World Brewing Congress 2000

Oral Presentations

The technical program of the World Brewing Congress held from 29. July to 2. August in Orlando, Florida consists of 60 oral presentations and 61 posters. Organized by the MBAA and ASBC and supported by all major Brewing Organizations, contributions from all over the world offer a complete spectrum of todays activities in research, practical brewing and in the suppliers industries.

O-1 Review of The Hop Research Council at the Year 2000

L.C. Verhagen

Hops is an essential ingredient of beer. Research is needed to assure the quality of hops as a raw material, as well as for understanding its impact on the quality of the beer brewed with it. In the US much of the hop research has been supported by and done under the auspices of the United States Department of Agriculture. In addition to the USDA's key role in the US hop research, brewers, dealers and growers have recognized for years that it is essential to work together to keep up with the industries' needs. This led in 1979 to the foundation of the Hop Research Council (HRC). Since its formation, HRC has continuously supported research programs in the areas of hop breeding and genetics, i.e. new varieties, plant protection, biological pest control and integrated pest management, pesticide registration, hop chemistry and hop flavor. Today both, the hop and the brewing industry are undergoing significant changes. Oversupply of hops is leading to reduced acreage of hops and consolidations, with the effect that the resources available for basic and applied hop research are also slowly eroding. Therefore the role of HRC to fund research needed by the hop industry to assure its long-term sustainability is becoming increasingly more important. In this lecture the accomplishments of HRC since its foundation will be highlighted, as well as HRC's mode of operation, membership, financial structure and strategic plan.

O-2 Analysis of lupulin-specific expressed gene responsible for hop resin biosynthesis

Yukio Okada, Dae Yeon Suh, Ushio Sankawa and Kazutoshi Ito

Recently, two new breeding methods using biotechnology have been established in many plants. One is transformation and the other is marker assisted selection (MAS). These techniques make easy to endow any desirable traits in plant breeding. However, genome analysis of objective plants is necessary to apply these techniques. In hop breeding, it is important to control the content and quality of resin and essential oil for beer brewing. Although isolation of the genes responsible for these traits is useful for the application of transformation or MAS to control these compounds, there were no information available about these genes. Therefore, we examined to isolate lupulin specific genes which are functional in lupulin glands specifically, because these compounds are accumulated in lupulin glands specifically. As the result, one interesting gene, which was similar to chalcone synthase gene, was isolated. The biosynthesis of alpha-acids' and beta-acids' precursors is catalyzed by chalcone synthase-like enzyme, namely valerophenon synthase (*Fung* et al.). The expression experiments indicated that the product of the isolated chalcone synthase-like gene had not only chalcone synthase activity but also valerophenon synthase activity. We confirm that this chalcone synthase-like gene is the gene responsible for resin biosynthesis.

O-3 Improving hop utilisation and flavour control through the use of pre-isomerised products in the brewery kettle

Richard J.H. Wilson, Trevor R. Roberts, Robert J. Smith and Martin Biendl

Many breweries now brew with isomerised hop pellets, eliminating about one third of their former purchase of bittering hops and an even greater part of their aroma hops, at the same time gaining the ability to vary the hoppy flavour of beer without risk of losing economic advantage. The same principles can be applied to hop extracts. A CO_2 extract of hops was converted into two forms of isomerised kettle extract. In the first, "IKE", the original alpha-acids were converted into iso-alpha-acids, while in the second, "PIKE", these were further changed into their K^+ salt forms, yielding a product that was rapidly dispersible into hot wort. Pilot brewing trials showed that utilisation values were thereby greatly increased, without apparent change to the beer flavour. Moreover, late addition to the kettle resulted in similar enhancement of hop oil components to the beer as for a CO_2 extract control brew. And even when PIKE was added only to the whirlpool during casting, utilisation of the iso-alpha-acids remained very high. The production of lightstable beers is commonly achieved via use of bitterness derived solely from post-fermentation addition of reduced, isomerised alpha-acids. However, this does pose the risk of encountering serious wort infections. Further brewing studies showed that the addition of rho-iso-alpha-acids to the kettle instead still allowed the achievement of high utilisations. If hop oil components were also added to the kettle, then a beer could be brewed that was similar to that produced by use of CO_2 extract, excepting only that the bittering component was necessarily different.

O-4 Germination and malt quality

M. Krottenthaler, B. Sacher and W. Back

Actual barley varieties often show a disharmony concerning cytolytic and proteolytic enzymatic power. Classical germination regime often did not lead to satisfactory malt quality. It has to be

proved, if germination technology can equalize a poor cytolytic and a strong proteolytic power, to produce malt which shows a good filtration efficiency and good taste stability. Pilot scale malting of barley varieties with different characteristics concerning cytolytic and proteolytic power was done. Thereby the parameters of germination, such as time (4 – 6 – 8 days), temperature (12 – 15 – 18 °C) and moisture (41 – 45 – 49 % water content) were modified. Estimation of variance components of malt ana-lyses shows that excluding diastatic power and protein content, malt quality parameters can definitely be influenced by germination technology. Germination temperature of 18 °C leads to good cytolytic modification and therefore to a good processing performance of the malt. Via rootlets low molecular protein is separated from the malt and a moderate Kolbach index was found. Barley variety, year of the crop and other parameters affect malt quality. This paper shows how the germination regime can influence malt quality to achieve the specifications given by the breweries.

O-5 Unraveling the cell walls from barley endosperm

C.W. Bamforth

The walls surrounding the cells in the starchy endosperm of barley have attracted much attention for over a century, yet still there remains much to unravel about them. What is the architecture of the walls, insofar as how do the beta-glucan, arabinoxylan, protein and phenolic acids interface with one another? Is the wall layered? In turn, how does the structure influence the digestibility of the walls? What is the sequence of enzymic breakdown of the walls – and why do most brewing scientists seem to disregard the importance of the arabinoxylan, despite its accounting for one-fifth of the wall biomass? What are the kinetics of cell wall degradation: can one model changes in cell wall polymers in the brewhouse? What are sensible, meaningful and reliable techniques for assessing the content of wall materials and the enzymes that digest them in barley and malt? This paper will for the most part focus on reviewing the vast literature on cell wall polymers, but will also include some recent data that sheds light on the solubilization of cell wall polymers in mashing.

O-6 Agronomic and process effects on wort and beer variability

Nona M. Mundy, Albert Linnebach and Anthony J. Cutaia

Variations in analytical measures of wort and beer are an accepted fact of life in data collection. This study attempts to clarify and quantitate the sources of this variation by utilizing a nested, hierarchally designed experiment to estimate components of variance. Four barley varieties were employed with growing location; malting process; brewing process; and analysis as candidate variance component factors. Malting was accomplished in a one-ton pilot malting plant with brews prepared in a ten-barrel research pilot brewery. Over thirty wort and beer attributes were analyzed in duplicate. Analysis of variance (ANOVA) demonstrated that, although the brewing process itself is a significant contributor to measurement variation, additional sources of variation are significant for particular analyte classes. This is of particular interest when blending schemes are considered.

O-7 Quantification of beer freshness after brewing using the Kirin Freshness Value

Osamu Ogane, Takayoshi Katayama, Yoshiyuki Tateishi, Toshinori Hirano and Fumihiko Yokoyama

It is now possible to quantitatively measure beer freshness using the Beer Freshness Value developed by Kirin. We have investigated the application of the quantitative beer freshness value in the management of beer freshness from the end of the brewing process until the beer is consumed. Immediately after brewing, the freshness value is set at 100%, which can easily be understood by consumers, and the value then decreases from this point. The decrease in the freshness value is expressed as a function of time and storage temperature as shown below:

Freshness Value (%) = 100EXP(-Integral(K) dt) =100X(t) /X(o)

K= deterioration constant in beer quality over a set period of time at constant temperature (1 unit/day); t = days in storage; X(t), and X(o)= the experimentally determined values for freshness.

