cost without compromising performance, this revolutionary system brings simple, affordable hygiene monitoring to all brewing companies. If you are already doing ATP testing, come by our booth and inquire about our universal Snapshot ATP swabs that can save up to 50%.

216 † **Hygienic Process Equipment/Tyco Flow Control,** 1195 Airport Rd., Lakewood, NJ 08701; Phone: +1.732.730.1008, Website: www.tycoflow.com. *Products or Services:* The recent amalgamation of Keystone Hygienic Products Division and Hovap International has formed a world leader in innovation, design, and manufacturing, leading to a new division within Tyco Flow Control. The Hygienic Process Equipment Division provides a comprehensive range of flow control equipment, specifically designed to offer solutions for hygienic/sanitary applications within the brewing industry and features the industry's only patented mixproof valve that can claim to be 100% WATERHAMMER PROOF.

812 **Industrial Environmental Coatings Corp., DBA Enviroline Group,** 1831 Blount Rd., Pompano Beach, FL 33069; Phone: 1.800.449.6525 or +1.954.978. 9355, Fax: +1.954.978.3913, Website: www.envirolinegroup.com. *Products or Services:* Enviroline Group manufactures Enviroline® and Envirothane® Series products that are high solids and offer excellent chemical and temperature resistance with an extremely fast cure. Ask us about our coatings and linings that meet FDA requirements for food and beverage storage and are suitable for lining beer and other beverage tanks.

303 **INEOS Silicas,** 111 Ingalls Ave., Joliet, IL 60435; Phone: +1.815.727.3651, Fax: +1.815.727.5312, Website: www.ineossilicas.com. *Products or Services:* Global supplier of silica-based beer stabilizers, including the Lucilite and Chill-Garde product range. Please stop by to learn about our products for protein and tannoid removal and to discuss how we can help reduce costs and improve beer quality.

EF **The Institute & Guild of Brewing (IGB),** 33 Clarges St., London W1J 7EE, United Kingdom; Phone: +44 20 7499 8144, Fax: +44 20 7499 1156, Website: www.igb.org.uk. *Products or Services:* The IGB is a global members' organization dedicated to the advancement of education, skills, and knowledge within the brewing, distilling, and related industries. Core business is training leading to examinations—IGB qualifications are internationally accepted benchmarks. The IGB publishes the monthly *Brewer International*, the *JIB*, and its company directory.

712 **International Centre for Brewing and Distilling,** Heriot-Watt University, Riccarton, Edinburgh EH4 4AS, United Kingdom; Phone: +44 131 451 3184, Fax: +44 131 449 7459, Website: www.sls.hw.ac.uk/ icbd/ icbd.htm. *Products or Services:* The mission of the International Centre for Brewing and Distilling (ICBD) at Heriot-Watt University in Edinburgh, Scotland, is to be a center of excellence that provides, in the English language, education and training of the highest caliber to employees and prospective employees of the malting, brewing, distilling, packaging, and associated industries and institutions in the United Kingdom and overseas.

101 **Ionics Instrument Business Group,** 6060 Spine Rd., Boulder, CO 80301; Phone: 1.800.255.6964 or +1.303.444.2009, Fax: +1.303.444.9543, Website: www.ionicsinstruments.com. *Products or Services:* Ionics Instruments will exhibit the Sievers model 355 sulfur chemiluminescence detector (SCD), used in brewing laboratories to detect sulfur compounds that contribute to flavor, aroma, and color. The SCD is extremely sensitive, has a linear response greater than three orders of magnitude, and is not subject to hydrocarbon quenching. An optional flame ionization detector (FID) adapter can be used in-line with the SCD, providing the user with FID and SCD information from one injection. Both headspace and liquid injection techniques can be used for samples introduction with SCD. The Sievers model 255 nitrogen chemiluminescence detector (NCD) will also be exhibited.

601 **ISP,** 1361 Alps Rd., Wayne, NJ 07470; Phone: +1.973.628.4000, Fax: +1.973.872.1583, Website: www.ispcorp.com. *Products or Services:* ISP is recognized worldwide for its Polyclar® line of products (PVPP) used for the stabilization (longer shelf life and improved flavor) and clarification of beverages. Polyclar V & VT for wine clarification and removal of astringent flavors. Polyclar 10, Polyclar Super R, Polyclar Plus 730, and Polyclar Brewbrite for stabilization of beer by removing haze-causing precursors in beer.

610 **JohnsonDiversey, Inc.,** 3630 E. Kemper Rd., Cincinnati, OH 45241; Phone: 1.800.233.1000, Fax: +1.513.956.4841, Website: www.johnsondiversey.com. *Products or Services:* JohnsonDiversey complements your brewing expertise from brewhouse to packaging hall. Wherever you have hygiene needs, we have the cleaning and sanitizing technology to ensure product quality, increased productivity, and reduced costs. Backed by fast and reliable support, we are the trusted partner for both brewing and nonbrewing processes.