Thus by kinetic analysis of beer freshness, we have been able to develop a new freshness value with a wide range of applications. Moreover, by simulating the decrease in freshness during packaging, storage and transport we can use the Kirin Freshness Value to quantify the effectiveness of measures used to maintain beer freshness in order to supply fresh and tasty beer to our customers.

O-8 Beer mouthfeel: the expert taster's and the consumer's perception

Karin Pawlowsky, Wen Wu, Sachin Chandra and Paul Hughes

In the literature beer mouthfeel is often described as being an important contributor to beer flavour. However, very little research has been carried out to improve our understanding of beer texture. We have developed a sensory terminology for the description of beer mouthfeel and successfully employed it to differentiate between beer types on the basis of their textures. Experimentally, to minimise any interference of aroma and taste, a reference beer was used and various texture-altering substances added. Expert tasters were able to discriminate between the samples. A consumer group of typical lager drinkers was also able to distinguish the beers. Preference mapping of the consumers' ratings indicated the existence of groups with different preference patterns.

O-9 Gas Chromatography-Olfactometry and beer flavor

H. Goldstein, A. Murakami, A. Navarro and D. Ryder

Gas Chromatography-Olfactometry (GC-O) is the method of choice when trying to arrive at an understanding of the flavor attributes of foods and beverages. Other detection methods used in conjunction with gas chromatography such as Flame Ionization Detection (FID), Flame Photometric Detection (FPD), Mass Spectrometry (MS) give the investigator information concerning the chemical or spectral nature of the compound which is responsible for a peak. GC-O gives the investigator an idea as to the aroma or smell of the compound associated with a given GC retention time which is important when trying to achieve an understanding of the flavor attributes of the sample. GC-O alone and in conjunction with dilution techniques has been applied to samples of pilot plant produced hopped and unhopped beers in an attempt to determine the hop-derived flavor active compounds responsible for the

flavor of kettle-hopped beer. Although GC-FID indicated that there was a significant difference in the two samples, only linalool and two unknown compounds with a mercaptan-like aroma were present in the hopped beer sample and not the unhopped beer sample by GC-O. In a separate study, GC-O was employed to determine the aroma-significant components of hops using headspace samples. Comparison of these results with those obtained by employing hop oil samples indicated great differences. When compared with the GC-O of beer, little in common was observed.

O-10 Evaluation of taste quality of beer using taste sensing system

Yoshinobu Naito, Katsushi Sato, Yoshikazu Kobayashi, Hidekazu Ikezaki, Akira Taniguch and Kiyoshi Toko

There are many kinds of taste substances in a beer, therefore, the evaluation of beer taste quality by human sensory tests is difficult. We reported a taste sensing system in 65th ASBC Annual Meeting in 1999. This system consists of multichannel taste sensor with lipid/polymer membranes. One of the characteristics of the taste sensor is global selectivity. This system can distinguish between fresh and heat-deteriorated beer. It is able to quantify the bitterness and sourness. Furthermore the taste sensor can obtain many other information from a typical taste of beer. In this study, we investigate the correlation between sensor output and human sensory test for other taste, such as satisfy, rich, smooth, clear, delicate, crisp, etc. A total of 16 people took part in sensory test. As a result, beer samples are discriminated into two groups. One is satisfying taste and the other is characterless or watery taste. We found high correlation between outputs of taste sensor and the result of human sensory test. Therefore, it is concluded that this method is useful for evaluation of taste quality, satisfy, full body, delicate, and so on. Taste sensing system can be applied as a substitute method for human sensory tests and physicochemical analysis of beer.

O-11 Malt quality and flavor stability

M. Uchida, M. Sawada, K. Oshita, A. Isoe and Y. Kawasaki

As malt quality is considered to influences beer flavor stability, the selection of malt is important to produce beer with good flavor stability. However, evaluation method of malt from the viewpoint of flavor stability is not necessarily enough. In this paper, active oxygen evaluation system composed of ESR (Electron Spin Resonance) method and CL-FIA (Chemiluminescence-Flow Injection Analysis) method were applied for investigating the effect of malt quality on beer flavor stability. ESR method can estimate OH-radical generation activity of wort and EA-value (Endogenous Antioxidant activity) of beer, which are determined from the behavior of OH-radical generated in wort and beer during forced oxidation. CL-FIA method can investigate H_2O_2 generated in wort and beer during forced oxidation, which is one of the key intermediates for OH-radical generation from oxygen. The relationship between malt modification and beer flavor stability was investigated by changing malting conditions. When malt of higher modification was used for beer brewing, generation of H_2O_2 and OH-radical in wort during forced oxidation was accelerated and EA-value of finished beer became lower, resulting in poor flavor stability. The acceleration of OH-radical generation was considered to be mainly due to the increase in Maillard reaction products and iron, which could accelerate OH-radical generation in wort and beer. It was clarified that malt quality was also very important from the viewpoint of active oxygen generation activity in resultant wort and beer, which influenced beer flavor stability

O-12 Multivariate modeling of sensory and chemical data to understand staling in light beer

Robert T. Foster II, Eric Johann Samp and Hugo Patino

To an effort identify key staling compounds in light beer, an attempt was made to model chemical data with sensory data using multivariate statistical methods. Trained sensory panelists evaluated packaged beer samples for 31 flavor attributes, of which 12 were used in the model to describe staling. Beer chemistry was evaluated on the same samples using an in-house gas chromatographic method. This method was developed to detect carbonyl compounds and other flavor-active compounds in beer with minimal artifact formation. The packaged beer samples were a combination of fresh and aged light beer. Partial Least Squares (PLS) analysis was employed on the data to model the 38 known and 46 unknown compounds to the 12 mean sensory scores. The results of the NIPALs algorithm yielded a four dimensional model, verified through cross-validation, with good prediction capability. Some of the known compounds found to be significant indicators of staling from the PLS models were 2-furfural, furfural acetate, furfural alcohol, and some alkadienals. Of the known furfural compounds measured, PLS coefficients for 2-furfural and furfural alcohol loaded positively for staling whereas, the coefficients for furfural acetate decreased upon staling. A similar result was also observed from the models yielding a negative coefficient for ethyl hexanoate indicating that this compound decreases with staling. For the unknown peaks that were identified as significant in the PLS modeling, most unknown peaks loaded positively with staling; however, a few loaded negatively indicating that these components reduce with staling. These models may prove to be useful tools in determining levels of beer staling and may also be useful in evaluating flavor stability since the chemistry results can be used to predict those sensory scores related to staling.

O-13 Yeast management – The balance between fermentation efficiency and beer quality

Graham G. Stewart

It is important to jealously protect the quality of cropped yeast because it will be employed to pitch subsequent fermentations and will therefore have a profound influence on the quality and stability of the resulting beer. The advent of a number of fermentation and yeast handling systems has improved wort fermentation efficiency and productivity but unless the yeast is managed with appropriate operating procedures both beer and yeast quality will be jeopardized. Developments that will be discussed as examples of potential problem systems will be: fermentation of high gravity worts, yeast cropping with a centrifuge, the use of multi brew fermenters and the introduction of immobilised yeast cells for both primary and secondary fermentation.

O-14 Measuring yeast quality – A review

K. A. Smart

Beer quality is strongly influenced by the biochemical or fermentation performance of the yeast during fermentation. Fermentation

performance may be defined as the capacity of a brewing yeast biomass to consistently exhibit four key attributes: cell proliferation, the utilisation of fermentable carbohydrates leading to ethanol production (attenuation), the aggregation and subsequent sedimentation of biomass at the end of fermentation (flocculation) and flavour development. Brewers therefore require consistent quality and quantity of pitching yeast. Pitching yeast may be quantified manually, by volume or cell counting using a microscope or by the utilisation of automated systems that rely on cellular conductance. Consistent quality may be defined as the purity, stability and physiological condition of the yeast. Although the purity and stability of the pitch may be determined using both physiological and genetic analyses, predicting the capacity of pitching yeast to perform well during fermentation is, however, more complex. The potential of methods that have been utilised to predict individual and combined parameters of fermentation performance is reviewed.

O-15 Mode of action of a novel yeast factor increasing yeast brewing performances

M. Dillemans, L. Van Nedervelde and A. Debourg

Previous work shown that a yeast peptide complex (YPC) obtained by alcoholic extraction of yeast stimulates yeast metabolism. In brewing conditions, it has been shown that this peptide factor reduces the major negative effects of high gravity brewing. It not only enhances the fermentation rate, the final attenuation and the resistance to ethanol and osmotic stresses, but also maintains the stability of yeast performances during successive high gravity wort fermentations. The results show that the addition of YPC not only strongly stimulates the fermentation power on glucose and maltose, but also growth. Therefore, it has been suggested that the YPC factor increases the energetic level by stimulation of glucose metabolism. Indeed, the results indicate at least 3 ways in which the YPC controls glycolysis in yeast: it stimulates glucose uptake, increases fructose-2,6-biphophate intracellular concentration and increases pyruvate decarboxylase activity. Moreover, results also demonstrated that YPC exhibits an insulin-mimetic activity not only on glycolysis but also on the overall metabolism, stimulating mitochondrial enzymes, confirming the crucial role of mitochondrial energy-generating systems in the resistance to stress under fermentation conditions.

O-16 Novel primary fermentation with immobilised yeast system

E.J. Pajunen, T.T. Viljava and H.O. Lommi

Beer of good organoleptic quality has been fermented in a simple single-reactor system in large pilot scale with yeast immobilised on a fixed bed of wood chips. The bed volume was 1 m^3 and production rate 50 litres/hour. When scaled up the system is also economically attractive. The savings are partly due to smaller capital investment compared with conventional fermentation: the plant itself is cheaper, and the need of building area and space is smaller. Additional savings come from high volumetric productivity. Losses are smaller because of reduced yeast growth and less tank bottoms. Production costs in general, like the cost of cleaning chemicals, are smaller because of smaller equipment volume. Fast throughput and the small volume of beer in process at one time lead to savings in production logistics by increasing flexibility in day-to-day production planning and making possible rapid responses to changing production needs in exceptional situations. In spite of some extra costs attributable to increased pumping in the system, the net economical balance is clearly in favour of the new process. The system is modular which makes it easily adaptable to varying capacity needs. The process is designed to be integrated with continuous maturation, thus providing all the benefits of a truly continuous process.

O-17 Modelling primary fermentation

Andrew Hind

Fermentation modelling aims, in order of difficulty, to predict reliably the results of small well-mixed fermentations, to predict reliably the results of large scale fermentations, to optimise current fermentation systems, to develop control strategies and finally to design new fermentation systems. In order to achieve this it is necessary to consider initial wort composition, the design of the fermentation vessel, production operations, the biochemical transformations involved, heat, mass and momentum transfer and the final product. This presentation describes the development of simple fermentation models by considering mass transfer, mixing and the biochemistry. A simple energy balance equating the energy input from bubble rise with energy losses arising from fluid flow allows a crude prediction of the velocities to be found in a range of fermentation systems. Combined with a reliable model of well mixed fermentation, including the effects of static pressure, dissolved CO_2 concentration, temperature, biomass and mixing intensity this should provide the simplest overall model of fermentation; akin to the short cut reactor design methods used in the chemical industry. The issues and results from developing this type of model are presented.

O-18 Patterns of innovation in brewery fermentations

Alastair Pringle

New ways of fermenting wort to produce beer have been developed over the past 100 years. While some fermentation techniques have been adopted by the majority of brewers, many fail to gain wide acceptance. An examination of why some innovations were successful and why others were not was performed by categorizing fermentation techniques into the patterns of evolution of technological systems identified in TRIZ. Through these patterns of innovation it was possible to explain why innovations were successful and predict which innovations will be successful in the future.

O-19 Review on a new concept for brewery effluent treatment

P.R.C.M. Schnellen, T.L.F.M. Vereijken and P. Yspeert

About five years ago a new concept was used to satisfy the typical demands that many breweries world wide formulate when considering an effluent treatment plant on site: no sludge production, no smell and no space available. Currently many breweries use this conceptual design, which includes the most compact anaerobic and aerobic technologies. This paper uses the operational results of the effluent facility at the Grolsche Bierbrouwerij Nederland B.V. to evaluate the pro's and con's of the concept. The characterization of the brewery effluent has a wide impact on the determination of process parameters for design purposes, and also reveals valuable information of the status of internal sanitation

programs. It was found that on brewery level several important effluent parameters appear to relate closely to the relative production level, which information can be used to properly determine the sizing of the required pre-treatment. When evaluating brewery effluent, characterized by many unexpected fluctuations in COD, pH, TSS etc., this is an important factor. Regular monitoring of the described relations also allow for an improved environmental quality control. Other aspects like hydraulic buffering, pre-acidification processes, and influence of variability on the anaerobic process were studied during the 5 consecutive years. The improved understanding of these aspects, described in the article lead to a more compact and secure design philosophy, valuable for future applications. The article finally signals the ongoing developments in the field of reactor-design and bio-control technology, which are all based on the experiences at brewery applications like Grolsch.

O-20 Fuel cell cogeneration system using biogas from brewery effluent

Hiroto Sato

A rare-in-the-world fuel cell cogeneration system using biogas generated from the effluent of a beer brewery commenced operations in Chiba Brewery of Sapporo Breweries in June 1998. Fuel cell cogeneration systems are low in the emissions of nitrogen oxides, and can achieve high power generation efficiency, thereby able to constitute environmentally friendly cogeneration systems. The New-technology at this project is the use of biogas generated from organic wastes instead of fossil fuel gases for fuel cells can further mitigate environmental loads on the earth. This system is structured by an anaerobic wastewater treatment plant, a biogas pre-treatment plant and a fuel cell cogeneration plant. In this anaerobic wastewater treatment plant, effective biogas generated by methane fermentation can be recycled for the energy in our brewery. We've decided to install Toshiba's 200kwe fuel cell, PC25TMC, which can utilise 80% of energy content of biogas. This biogas contains impurities harmful to fuel cell operations. The biogas pre-treatment plant was designed to reduce their harmful components. Thus this system can save total energy consumption of the brewery by about 4%. And we got the authorization in accordance with "the Special Law concerning the Promotion of the Widespread Use and Others of New Energy" designated fuel cell power generation as one of new energy technologies.