204 **Kalsec Inc.,** P.O. Box 50511, Kalamazoo, MI 49005-0511; Phone: +1.269.349.9711, Fax: +1.269.382.3060, Website: www.kalsec.com. *Products or Services*: Kalsec®, the originator of tetrahydro-isohumulone and hexahydro-isohumulone is today the world's leading producer of isomerized and reduced hop extracts. These specialty extracts provide brewers around the world with the tools to obtain

precise bitterness control, light stability, foam enhancement, cost effectiveness, and flexibility in the processing of their products. Kalsec®'s individually selected hop oil fractions and hop acid/hop oil blends give beers distinct character; in most cases specifically tailored to the requirements of the brewery. We assure the highest quality of our products with unsurpassed uniformity. The Kalsec® product line consists of Isolone®, Tetralone®, Hexalone®, KAE®s, HAB®s, and CPF®s.

105 **Keg Club Inc.,** 9 Greenwood Tr., Brantford, ON N3R 6G4, Canada; Phone: +1.519.751.1201, Fax: +1.519.753.2305, Website: www.kegclub.com. *Products or Services:* Keg Club Inc. produces and supplies draft dispensing products like backpack dispensers and keg coolers. Keg Club Inc. is the North American office for Schaefer Kegs (www.schaeferkegs.com) and Vin Service (www.vinservice.it). World leaders in kegs, draft towers, and chillers for all types of beverages, along with self-contained kegs with built in gas, the freshKEG, keggy. All factory direct.

412 **LemnaTec,** 18 Schumanstr., 52146 Wuerselen, Germany; Phone: +49 2405 412612, Fax: +49 2405 412626, Website: www.lemnatec.com.

416 **Loeffler Chemical Corporation,** 5700 Bucknell Dr., Atlanta, GA 30336; Phone: +1.404.629.0999, Fax: +1.404.629.0690, Website: www.loefflerchemical.com. *Products or Services:* The Loeffler Chemical Corporation is one of the leading suppliers of sanitation products for breweries and offers a complete line of sanitation products for brewery applications. Innovative cleaning technologies are presented that enable breweries to improve cleaning results while reducing downtime, labor, and total cleaning cost.

EF **Master Brewers Association of the Americas (MBAA),** 3340 Pilot Knob Rd., St. Paul, MN 55121; Phone: +1.651.454.7250, Fax: +1.651.454.0766, Website: www.mbaa.com. *Products or Services:* MBAA is dedicated to the technology of brewing. Stop by our exhibit to learn how MBAA offers practical solutions, resourceful safeguards, and innovative technologies to strengthen your ability to succeed as a brewing professional. Pick up a membership application, page through the new *A Handbook of Basic Brewing Calculations*, learn about the upcoming Brewing & Malting Course, or purchase MBAA logo wear.

211 **Mehrer-Compressors (Josef Mehrer GmbH & Co. KG),** Rosenfelder Str. 35, P.O. Box 10 07 53, D-72307 Balingen, Germany; Phone: +49 7433 26050, Fax: +49 7433 260541, Website: www.mehrer.de. *Products or Services:* Mehrer specializes in oilfree *piston* compressors and booster systems for air and process gases, operating at pressures up to 60 bar(g)/850 psig and 200 kW/270 hp, compressing air, and a wide variety of pure and mixed gases. Our delivery program also comprises oilfree screw compressors for air applications with final pressures of 8/10 bar(g) (114/142 psig) and volume flows up to 3.000 m_3/h.

710 **Metrohm-Peak, Inc.,** 12521 Gulf Freeway, Houston, TX 77034; Phone: 1.800.410.7118, Fax: +1.281.484.5001, Website: www.mp-ic.com. *Products or Services:* Metrohm-Peak—Ion chromatography instrumentation: Intelligent range of ion chromatography instrumentation, automation, consumables, software, accessories and services. Benchtops and onlines offer superior innovation, affordability, reliability, and superior quality—backed by unrivaled service and support.

605 **MEURA (Brewery Equipment) Ltd.,** 1 Park Farm, Ermine St., Buntingford, Herts SG9 9AZ, United Kingdom; Phone: +44 1763 272680, Fax: +44 1763 272321, Website: www.meura.com. *Products or Services:* Here at MEURA, founded in 1845, we are specialists in the design and engineering of equipment for the brewing, distilling, and associated process industries. With our in-house research and development facility, we are able to develop new equipment and processes, as well as carry out confidential research projects for our customers. Our expertise covers dry goods handling, dry and wet milling, brewhouse process vessels and equipment, including the world-leading Meura 2001 Mash Filter, yeast handling systems, spent grains handling, and storage systems. MEURA—Traditionally Pioneers Since 1845.

809 **Microanalytics, a MOCON Company,** 2011A Lamar Dr., Round Rock, TX 78664; Phone: +1.512.218.9873, Fax: +1.512.218.9875, Website: www.mdgc.com. *Products or Services:* A subsidiary of MOCON specializing in MDGC-based integrated systems and contract analytical services. Utilizing our state-of-the-art AromaTrax® GC-olfactometry systems, Microanalytics is emerging as the leader in the specialized field of aroma and off-odor analysis. Uniquely experienced in delivering rapid solutions to 'real-world', crisis-driven off-odor and off-flavor problems. Application areas represent a wide-ranging diversity: aroma, odor, and flavor impact investigations across food, beverage, packaging, and environmental matrices. Providing solutions to the food, pharmaceutical, medical, and petrochemical markets.