O-21 D&G CO_2 Strategy

Cedric M. Blair

Following a detailed study of CO_2 and usage at D&G by W.S. Atkins in 1995, a three phase development programme was recommended. Phase 1: Replacement of failing storage tanks to alleviate storage problems and eliminate the potential safety risks arising from ageing high pressure vessels. Phase 2: Install CO_2 Production Plant (Generation & Liquefaction) to give D&G immediate self-sufficiency in CO_2 for the brewery and soft drink operations, whilst generating substantial revenue savings. Phase 3: Improve recovery of CO_2 from fermentation by installation of a low purity type recovery system whilst retaining certain items from the existing recovery plant. Following the lessons learnt from the Guinness Dublin CO_2 tank failure, a new tank specification, produced jointly by Guinness & W.S. Atkins Ltd. was decided on for the D&G facility. Manufacturing operations all over the world are discovering the reliable, maintenance-free way of storing carbon dioxide. Replacing mechanically refrigerated foam insulated storage tanks with vacuum insulated (VJ) tanks mean more dependable operations and lower operating costs. The tanks are double-walled vessels with an evacuated annular space filled with pertite, which is an insulating powder manufactured from volcanic rock. The high performance insulation system enables us to entirely eliminate the need for auxiliary mechanical refrigeration on most applications. The inner vessels are designed to either the ASME Pressure Vessel Code (USA), or the AD-Merkblätter Code, Germany. Additional performance features and benefits include: Superior insulation system means low evaporation rate and less lost product. A no-loss system can be achieved with proper matching of tank and processes. The vessel, support system, legs and bolting pads are designed for wind and earthquake loads. Liquid level indication by differential pressure gauge with remote LCD readout. The pressure indicator is mounted on the low-pressure side of the level indicator. Regulated tank pressure building for constant product supply via an ambient vaporiser and a supplemental electric vaporiser. Economiser circuit that preferentially sends gas to the process, if the tank pressure has risen above normal operating pressures, before vaporising more liquid through the product withdrawal line. Bursting disc for outer vessel protection from overpressure. Back pressure regulator that will vent to atmosphere at a set point below the safety relief settings. CO_2 Generation Plant. The CO_2 production facility is split into two main components namely the generating unit and the liquefaction unit. Generating Unit. The Plant is based on the combustion of fuel in the lye heater unit. The combustion gas, which among other things contains CO_2 and small amounts of SO_2, is scrubbed in the flue gas scrubber where the SO_2 is removed. From the flue gas scrubber, the flue gas goes to the absorber where the CO_2 is absorbed by a liquid solution of MEA in counter flow with the flue gas. The rest of the gas leaves the top of the absorber. An exhauster is installed to take the flue gas through this system. The MEA, which has absorbed the CO_2 (rich lye), is pumped from the bottom of the absorber through the lye cooler where it is preheated to the stripper where the CO_2 is boiled out of the MEA. The stripper is connected with the lye heater and from there the MEA, which is now without CO_2 (lean lye) is pumped through the lye cooler where it is cooled down and pumped back to the absorber. Liquefaction Unit. The CO_2 together with some steam leaves the top of the stripper and goes to the gas cooler where the steam is condensed and the CO_2 is cooled. The CO_2 goes from the gas cooler through the potassium permanganate scrubber, where NOX and any MEA vapour is removed and then to the CO_2 compressor where the CO_2 is compressed to about 15 bar in two stages. From the CO_2 Compressor it goes through the Dehydrator, where it is dried to a dew point of 60 degree C, then through the activated carbon filter which removes any odour to the CO_2 condenser. It is then cooled down to about 30 degrees C and liquefied by means of the Refrigeration Plant. CO_2 Recovery Upgrade. The final phase of the D&G CO_2 strategy involves the installation of a low purity recovery plant (i.e. Perry Atkins System) to maximise on-site recovery of CO_2. This new Perry Atkins type system is based on liquefying 70% of the total CO_2 leaving the fermenters, and is considered "Best Practice" for a collection plant which accepts low purity feed gas. With a low purity collection system, fermenters should be connected to recovery immediately after filling. This has the additional benefit of simplifying operating procedure in the Cellars, reducing the likelihood of excessive CO_2 venting from FVs. In addition, CO_2 can also be collected from process operations where the main source of recoverable CO_2 is from BBTs. All the BBTs are

currently piped into common vent headers. It would be a simple task to pipe these back into the foam trap for recovery.

O-22 HACCP and ISO9002 (ANSI/ISO/ASQC Q9002) in breweries

Gordon Jackson

HACCP is now used world-wide to assure the safety of beer, to protect brands, to satisfy the requirements of contract clients and to fulfil regulatory requirements. The examples given will be based primarily on experiences in Europe where HACCP is mandatory. It will also include data from a benchmarking exercise on HACCP. The aim was to identify best practice in assuring product safety but the results have also identified a number of areas which are not normally fully addressed as part of the HACCP scheme in breweries. A further benchmarking exercise is being carried out and initial data from this will be available. The presentation will give examples of how breweries in Europe have integrated HACCP into ISO9002 quality management systems and will also explore the implications for breweries of the new International Standard 9001 which will be implemented in the new millennium.

O-23 Development of a special foodstuff for ulcerative colitis: Germinated barley foodstuff from brewer's spent grain

Osamu Kanauchi

A new protein-rich, fibrous foodstuff was made from brewer's spent grain by physical isolation (milling and sieving). This product, named germinated barley foodstuff (GBF), contains glutamine-rich protein and hemicellulose with high water-holding capacity. In addition to the effect of GBF on improving bowel movements in healthy volunteers and animals, the consumption of GBF can prevent inflammation and diarrhea in a colitis model, largely by increasing luminal short-chain fatty acid production and conspicuous water-holding capacity. The aim of this study was to evaluate the safety and efficacy of GBF, as a novel nutritional therapy in the treatment of patients with ulcerative colitis (UC). Patients showed improvements in their clinical activity index scores and endoscopic score, as well as demonstrating an increase in stool butyrate concentrations after GBF administration. No side effects related to GBF were observed in patients with UC. Further we examined the mechanism by which GBF exerts its effects. We found that butyrate is produced through the fermentation of GBF by Eubacterium, with the aid of Bifidobacterium, in the gastrointestinal tract. GBF promotes bacterial butyrate production and improves intestinal barrier function, resulting in the mitigation of colitis. GBF, which is derived from a major by-product of beer brewing, has the potential to be a nutritional therapy for ulcerative colitis.

O-24 The behaviour of ochratoxin A in brewing

Denise Baxter, Ian Slaiding and Barbara Kelly

In recent years there has been increasing concern about potential contamination of foods, including beer, with mycotoxins. Legislation to impose limits for ochratoxin A and other mycotoxins is being drafted by several countries. A number of workers have examined the extent to which Fusarium mycotoxins can survive brewing but much less is known about the behaviour of ochratoxin A, in spite of its greater toxicity. This paper will report the results of brewing trials using malts containing unusually high levels of ochratoxin A. The results will be discussed in the context of a generalised model for assessing the potential for toxicants from raw materials to survive processing and contaminate the final product.

O-25 In-house academy of Brewing Technology

H. Kuroda

As a result of modern beer production procedures becoming more industrialized and fully automated, the systems are becoming like "black boxes". This has caused the younger generation to loose touch with the "real" process of beer making and the quality of workers would not be maintained in the near future. To make up for these gaps, Sapporo established the "Sapporo Academy of Brewing Technology", an in-house school. Founded in 1995, the 900 square meter teaching facility is located adjacent to the Shizuoka Brewery, Brewing Research Laboratories, and Micro Brewery. Currently, there are more than 30 "hands-on" programs. Some of the programs include: "Brewing Technology Training" which offers participants the opportunity to brew beer by deciding on the specifications of their "own" beer and using desktop brewing apparatus. "Malting Technology" employs a small-scale malting device to replicate the actual process. "Microbiological Control Technology" guides participants through cleaning and sterilizing experiments. "Packaging Technology" includes the practical handling of equipment such as a seamer, a labeler, an EBI and others. Here, Sapporo's experts conduct lectures covering theory and practical application using thorough "hands-on" experience by participants. As a result of attendance by staff members and operators from all Sapporo branches, the reliability of human resources improved successfully.

O-26 New brewhouse in Suntory Kyoto Brewery with recent technology toward the coming century

Osamu Takemura, Akira Kogin, Haruyoshi Sotome, Yuiichi Tatumi, Yusuke Umezawa, Kaneo Oka, Masaaki Uchida, Tetsuo Morita, Hiroshi Ikeda and Yoshi Kakimi

In Suntory Kyoto Brewery, a new brewhouse with 1000 hl brew length and 10 brews per day capacity has been started in 1999. Various innovative technologies have successfully introduced into this brewhouse for high quality and high efficiency, such as (1) a facility design which enables to brew any kind of beer between 100% to 25% malt ratio, (2) a technology reducing the damages generated by share stress, oxygen pick-up and thermal load, (3) a technology optimizing hot-break formation and cold-break amount. In this paper, at first, we will discuss beer quality that greatly improved on taste, its stability, foam, etc. with the technological interpretations. Secondly, we will also present a computer-aided process information system which has made it possible to reduce manpower up to 50 thousands KL-wort/man/year. Finally, we will refer to energy saving technologies that have reduced energy consumption of brewhouse by 11%. This result corresponds to 11% of our target, in which total CO_2 emission in 2010 is required to be less than 94% of one in 1990, according to the policy of Brewers Association of Japan. Thus, it must contribute to the environmental protection.

O-27 Relational Brew Data Fandango: Implementing a database and work station operating system at a regional craft brewery

Matt Swihart

A relational database operating system has been implemented at Full Sail Brewing Co. to manage all production and quality assurance information. Work stations, positioned in the key areas of quality control, brewing, laboratory, filtration, and packaging, allow individual departments to input real time data at each manufacturing step of beer production. With the combination of user friendly input screens and rapid data acquisition, each department has immediate access to any beer's specific status. The database can track any amount of blending of product from raw materials through packaged beer. The operating system has dramatically reduced paperwork and the total man-hours associated with documentation. Immediate feedback of items such as brewhouse efficiency, plant yield, and microbiology provide a more rapid response to quality assurance issues.

O-28 Studies of fouling in wort boiling systems

K.L. Tse and P.J. Fryer

Fouling is an inherent aspect of the wort boiling process, arising as a consequence of one of the principle objectives, namely the coagulation of proteins and tannins as hot (and cold) break. Although a well recognised problem, with severe implications for process efficiency and necessitating brewhouse down-time for CIP, little work has been undertaken previously into the nature of the mechanisms of fouling. Consequently, this study reports on work carried out in a model wort boiling system, the aim of which was to determine the predominant influences on the fouling process. The model system was designed to allow the various process modes to be investigated (atmospheric boiling, low pressure boiling, high pressure boiling) and in addition, enabled boiling to be carried out under both (traditional) convection driven and mechanically agitated mixing regimes. The individual influences of various operating parameters on the mechanism of fouling were quantified, including the effect of wort velocity, boiling time, heat flux and agitation. Potential methods for reducing the rate of fouling were also investigated, with the overall aim being to decrease the down-time for cleaning in commercial systems. With considerations of maintaining final product quality, the impact of each of the operating parameters on wort quality was monitored through the use of various analytical techniques.

O-29 The role of mashing, wort filtration and the fermentation process on trans-2-nonenal formation in beer

Tetsuji Yasui, Toshihiko Takeuchi, Yuko Kobori, and Motoo Ohkochi

Both nonenal potential and sulfite in fresh beer have been confirmed to affect trans-2-nonenal formation when beer samples in a practical brewery environment were subjected to accelerated aging. We have thus studied the influence of the brewing process on the levels of nonenal potential and sulfite in beer in laboratory and pilot scale brewing. The nonenal potential in wort decreased during fermentation, but fermentation conditions had little effect on the amount of decrease. The level of nonenal potential in beer has been shown to be determined by the wort level. Both the mashing and wort filtration processes affected the nonenal potential of filtrated wort. In particular, the level of nonenal potential in filtrated wort was freely controllable by changing wort filtration conditions without affecting the turbidity of the filtrated wort. Wort composition, in addition to wort aeration and fermentation temperature, has been shown to influence sulfite formation during fermentation. In this paper we report on how mashing, wort filtration and the fermentation process affect trans-2-nonenal formation in beer.

O-30 Development of a device to determine the rheology of mash

J. Herrmann and K.Sommer

Mash is a heterogeneous solid/liquid suspension. Whereas the filtered wort is well investigated, the mash itself and the influence of solids on the rheology is not devised. The rheological properties of the liquid component are nearly the same as water. The rheological influence of the fine and coarse grits and the husk are investigated. It was found that the strength of the torque in a stirred vessel is closely related to the overall quality and the viscosity of finely ground malt. Based on this idea a construction of a viscosity analyser is suggested. The operation and the method is described. The apparatus measures temperature, revolutions per minute and the torque continuously. The data are evaluated and the result is a so-called process viscosity. The parameters are grist composition, temperature profiles and raw materials (barley malt, sorghum and rice). The relation between the parameters and the process viscosity is discussed. The trace-line of the process viscosity during the mashing procedure shall bring fairly quantified results dimensional solutions in the future.

O-31 Can malt quality be manipulated to improve beer foam quality and haze stability? Differentiation between foam-positive and haze active proteins originating from malt by immunological methods

D.E. Evans, M.C. Sheehan, R.L. Tolhurst, D.C. Stewart, J.S. Skerritt and A. Hill

Beer foam and storage haze stability are of critical importance to brewers as they are amongst the first characteristics by which a consumer judges the quality of their beer. Key malt derived foam-positive proteins including protein Z4, LTP1 and some members of the hordein storage protein family interact principally with hop acids to stabilise foam. Silica mediated beer stabilisation procedures remove haze active protein with high levels of proline (>30%) and glutamine (>30%), suggestive of hordein origin, without reducing foam stability. Polyclonal antibodies were raised to protein fractions of enriched beer foam proteins and proteins extracted from silica used for beer stabilisation. These antibodies were subsequently used to select foam-positive and haze active hordein recognising monoclonal antibodies to enable the development of quantitative double sandwich, enzyme-linked immunosorbent assays (ELISA). These ELISAs were found to measure different malt derived proteins. Progress is reported with the application of these ELISAs to predict beer quality from malt used to brew beer using a small scale brewing procedure (700-800 mL). It is anticipated that the ELISAs may be applied to select and manipulate malt for brewing to improve beer foam stability while reducing the likelihood of storage haze formation.