213 **Millennium Chemicals,** 6752 Baymeadow Dr., Glen Burnie, MD 21060; Phone: +1.410.762.1014, Fax: +1.410.762.1041, Website: www.millenniumchem. com. *Products or Services:* Millennium Chemicals' Sil-proof® line of high-performance amorphous silica xerogel products are designed to selectively remove the undesirable haze-producing proteins from beer. Millennium Chemicals supports the Sil-proof line of beer-grade silica gel stabilizers with an experienced technical support team, a fully equipped analytical beer laboratory, and a state-of-the-art research facility.

402 **Millipore Corp.–Food and Beverage,** 900 Middlesex Tpk., Billerica, MA 01821; Phone: +1.845.621.6560, Fax: +1.845.621.6544, Website: www.millipore.com. *Products or Services:* Microbial Management Solutions. Millipore combines filtration for removing microorganisms and contaminants and proven monitoring tools so brewing processes yield safe product—the first time and every time. From clarification/prefiltration through final filtering, Millipore has the right mix of products and services to optimize your process, ensuring product quality and safety.

214 **MLT Research/Gen-Probe,** 5 Chiltern Close, Cardiff Industrial Park, Cardiff CF14 5DL, United Kingdom; Phone: +44 2920 747033, Fax: +44 2920 747118, Website: www.mltresearch.com.

811 **Modern Brewery Age,** 50 Day St., P.O. Box 55550, Norwalk, CT 06856; Phone: +1.203.853.6015, Fax: +1.203.852.8175, Website: www.breweryage.com. *Products or Services: Modern Brewery Age* publishes a quarterly magazine, weekly e-mail Tabloid, and annual *Blue Book*. Magazine editorial is specifically written for those in management levels of breweries, large and small, as well as executives who run beer wholesale and distributor operations. The e-Tabloid delivers timely reports and current events/news happening in the malt beverage industry. The annual *MBA Blue Book* is the only comprehensive beer industry directory that lists companies in all segments of the trade, presents updated legal information, and offers decision-makers an easy-to-use Buyer's Guide.

514 **MYNAH Technologies,** 504 Trade Center Blvd., Chesterfield, MO 63005; Phone: +1.636.681.1555, Fax: +1.636.681.1660, Website: www.mynah.com.

411 **NORIT Process Technology,** 1330 Anvil Dr., Rockford, IL 61115; Phone: +1.815.639.0322, Fax: +1.815.639.1135, Website: www.noritpt.nl. *Products or Services:* NORIT Process Technology, a member of the NORIT Group, is a leading supplier of cross flow beer membrane filtration as an alternative to kieselguhr in the brewing industry. NPT also offers technology for the decolorization of beer using a combination of membranes and activated carbon and membranes for the production of process water and treatment of wastewater.

408 † **NOVOZYMES,** Neumatt, CH-4243 Dittingen, Switzerland; Phone: +41 61 765 6111, Fax: +41 61 765 6333, Website: www.novozymes.com. *Products or Services:* NOVOZYMES is the biotech-based world leader in enzymes and microorganisms. With a few exceptions, NOVOZYMES has introduced every new enzyme for the brewing industry. Our international team of expert brewmasters help breweries worldwide in optimizing enzyme solutions and ensure "smooth brewing operations". From adjunct liquefaction through mashing, fermentation, attenuation control, and during maturation, our brewing experts deliver efficiency and innovation to the brewhouse.

400 **optek-Danulat, Inc.,** N118 W18748 Bunsen Dr., Germantown, WI 53022; Phone: +1.262.437.3600, Fax: +1.262.437.3699, Website: www.optek.com/brewing. *Products or Services:* optek's in-line instrumentation provides precise control of color, haze, and concentration. Our in-line photometers and insertion probes control 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.

315 **Packaging Technologies (1991) Inc.,** 310 Courtland Ave., Concord, ON L4K 4Y6, Canada; Phone: 1.800.303.5883 X218, Fax: +1.905.738.7065, Website: www.ptibox.com. *Products or Services:* Packaging Technologies (1991) Inc. is a fully integrated producer of high-quality fine flute, high-graphic corrugated retail packaging. We offer a complete service from graphic and structural design concepts through to production of up to 8-color flexo preprint and single-face litho laminating.

506 **Pall Corporation,** 25 Harbor Park Dr., Port Washington, NY 11050; Phone: +1.516.484.3600, Fax: +1.516.484.3877, Website: www.pall.com. *Products or Services:* Pall Corporation is the global leader in the field of filtration, separation, and purification. The company provides leading-edge products to meet the demanding needs of customers in food & beverage, biotechnology, pharmaceuticals, medicine, semiconductors, municipal drinking water, and aerospace. Further information can be found on our website at http://www.pall.com.

103 † **PBM, Inc.,** 1070 Sandy Hill Rd., Irwin, PA 15642; Phone: +1.724.863.0550, Fax: +1.724.864.9255, Website: www.pbmvalve.com. *Products or Services:* PBM's Sanitary Rising Stem Sampling Valve product line is specifically designed for taking process samples in breweries to ensure quality, consistency, taste, and sterility.

410 **Ponndorf,** Leipziger Strasse 374, Kassel D-3500, Germany; Phone: +49 561 511415, Fax: +49 561 511424.

716 **PreSens Precision Sensing GmbH,** Josef-Engert-Str. 9, D-93053 Regensburg, Germany; Phone: +49 941 942720, Fax: +49 941 9427227, Website: www.presens.de. *Products or Services:* PreSens (Regensburg, Bavaria, Germany) oxygen meters are based on an optical principle. They measure oxygen down to 1 ppb DO—in-line in the brewing and the filling process. Oxygen ingress can be measured in PET bottles. In contrast to classical amperiometric electrodes, these systems show higher precision and demand lower maintenance.