O-32 Dynamic behavior of carbon dioxide gas relating to formation and diminution of foam layer

Y. Mitani, M. Joh, S. Segawa, K. Shinotsuka and K. Ohgaki

We speculated that the bubble nucleation occurs from beer itself. We have developed a method for observing the liquid microstructure for beer. Observation was conducted under an electron microscope using specimens prepared by forming thin film replica of beer. We have succeeded to observe the micro-bubbles which are the origin of bubble growth. Immediately after opening the bottle, there observed micro-bubbles in beer with uniform sizes of around 100 nm. These micro-bubbles presumably appeared by a concentration fluctuation of carbon dioxide gas in a beer. During the bubble formation period, carbon dioxide gas migrates to bubble nuclei on the basis of diffusion law. On forming a foam layer, the carbon dioxide gas should diffuse to atmosphere, where the carbon dioxide gas concentration is further small. The most significant cause of the reduction of foam volume is speculated as the diffusion of the carbon dioxide gas. In this regard, we conducted computation on the diffusion rate of carbon dioxide gas. The computation supported the speculation. Then, we tested for stopping the diffusion-transfer of carbon dioxide gas, and significantly delayed the foam diminution speed. Furthermore, we have found that the diffusion of carbon dioxide gas across the bubble thin film contributes to the rupture of bubble. This is the second cause of foam volume reduction. On considering bubble formation and foam growth/diminution, unreasonable conclusion may be derived unless the dynamics of carbon dioxide gas is taken into account. This paper presents a concept of foam growth/diminution on the basis of dynamism of carbon dioxide gas.

O-33 Formation and collapse of beer foam

Sven Fischer and Karl Sommer

In order to study influences on foam formation and foam collapse, experiments with different gas concentrations and compositions (carbon dioxide and nitrogen) were carried out. The aim was to determine the physical properties of beer foam without changing the chemical composition. The results showed a considerable influence of the gas composition on foam formation and collapse. In a next step the physical processes causing the collapse of beer foam were investigated more closely. The aim was to evaluate the physical processes like drainage, coalescence, disproportionation and film rupture. Beer is frothed up into a container in which samples of different chemically treated materials are fixed. The kinetics of foam collapse were recorded. New is, that in our work the composition of the beer and the amount of dissolved gas is kept constant, varying only the properties of the treated surfaces. With the gained knowledge it is possible to influence the amount and structure of foam to a great extent.

O-34 Contribution of wheat and wheat protein fractions to the colloidal haze of wheat beers

F. Delvaux, W. Gys, J. Michiels, F.R. Delvaux and J.A. Delcour

Wheat or fractions thereof are commonly used as adjunct in beer production because of their cost effectiveness. They influence brewing process parameters as well as the quality of the final product. The published observations with regard to the influence of wheat on colloidal haze are contradictory. Such haze can be desirable (as in Belgian white beers) as well as undesirable (as in Pilsner beers). Therefore, in this study, the contribution of wheat and wheat protein fractions to the colloidal haze was investigated using two different fractionation-reconstitution experiments. To this end, wheat was milled into flour and bran. The flour was separated into starch, gluten and water extractables. The bran was further fractionated into a water-unextractable and a water extractable fraction. The cereal was also submitted to an Osborne type fractionation. In a laboratory scale brewery, different brews were made with barley malt (60%) and either reconstituted wheat fractions or wheat itself (40%). The haze in the beers was evaluated nephelometrically. By recombining the different wheat fractions, the effect of each fraction could be assessed individually, and this revealed the global contribution of wheat to colloidal haze in wheat beers.

O-35 The relationships between malting conditions and foam-active protein content in malt, wort and beer

K. Oshita, T. Kakui, Y. Kunishige, A. Isoe and Y. Kawasaki

We have developed a new method for determining foam-active protein in beer by using enzyme-linked immunosorbent assay (ELISA), and have investigated the relationship between brewing conditions and foam-active protein content in wort and beer. In this paper, the relationships between malting conditions and foam-active protein content in malt were investigated. Foam-active protein content in malt was evaluated by preparing congress wort with finely milled malt. Optimum malting conditions for foam-active protein content in malt differed depending on quality of barley. In the case of barley with average nitrogen content, the less the protein was degraded during malting, the higher the foam-active protein content in malt was. However, in the case of barley with high total nitrogen content, there existed optimum protein degradation during malting. The same could be observed of the relationship between cell wall modification during malting and foam-active protein content in malt. It was also found that foam-active protein content in wort was influenced by milling condition especially when cell wall modification of malt was insufficient. This suggested that not only protein degradation during malting but also cell wall modification must be taken into account for increasing foam-active protein content in wort. Brewing trial was performed using malts with high foam-active protein content and low foam-active protein content, which were malted from same barley lot by changing malting conditions (cast moisture and germination period). The relationships among foam-active protein content in malt, wort, beer, and beer foam stability were discussed.

O-36 Applications of chemometrics in brewing

Karl J. Siebert

Chemometrics, or the application of multivariate mathematical and statistical methods to chemical measurement data, is well suited to the nature of measurements typically made in brewing today (where it is quite common to make multiple measurements on a set of samples). There is a need for procedures that focus on the important information in a large data set and ignore noise and redundancy. Identification of the class to which a sample belongs from multiple analytical results is known as pattern recognition. Examples include determining the cultivar or geographical origin of raw materials, or the brand or manufacturing site of a finished product from analytical measurements. The behavior of systems

can be modeled to improve understanding or performance. Systems may be analytical methods, process operations, product properties as a function of product composition, or compound properties as a function of structure. Examples of chemometric applications in brewing will be described. These include identification of hop cultivars from analysis of essential oils, optimization of HPLC mobile phase composition, modeling haze intensity from product composition, and modeling the flavor thresholds of organic acids in beer from their structures.

O-37 A novel quantitative detection method of beer-spoilage bacteria using rRNA targeted fluorescent probe

Takaomi Yasuhara, Toshifumi Yuuki and Noboru Kagami

Over the past decade, the polymerase chain reaction and fluorescent antibody methods have been developed and successfully applied as powerful tools to detect specific bacteria in the food industry. But these methods still have limitations involving the specificity and reliability of detection, and remain incapable of assessing the viability of the cells. Therefore, more rapid and direct methods are needed to accurately detect and enumerate viable beer-spoilage bacteria. The fluorescence in situ hybridization (FISH) technique offers great potential for assessment of viable bacteria populations. In this study, we designed oligonucleotide probes targeted to 16S rRNA of beer-spoilage bacteria and assessed the sensitivity and specificity of the FISH method, using the bacteria spiked into beer. The study demonstrated that the FISH technique can be applied directly to beer samples without a culturing step, which normally requires several days. The study also showed that the technique is capable of detecting beer-spoilage bacteria in a species-specific manner within five hours. We therefore confirmed the FISH is a new rapid detection system of beer-spoilage bacteria. In addition, we will present the several useful applications of the FISH to the unique quantitative method using internal control bacteria and the assessment of the viability of beer spoilage bacteria.

O-38 Innovation of quality management for microbial control based on new method for detection of brewery contaminants and Computer-aided Quality Tracing System

Hiroshi Yamamoto, Noriko Amaya, Hiromasa Yamauchi, Norihide Amano, Eiichi Honno, Katsushi Kakihara, Yoshi Kakimi and Yoshio Monji

We have developed the innovative quality management system for microbial control in order to raise the level of microbial quality assurance. In this system, we have integrated two key technologies. One is the new technique (Microstar-RMDS-PCR) for the rapid detection and recognition of microbial contamination in process. In this method, microcolonies were detected quantitatively by ATP-bioluminescence assay on the membrane filter. And we adopted track-etched polycarbonate membrane filter to trap microorganisms. Furthermore PCR technique was combined with this ATP assay. As a result, we succeeded in detecting selectively 1 cell of beer spoilage microorganism per sample within 24 hours. The other is the Computer-aided Quality Tracing System (CAQTS). This system consists of the microbial quality databank and the production process tracing system. Using CAQTS, the microbial trouble-analysis got more precise and quick. After introducing the system (Microstar-RMDS-PCR and CAQTS) into brewery, the duration of the microbial trouble-shooting have been reduced to one-fifth of that of the former system. As a result, we are able to solve the microbial problem before the trouble expands. We are keeping a satisfactory level of microbial quality assurance.

O-39 Systematic strategy for rapid detection of beer-spoilage microorganisms (A review)

Y. Nakakita, T. Takahashi, Y. Tsuchiya, J. Watari and K. Shinotsuka

Several methods to detect or identify specific species in beer-spoilage microorganisms have been reported by many researchers. However, from the discovery of novel beer-spoilage bacteria, we thought that the following studies would become very important on the next stage in order to establish better quality assurance. (1) Exploration of new beer-spoilage microorganisms that have not yet been isolated: We isolated some new beer-spoilage bacteria with unique growth manners. (2) Development of the high performance method or device for detection of all contaminants: We developed the detection device, called Micro-Star RMDS-SPS, based on ATP bioluminescence method. This device led to the remarkable shortening of cultivation time for contaminants. (3) Development of the rapid and practical method for prediction of the beer-spoilage ability of contaminants: We obtained monoclonal antibodies (MAbs) specific for the beer-spoilage ability of lactic acid bacteria, and also developed the simple, rapid, and sensitive kit using the MAbs in order to predict the beer-spoilage ability. We believe that the application of these tools to the rapid detection of beer-spoilage microorganisms would make the powerful quality assurance system.

O-40 Malt-induced premature yeast flocculation

B. Axcell and W. Vundla

The phenomenon of malt-induced premature yeast flocculation occurs sporadically in the Brewing industry and seems to be linked to particular crop years and to particular malting plants. This generally results in residual fermentable carbohydrate being left in the beer and consequent poor alcohol yields. Its occurrence is not related to any parameter in conventional malt analysis and is normally only detected by using some form of predictive fermentation test. Both proteins and carbohydrate have been implicated in the literature as being responsible for inducing the effect. Research is presented that highlights the possible origins of the flocculating factor(s) and suggests how to potentially control its production in the maltings.

O-41 Application of PCR to determine the flocculation property in brewer's yeast

Makiko Jibiki, Tomoko Ishibiki, Toshifumi Yuuki and Noboru Kagami

The ability of brewer's yeast to flocculate is a very important character, since it affects beer flavor, the efficiency of yeast separation from green beer and the filtration performance. Understanding and measuring yeast flocculation has been a major topic of brewing scientists since the last century. One of the issues related to this area of research is that the flocculation ability is sometimes lost with the repeated use of the brewing yeast. It is thus necessary to elucidate the mechanism underlying this phenomenon. The conventional methods for determining the flocculation

properties involve the cultivation and fermentation test of the yeast. The result obtained from these time-consuming processes, do not readily provide a clue as to what factor has caused problem. New approach have become available by employing recently developed techniques that analyze yeast DNA. Chromosome fingerprinting has been used to study the karyotype of brewer's yeast, in order to examine the stability of brewer's yeast. This method can be also used to distinguish different yeast strains. But it is not always within the scope of chromosome fingerprinting method to distinguish flocculent and non-flocculent yeast. Therefore we have developed a PCR method, based on one of the flocculation genes, to determine the flocculation ability of yeast. It was also shown that this method is able to detect mutants which have lost flocculation properties. This method not only yields rapid results but also has advantages in reliability and reproducibility.

O-42 Controlled expression of FLO1 in *Saccharomyces cerevisiae*

K. Verstrepen, F. Bauer, I. Pretorius, J. Thevelein and F. Delvaux

A correct flocculation behaviour of yeast is of capital importance for the brewing industry, since early flocculation leads to stuck fermentations, while a too weak or late flocculation gives rise to clarification problems. A strategy to alter the flocculation behaviour of yeast in such a way that flocculation occurs towards the end of fermentation, was developed. In a double cross-over event, the wild-type FLO1 promoter of the non-flocculent *S. cerevisiae* FY23 strain and several industrial strains was replaced by a construct consisting of the SMR1-410 marker gene and the HSP30 promoter, thereby bringing the wild-type FLO1 open reading frame under transcriptional control of the HSP30 promoter. Selected transformants were tested using the flocculation assay described by *Soares* and *Mota* (1996). A very strong flocculation (90 percent vs. 10 percent for the wild-type) at the end of fermentation was observed, whereas the other properties of the wild-type were conserved. Moreover, it was shown that the transformants were stable and that flocculation could be promoted earlier during fermentation by a heat-shock treatment. The transformants were then used for several wort fermentations to further evaluate their fermenting capacities. The results suggest that the flocculation properties of most (including aneuploid) yeast strain can be improved using the described genetic strategy.

O-43 From filter presses, over centrifuges to cross flow and vibrating membrane filtration, a review on recovery of beer from surplus yeast

Niels Laurits Hansen

In the last four decades breweries have been more and more conscious about extract losses especially from surplus yeast. Techniques based on yeast filter presses, centrifuges and cross flow membrane filtration have been implemented. The techniques offer varying advantages and disadvantages characterised by the extract recovery rates, running costs and resulting quality of the recovered beer. The Pall VMF (vibrating membrane filter) has the potential to bring the treatment of surplus yeast into the new century by offering high extract recovery rates comparable to filter presses, low running costs due to a minimum power consumption and a high resulting beer quality comparable to cross flow filtration. This can be ascribed to the diafiltration or continuous lautering principle introduced by Carlsberg. Practical examples of the above mentioned techniques within the Carlsberg Group will be given.

O-44 Beer stabilization, going to the next millennium with the experience of yesterday

K.P. Niemsch

Beer stabilization commences with the quality of the brewing raw materials. A sophisticated technical production process, appropriate equipment and quality consciousness of the brewers are fundamental requirements for a successful and efficient beer stabilization. So the application of the stabilizers is not to be seen as a single measurement to prolong shelf life, but it is an additional step towards this target. Following a brief historical review of stabilization techniques and the biochemical reaction of haze formation, advantages and disadvantages of actual treatments will be compared. Finally results of commercial trials with silica gels and PVPP will be discussed, leading future trends and the prediction of shelf life.

O-45 Influence of hydrostatic high pressure on the filterability of beer

S. Fischer, W. Russ and R. Meyer-Pittroff

The high pressure treatment of food stuffs becomes more and more interesting for the industry. But not only in fruit juices, -purees or sauces like avocado-dip are a lot of possibilities. There is also an very interesting potential in fruit wines, rice wines and in beer.The main idea was to determine the influence of high pressure on several brewing processes. During this work we determined, that it is possible to reduce the filtration time. The filtration time was determined on an laboratory filter by Sartorius, Göttingen, with an mash size of 15 micrometers. The temperature was 0 – 1 degree centigrade. For measurements of the particle size the absorption after several centrifugations was determined. The result is, that it is possible to reduce the filtration time of beer up to 50 per cent, treating the beer with 300 MPa, although the particle size does not change. At higher pressures the filtration time becomes worse, and at 700 MPa the particles become smaller. The high pressure treatment has no negative influence on the foam stability, the taste and the color of the beer.The high pressure treatment shows besides the influence on the filterability a lot of interesting possibilities, for example the influence on foam and microbiological stability, and also the isomerisation of alpha acids is an very interesting aspect. But it is very important to know more about the effects of high pressure on the ingredients and to develop new, continuos working high pressure plants.