417 † **Procon Technologies Inc.,** 9310 60th Ave., Edmonton, AB T6E 0C1, Canada; Phone: +1.780.437.0244, Fax: +1.780.438.2893, Website: www.proconsystems.com. *Products or Services:* Procon Technologies Inc. is a distributor of sophisticated electronic industrial instrumentation serving customers in the United States. The products and services sold by Procon Technologies include near-infrared moisture, fat, protein, and solids analyzers; ultrasonic concentration analyzers and density gauges; and process refractometers.

604 **Profamo, Inc.,** 7506 Albert Tillinghast Dr., Sarasota, FL 34240; Phone: +1.941.379.8155, Fax: +1.941.379.8699, Website: www.profamo.com. *Products or Services:* Profamo, Inc. will exhibit at WBC 2004 Dr. Thiedig's well-known Digox 5 dissolved oxygen meters and in-line CO_2 meter; Steinfurth's CO_2 meters, temperature

and pressure loggers, and portable and bench top torque testers; Pfeuffer's Tannometer, Friabilimeter, Sortimat, and Viscomat; Lg Automatic's foam tester, mash bath, sampling device, bottle turner, and hazemeter; Keofitt's sterile sampling systems; Gerhardt's systems for sample digestion, distillation, shakers, and hot plates; OxySense's noninvasive oxygen measurement system; and ACM's decarbonizer.

611 **PureMalt Products Ltd.,** Victoria Bridge, Haddington, Scotland EH41 4BD, United Kingdom; Phone: +44 1620 824696, Fax: +44 1620 822018, Website: www.puremalt.com. *Products or Services:* Following on from the successful range of BrandMakers, which deliver flavor and color management for variety beers in the cellar, PureMalt's program of continuous improvement has developed an outstanding malt base for the production of nonalcoholic and reduced-alcohol beers. This will be demonstrated on our stand in San Diego.

906 **Reotemp Instrument Corp.,** 10656 Roselle St., San Diego, CA 92121; Phone: +1.858.784.0710, Fax: +1.858.784.0720. *Products or Services:* REO*TEMP* is an ISO 9002 manufacturer of 3A sanitary temperature & pressure instrumentation: Bimetal Thermometers, RTD's and Thermocouples Thermowells, Pressure Gauges, Diaphragm Seals and Pressure Transmitters. REO*TEMP* also specializes in sanitary diaphragm seal assemblies for pressure gauges, switches and transmitters. Custom remote capillary systems and autoclave configurations also available.

603 † **Rockwell Automation,** 1201 S. 2nd St., Milwaukee, WI 53204; Phone: +1.414.382.2000, Fax: +1.414.382.4444, Website: www.rockwellautomationcom/beverage. *Products or Services:* Rockwell Automation is a leading industrial automation company focused to be the most valued global provider of power, control, and information solutions. Rockwell Automation offers solutions for brewers and OEMs that combine world-class application engineering, products, and optimization services for brewers to achieve new levels of brewery production throughput.

311 **S.S. Steiner, Inc.,** 655 Madison Ave., New York, NY 10021; Phone: +1.212.838.8900, Fax: +1.212.593.4238, Website: www.hopsteiner.com. *Products or Services:* S.S. Steiner was started in 1845 as a small hop dealership and is today one of the largest international hops growing, trading, and processing firms. The success of the Steiner group is largely due to our continuity as a family-owned and -run business and to the hard work and innovation of present and past management and employees. We are a leading developer of innovations in hop technology and are one of the world's main producers of hop pellets, extracts, and refined hop products. The quality of our relationships in hop growing and brewing ensures quality in the entire hop chain. S.S. Steiner is "Committed to the brewer".

307 **Sartorius AG,** Weender Landstr. 94-108, 37075 Goettingen, Germany; Phone: +49 551 3083700, Fax: +49 551 3083754, Website: www.sartorius.com. *Products or Services:* Sartorius AG is an internationally leading process technology supplier covering the biotechnology and mechatronics segments. Its biotechnology segment focuses on filtration and separation applications, fermenters, and proteomics. Recently, Sartorius introduced a new crossflow system for beer clarification, a joint development with its alliance partner Alfa Laval. With the complete range of products for membrane and fine filtration, Sartorius wants to become a leading filtration supplier for the brewing industry.

206 **Sellers Cleaning Systems,** 420 Third St., Piqua, OH 45356; Phone: +1.937.615.3552, Fax: 1.800.328.7573, Website: www.sellersclean.com. *Products or Services:* Sellers Cleaning Systems offers the broadest line of rotating spray nozzles available, for both CIP and portable cleaning applications. Our Jumbo, Tankman, and Sellers 360 models are used extensively in the industry today. Visit our booth and see our new CIP-check monitoring system.

509 **Siebel Institute of Technology/World Brewing Academy,** Suite 2F, 1777 N. Clyborne Ave., Chicago, IL 60614; Phone: +1.312.255.0705, Fax: +1.312.255.1312, Website: www.siebelinstitute.com. *Products or Services:* Featuring information about World Brewing Academy and Siebel Institute courses, yeast services, and laboratory media, Siebel Institute consultancy services, and Siebel Institute laboratory services. Contact us by e-mail at info@siebelinstitute.com.

612 **Siemens Energy & Automation,** 5300 Triangle Parkway, Norcross, GA 30092; Phone: +1.847.382.6707, Fax: +1.847.382.8475, Website: www.siemens.com. *Products or Services:* Siemens Energy & Automation will showcase their integrated quality solution, including the number one LIMS in the food and beverage industry (ARC), integrated with "Braumat" based on PCS-7 batch management process control system, with route control for maximum capacity utilization in the brewhouse.

801 **Sigrist-Photometer/Peak Process Controls Inc.,** Hofurlistrasse 1, CH-6373 Ennetburgen, Switzerland; Phone: +41 624 5454, Fax: +41 624 5455, Website: www.photometer.com or www.peakprocess.com. *Products or Services:* Sigrist-Photometer is a leading manufacturer of process and lab instrumentation for the brewing industry. Sigrist will have on display its line of dual-angle turbidimeters, colorimeters, and product identification instruments. For ease of installation and maintenance, all Sigrist instruments fit standard in-line housings. Peak Process Controls Inc. of Toronto, Canada, represents Sigrist in North America. Phone: +1.905.830.6835, Fax: +1.905.830.6846.

317 **Skalar, Inc.,** 5995 Financial Dr., Suite 180, Norcross, GA 30071; Phone: +1.770.416.6717, Fax: +1.770.416.6718, Website: www.skalar.com. *Products or Services:* Skalar Beer/Wort Analyzer: reduce expensive lab time and reagent use and provide consistent results by fast, accurate, simultaneous analyses for numerous beer and wort applications. Fully automated wet chemistry analyzer for a comprehensive multiparameter configuration. System fully controlled by data system and optional automated start-up/shut-down is available. Applications: alpha-amylase, diastatic power, beta-glucan, free amino nitrogen, polyphenols, diacetyl, viscosity, color, and total/free

SO_2 pH. Also: Total nitrogen/protein analyzer: combustion and TCD detection, Skalar Robotic line for automated probe tests (pH, ISE, and conductivity).

309 **SMART Brewing Services/Futuretec,** Oxford Brookes Enterprises, School of BMS, Oxford, Oxon OX3 0BP, United Kingdom; Phone: +44 1865 484413, Fax: +44 1865 484410, Website: www.smartbrewing.com. *Products or Services:* SMART Brewing Services at Oxford Brookes University provides education, consultancy, and contract research for brewing and related industries. See our new Business for Brewers E-Course. Futuretec will be launching innovative technology for drinks quality control monitoring and assurance.

409 **Südmo North America,** 1330 Anvil Dr., Rockford, IL 61115; Phone: +1.815.639.0322, Fax: +1.815.639.1135, Website: www.sudmona.com. *Products or Services:* Südmo, a member of the NORIT Group, is a leading supplier of high-quality stainless steel mix-proof (double seat) valves and of standard, long stroke, sampling, regulating, tank outlet, aseptic, butterfly, flow diversion, ball, and diaphragm valves. Südmo also supplies fittings, complete manifolds, and control tops that interface directly with simple I/O controls or ASI, DeviceNet, or Profibus.

813 **Teledyne Tekmar,** 4736 Socialville Foster Rd., Mason, OH 45040; Phone: 1.800.543.4461 or +1.513.229.7000, Fax: +1.513.229.7050, Website: www.teledynetekmar.com. *Products or Services:* Teledyne Tekmar (formerly Tekmar-Dohrmann) is the premier manufacturer of gas chromatography sample introduction instruments and total organic carbon/total nitrogen analysis instruments. We provide the latest in fully automated and productivity-enhancing technology. Our knowledgeable sales and service engineers offer unparalleled expertise to help our customers find the right instrument for their analytical needs and support to get the most from their instrument systems.

515 **Tuchenhagen Flow Components, LLC,** 90 Evergreen Dr., Portland, ME 04103; Phone: +1.207.797.9500, Fax: +1.207.878.7914, Website: www.tuchenhagen-fc.com. *Products or Services:* Tuchenhagen Flow Components, leading supplier of mix-proof valves and matrix piping technology, also manufactures the world's largest range of sanitary rising stem valves, including modulating, pressure relief, and vacuum valves, as well as range of pocketless inline instrumentation, cleaning devices, and modular vessel protection and cleaning systems. New products include our Eco-matrix tank piping system, pipeline expansion compensator, and intelligent valve control package.

615 **UC Davis Extension,** 1333 Research Park Dr., Davis, CA 95616; Phone: +1.530.757.8691, Fax: +1.530.757.8634, Website: www.extension.ucdavis.edu/brewing. *Products or Services:* UC Davis Extension (UCDE) brewing programs are world-renowned and the only North American programs accredited by the prestigious Institute and Guild of Brewing, London. UCDE is the only institution in the country to provide university-level qualification in brewing science and brewery engineering. Our graduates gain unparalleled expertise in brewing science, technology, and engineering, and they go on to become leaders in the brewing industry.

312 **ULTRA ANALYTICS–A HACH Company Brand,** 5600 Lindbergh Dr., Loveland, CO 80539; Phone: +1.970.207.1077, Fax: +1.970.207.1088, Website: www.hachultra.com. *Products or Services:* Know your dissolved gas concentration from lauter tun to package! Hach Ultra Analytics, formed through the merger of Orbisphere, Anatel, and Pacific Scientific Instruments, manufactures analyzers for dissolved oxygen, carbon dioxide, and nitrogen. Measurement parameters include inline, portable, and complete package analysis including TPO. Convenient onsite service contracts available.

704 **Union Engineering a/s,** Snaremosevej 27, DK-7000 Fredericia, Denmark; Phone: +45 76 20 7700, Fax: +45 76 20 7800, Website: www.union.dk. *Products or Services:* Union Engineering has been providing CO_2 recovery, CO_2 generation, and CO_2 extraction plants since 1933. In addition, Union provides CO_2 storage tanks, polishing filters, CO_2 purifiers, evaporators, cylinder filling stations, and CO_2 analysis equipment. Recovery, generation, and extraction of CO_2 from your source using Union Equipment provides beverage quality CO_2 from your own source; low operating costs; environmental benefits; cost-effective modular design; low installation costs; user-friendly, fully automated operation; and standardized solutions with proven reliability.

715 **USFilter,** 10 Technology Dr., Lowell, MA 01851; Phone: 1.800.466.7873, Fax: +1.518.758.2182, Website: www.usfilter.com. *Products or Services:* USFilter offers the most complete line of water and wastewater treatment equipment and technologies for the beverage industry. Our water treatment processes include filtration, enhanced filtration, and purification equipment. Our wastewater treatment technologies, including chemical/physical, biological, evaporation, and recovery, provides the tools you need to meet compliance issues, minimize waste, reduce BOD levels, or attain "zero water discharge". USFilter designs, builds, installs, and operates complete water and wastewater systems according to your specifications.

616 **vermicon AG,** Emmy-Noether-Str. 2, 80992 Munich, Germany; Phone: +49 89 158820, Fax: +49 89 15882100, Website: www.vermicon.com. *Products or Services:* vermicon AG develops rapid test kits for the detection and analysis of microorganisms in food, drinks, and water. VIT-Bier plus *L. brevis* and VIT-Bier Megasphaera/ Pectinatus are fast and reliable tests to detect the presence of beer-spoiling bacteria. The 2-in-1 tests detect, respectively, all beer-spoiling lactic acid bacteria/*Lactobacillus brevis* and *Megasphaera cerevisae*/ *Pectinatus*.

814 **Versuchs- und Lehranstalt fuer Brauerei (VLB),** Seestrasse 13, D-13353 Berlin, Germany; Phone: +49 30 450800, Fax: +49 30 4536069, Website: www.vlb-berlin.org. *Products or Services:* The VLB Berlin, established in 1883, is a German institute focused on beer brewing. Today, 100 people work in the areas of research, teaching, consulting, and service. Among other services, the VLB provides a brewmaster course in the English language, laboratory equipment, brewing yeasts, analyses, and consulting for brewers and maltsters.

508 **Waste Management,** 720 Butterfield Rd., 2nd Floor - IPS, Lombard, IL 60148; Phone: +1.708.473.4733, Fax: +1.702.447.5356, Website: www.wm.com.

803 **Waukesha Cherry-Burrell,** 611 Sugar Creek Rd., Delavan, WI 53115; Phone: +1.262.728.1900, Fax: +1.262.728.4904, Website: www.spxprocessequipment.com. *Products or Services:* Waukesha Cherry-Burrell, an SPX Process Equipment operation, manufactures a full line of positive displacement pumps, centrifugal pumps, air-actuated double-seat and single-seat valves, manual valves, scrape surface heat exchangers, fittings, and dispersion equipment. WCB is represented by a worldwide network of stocking distributors.

513 **Westfalia Separator, Inc.,** 100 Fairway Ct., Northvale, NJ 07647; Phone: +1.201.767.3900, Fax: +1.201.784.4331. Website: www.wsus.com. *Products or Services:* Westfalia is a major supplier of high-quality centrifugal clarifying equipment and technology to the brewing industry. We offer clarifiers/decanters for brewing applications such as tank bottom beer recovery, green beer, and hot trub wort clarification. High efficiency ensures a fast return on investment. Now offering a new system for elimination of DE filtration.

414 **WEYERMANN Specialty Malting Company,** Brennerstr. 17-19, 96502 Bamberg, Germany; Phone: +49 951 9322012, Fax: +49 951 35604, Website: www.weyermann.de.

511 **White Labs Pure Yeast & Fermentation,** 7564 Trade St., San Diego, CA 92121; Phone: 1.888-5-YEAST-5, Fax: 1.888.693.1026, Website: www.whitelabs.com. *Products or Services:* A full-service lab, specializing in pitchable, certified-pure, liquid brewers, distillers, and wine yeast; laboratory equipment; testing services; and easy-to-use quality control test kits. Our mission is to provide the highest quality liquid brewers yeast and lab products at a fair price with unparalleled service.

805 **The Wittemann Company, LLC,** 1 Industry Dr., Suite A, Palm Coast, FL 32137; Phone: +1.386.445.4200, Fax: +1.386.445.7042, Website: www.wittemann.com. *Products or Services:* Wittemann designs and manufactures high-quality equipment for the recovery and purification of carbon dioxide (CO_2). On display is the process of recovering CO_2 from fermentation that includes purification, compression, dehydration, and liquefaction. Also displayed is our industry standard "Pinpoint Carbonator", which is used for the carbonation of beer and/or water.

215 **Yakima Chief, Inc.,** 555 West South Hill Rd., P.O. Box 209, Sunnyside, WA 98944; Phone: +1.509.839.9022, Fax: +1.509.839.5570, Website: www.yakimachief.com. *Products or Services:* Leaf hops, pellet hops, pure resin CO_2 extract, beta-acid oil fractions, alpha-acid fractions, isomerized hop products, reduced hop products, light-stable hop products, effervescent hop character tablets, toll processing, and customized blending and packaging to meet special dosing requirements for kettle or postfermentation addition.

600 **ZIEMANN Ludwigsburg GmbH,** Schwieberdinger Strasse 86, 71636 Ludwigsburg, Germany; Phone: +49 7141 408322, Fax: +49 7141 408222, Website: www.ziemann.com.

EXHIBIT NUMERIC LISTING

101 Ionics Instrument Business Group
103 PBM, Inc.
105 Keg Club Inc.
107 Gerstel, Inc.
117 GKD–USA, Inc.
200 Bio-Chem Laboratories, Inc.
201 Briggs of Burton, Inc.
202 FOSS
203 Filtrox North America Co./Filtrox AG
204 Kalsec Inc.
206 Sellers Cleaning Systems
208 Bruker BioSpin Corporation, EPR Division
210 Danbrew Ltd. A/S
211 Mehrer-Compressors (Josef Mehrer GmbH & Co. KG)
212 Astoria-Pacific International
213 Millennium Chemicals
214 MLT Research/Gen-Probe
215 Yakima Chief, Inc.
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300 Buhler Inc.
301 Crispmalt/Brewers
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313 Genencor International, Inc.
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317 Skalar, Inc.
400 optek-Danulat, Inc.
401 Cool-System Bev. GmbH
402 Millipore Corp.–Food and Beverage
403 Gusmer*Cellulo*
404 Headmaster Limited
405 Gusmer*Cellulo*
406 Aber Instruments Ltd.
407 Haffmans
408 NOVOZYMES
409 Südmo North America
410 Ponndorf
411 NORIT Process Technology
412 LemnaTec
413 AcquiData, Inc.
414 WEYERMANN Specialty Malting Company
415 Brewers Digest
416 Loeffler Chemical Corporation
417 Procon Technologies Inc.
500 Cargill Sweeteners North America & Malt
501 BASF Corporation
502 Ecolab Inc.
503 brewmaxx
504 Anton PAAR USA
505 Huppmann Group
506 Pall Corporation
507 ENERFAB, Inc.
508 Waste Management
509 Siebel Institute of Technology/World Brewing Academy
510 Briess Malt & Ingredients Company
511 White Labs Pure Yeast & Fermentation
512 Emerson Process Management
513 Westfalia Separator, Inc.
514 MYNAH Technologies
515 Tuchenhagen Flow Components, LLC
516 Albert Handtmann Armaturenfabrik GmbH + Co. KG
517 Canongate Technology Inc.
600 ZIEMANN Ludwigsburg GmbH
601 ISP
602 GE Water Technologies
603 Rockwell Automation
604 Profamo, Inc.
605 MEURA (Brewery Equipment) Ltd.
607 domnick hunter inc.–Gas Purification Division
608 Canadian Malting Barley Technical Centre
609 domnick hunter inc.–Process Division
610 JohnsonDiversey, Inc.
611 PureMalt Products Ltd.
612 Siemens Energy & Automation
613 HDP-NERB
614 Adaptive Analyzer Technologies, Inc.
615 UC Davis Extension
616 vermicon AG
617 CE Elantech, Inc.
700 Frings America Inc.
701 Anton Steinecker Maschinenfabrik GmbH
702 Brewing Research International
703 Enzyme Development Corporation
704 Union Engineering a/s
706 Centec LLC
708 ChemTreat, Inc.
710 Metrohm-Peak, Inc.
711 Hanna Instruments
712 International Centre for Brewing and Distilling
713 EaglePicher Filtration & Minerals
714 AMC Technologies, Inc.
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809 Microanalytics, a MOCON Company
810 Endress + Hauser Inc.
811 Modern Brewery Age
812 Industrial Environmental Coatings Corp., DBA Enviroline Group
813 Teledyne Tekmar
814 Versuchs- und Lehranstalt fuer Brauerei (VLB)
815 Cambridge Wire Cloth Company
817 Hygiena
900 DIAGNOSTIX
904 Beckman Coulter Inc.
906 Reotemp Instrument Corp.

Elizabeth Foyer
EF American Society of Brewing Chemists (ASBC)
EF Brewery Convention of Japan (BCOJ)
EF European Brewery Convention (EBC)
EF The Institute & Guild of Brewing (IGB)
EF Master Brewers Association of the Americas (MBAA)

SUPPLIER SESSIONS

Newly introduced, these sessions offer an in-depth look at products and services for the industry. The presentations are each 45 minutes in length and offer the latest information on products, applications, and solutions.

SUNDAY, JULY 25

AMC Technologies/PreSens
Gregory A • 3:30 – 4:45 p.m.
Optical Oxygen Measurement Technology

Optical measurement technology (Fluorescence Quenching) for measuring trace dissolved oxygen down to 1 ppb for TPO, online, and portable instrumentation.

John Gleeson, AMC Technologies, 6617 Clayton Road, St. Louis, MO 63117 U.S.A.; Phone: +1.314.726.9969; Fax: +1.314.726.9989; www.amctechnologies.net and www.presens.de

MONDAY, JULY 26

EaglePicher Filtration & Minerals
Gregory B • 8:30 – 9:15 a.m.
Filtration Media

Optimizing filtration and improving shelf life, quality and integrity utilizing low BSI and Arsenic filtration media.

Kimberly Walsh, EaglePicher Filtration & Minerals, 9785 Gateway Drive, Suite 1000, Reno, NV 89521 U.S.A.; Tel: +1.775.824.7646; Fax: +1.775.824.7601; www.eaglepicher.com

PBM Inc.
Gregory A • 8:30 – 9:15 a.m.
Brewery Sampling Valves

Sample with this! PBM's Sanitary Rising Stem Sampling Valve product line is specifically designed for taking process samples in breweries to ensure quality, consistency, taste, and sterility.

Jim Pericles, Jerry Foley; PBM Inc., 1070 Sandy Hill Road, Irwin, PA 15642 USA; Tel: +1.724.863.0550; Fax: +1.724.864.9255; www.pbmvalve.com

Procon Technologies
Gregory A • 9:45 – 10:30 a.m.
In-Line Beer Analysis with Novel Analysis Technologies
Procon Technologies introduces Rhosonics In-Line Beer Analysis System.

Using several new technologies that include a unique automatic calibration system, it is possible to measure alcohol and extract in beer with high accuracy. The system takes care of occasional gas bubbles in the process line, improving reliability and accuracy.

Willem de Jong (Rhosonics), Procon Technologies, 30 Industrial Drive, Naperville, IL 60563 U.S.A.; Tel: +1.630.357.8540; Fax: +1.630.357.4918; www.procontechnologies.com

Tyco Flow Control / Hygienic Process Equipment
Gregory B • 9:45 – 10:30 a.m.
Patented Mixproof Valve Technology

Patented Mixproof Valve technology simplifies matrix design by eliminating waterhammer while Master Mind Control Top senses seat lift and provides valve leak detection.
Paul Lopez, 1195 Airport Road, Lakewood, NJ 08701 U.S.A.; Tel: +1.732.730.1008; Fax: +1.732.730.1038; www.tycovalves.com

TUESDAY, JULY 27

NOVOZYMES
Maggie • 8:30 – 9:15 a.m.
Viscoflow™

NOVOZYMES presents a new enzyme for improved predictability and economy of the brewing processes.

Noel M. Bautista, NOVOZYMES, Neumatt, CH-4243 Dittingen, Switzerland; Tel: +41 61 765 6111; Fax: +41 61 765 6333; www.novozymes.com

Rockwell Automation
Gregory A • 9:45 – 10:30 a.m.
Tracking and Tracing Solutions: Preserving Your Brand Value

Tracking and tracing of production information is important for regulatory compliance and a key component in preserving brand value. Learn how tracking and tracing solutions can help you meet regulations plus improve manufacturing efficiency and effectiveness to deliver consistent high quality products.

Paul Nowicki, Rockwell Automation, 2000 Regency Parkway, Cary, NC 27511 U.S.A.; Phone: +1.919.465.1741; Fax: +1.919.465.1742; www.rockwellautomation.com/beverage

domnick hunter inc., Gas Purification Division
Maggie • 3:45 – 4:30 p.m.
CO_2 Purification Device for Draft Beer Dispense

This presentation discusses the issues of protecting the quality of carbon dioxide used for serving draught beers at the point of sale. An in-line purifier is presented which as been designed to act as a safeguard against possible CO_2 contaminants and maintain the qualities of the beer as the brewer intended.

Gary Robson, 5900-B Northwoods Pkwy., Charlotte, NC 28269 U.S.A.; Tel: 1.800.345.8462; Fax: +1.704.921.1960; www.domnickhunter.com

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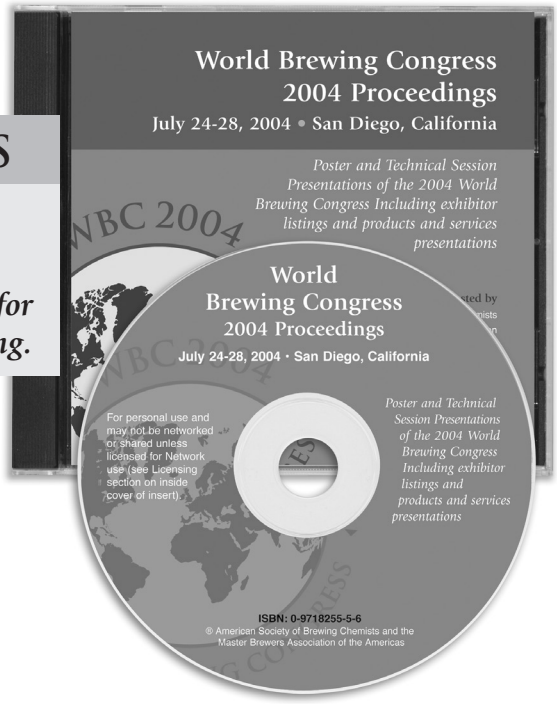

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