O-46 Beer Filtration with regenerated and improved diatomaceous earth: Experiences on a laboratory scale and in industrial application

N. Schmid, G. Hoehn, R. Meyer-Pittroff, E. Nitzsche and H. Jueptner

Diatomaceous earth (D.e.) is used world-wide in filtration for the food & beverage industry, the biotechnology, the pharmacy and the chemical industry. There is at present no satisfying techniques to reuse of the D.e. in the filtration. Existing techniques are either

not profitable (cost-intensive regeneration and disposal of D.e.), or technological not satisfying. The thermal technique developed by WTU - Wärmetechnik und Umweltschutz GmbH, the König-Brauerei GmbH & Co. KG and the Lehrstuhl für Energie- und Umwelttechnik der Lebensmittelindustrie, TU München – Weihenstephan, which operates at temperatures of approx. 550 °C, permits now, to regenerate used filter- slurry or to improve the pure D.e. World-wide annually approx. 850.000 t D.e slurry results only from beer filtration per year. With D.e slurry from breweries it could be already demonstrated that the regenerat D.e. treated by WTU technique results good, or nearly better technological characteristics, regarding differential pressure, haze, filter life and recycled regeneration of the filter aids. Numerous filtration in German breweries of repute affirm the results of the Laboratory experiments. Regenerat D.e were used up to 100%. Substantially better filtration characteristics showed up by the thermal regenerated D.e compared towards the pure D.e.

O-47 Membrane filtration for bright beer; an alternative to kieselguhr filtration

T.R. Noordman, C.J. Peet, J.L.M. Muller, W.G. Iverson, L. Broens and S. van Hoof

Clarification of beer is usually performed with kieselguhr filtration. However, the use of kieselguhr has several disadvantages. Disposal of the spent kieselguhr presents environmental and cost issues and the handling of kieselguhr in the brewery may require special measures to control the dust. Membrane filtration as an alternative to kieselguhr offers several advantages, including minimal waste disposal problems, long membrane life, and easy scale up through modular design. The key factor preventing the widespread use of membranes for bright beer filtration is fouling. A collaborative R&D project between Heineken Technical Services and Norit Membrane Technology has solved the fouling problem through the development of a new oxidative cleaning agent. We are now able to maintain run lengths of more than 10 hours, with costs of membrane filtration about 0.63 Euro per hectolitre. There are no differences in beer quality between membrane filtration and kieselguhr filtration. While the costs of membrane filtration are currently higher than the 0.45 Euro per hectolitre with kieselguhr, we expect that process optimisation and expanded use of membranes will reduce the costs of membrane filtration to less than the costs of kieselguhr filtration within the next 2 – 3 years.

O-48 Researches for assessing the chemical and physical stability already in the unfiltered beer

Andreas Papp and E. Geiger

In order of the consumers request getting the same quality of their beer all over the world 90 – 95% of all beers have to be stabilized, which is in direct contradiction to keeping the flavour, the foam and the whole quality genuine. Until now the chemical an physical stability of certain stabilization methods can only be measured by the force test (0/40/0°C or (0/60/0°C) in the final bottle. This poster will show differences in the composition of the polyphenols and proteins according to the use of different stabilization aids. The influences of monomer and oligomere phenols and phenolic acids as well as the influence of haze sensitive proteins on the haze building will be shown by using HPLC-Analyses and Electrophoresis. By using 2-D-Elektrophoreses of differently stabilized beers with different days of shelf life there are significant differences in the beer composition. The total amount of amino acids of hydrolyzed proteins will show the influence of some amino acids by building haze. The poster will also present the new developed antibody's against haze building proteins, which were isolated out of haze and will show the results by using an ELISA for the prediction of the expected chemical and physical stability already in the unfiltered beer. Because of the results with the used methods like immunological researches, 2-D-Elektrophoreses and HPLC-Analyses there will be a possibility to already know the sensitivity of haze building before filtration. In a long term it will be tried to develop a test which tells the breweries already in the unfiltered beer how much they have to stabilize according to their guarantee of shelf life.

O-49 Plastic beer bottles – Technology and trends

T. M. Buehler

Beer in plastic bottles has created great excitement in recent years. The quality of bottle materials with suitable barriers is now at a stage, where even distribution chains demanding longer shelf life can be satisfied. Hence focus of development has moved towards bottling and recycling. This paper will present a survey of the state of technology regarding gas barriers, bottling and recycling. Practice shows that recycling issues of different materials have created great concern, predominantly in one way applications. Recently these open questions have been addressed by nearly all PET-converters. The second main area of development is bottling: In order to achieve an adequate shelf life, technology for PET containers needs to be adapted to meet the requirements. Different solutions for recycling as well as for bottling have come up. Their practical viability and flexibility will be proven as the PET-market for beer evolves

O-50 Preservation of beer flavor in plastic bottles equivalent to that achieved in glass bottles

Joseph Paul Ciccone

The objective of this research is to determine if the flavor of beer packaged in plastic bottles can be preserved to the same degree currently achieved in glass bottles via the incorporation of Darex(®) oxygen scavenging technology (OST(®) in the bottle wall, the bottle closure or both. Test packs were conducted using carbonated water and beer. These laboratory test packs were conducted under conditions that result in packaged oxygen levels similar to those achieved on a modern high-speed bottling line. Oxygen content measurements were carried out on both the carbonated water and the beer samples for the normal shelf life of a bottled beer. Flavor panel evaluations were conducted on the beer over this same time frame. Some accelerated shelf-life studies were also conducted. An evaluation was made of the effects of monolayer PET, multilayer conventional barrier PET and multilayer oxygen scavenging PET bottles upon oxygen content and beer flavor during storage. The contribution of Darex OST® closures versus standard closures was also determined. The incorporation of an oxygen scavenger as a layer in multilayer PET bottles, especially in combination with an OST® closure, is shown to preserve the flavor of beer for a period of time similar to that achieved in glass bottles.

O-51 Opportunities in barrier and heat resistant plastic packaging for beer

Nina Goodrich

Barrier options for plastic beer packaging are changing rapidly. A variety of options currently exist that will meet barrier requirements. New barriers need to be evaluated in terms of cost, performance and environmental impact. This presentation will review the options available, show performance data on these options measured with a unique oxygen indicator at Amcor PET Technologies and review our environmental/recycle results with these technologies. Information will also be presented on the oxygen barrier of current glass/crown systems and be compared with plastic bottle barrier systems. The results will surprise.

O-52 Distributed Inspection System: The next level in packaging line inspection automation

Paul Lanthier

This Technical Paper defines the concept and describes the project's mandate, current practices, development stages, technologies used, application examples and our conclusions. Definition: A Distributed Inspection System (DIS) is comprised of:- Key-point Quality Inspection Stations containing the advanced technology tools required to make intelligent product quality determinations.- Centralized, global Operator Stations providing a comprehensive, single window to the process for effective control, trend observations and advanced process fault predictions.- Links to the Brewery's control and information management networks for automated sharing of critical information.- An open environment providing links to third party systems and interface to software tools. Mandate: This concept was derived from the Brewery's need to both augment and simplify its packaging line inspection strategies all the while increasing efficiencies and maintaining a high level of assurance in the quality of its products. The vision is further evolved through the use of multi-point inspection stations incorporating very fast, real time tools, where one need not compromise on line space and speed in order to gather optimum Quality information. Current Practices: In the industry, as a whole, efforts are being made to link individual inspection systems together though these solutions are usually geared to the specific supplier's products and do not represent a universal, open environment. Development Stages:- The first stage has been completed and is comprised of roughly 12 man years of engineering efforts. It is focused on the development of a real time networked environment which includes intelligent software tools. A number of inspection solutions have been derived from this platform.- The next stage is in the conceptual phase and will expand the data management functions, reduce hardware complexity, open the environment more and explore the DIS' statistical modeling capabilities as a process prediction tool.- In stage 3 third party inspection equipment suppliers will be invited to link to the DIS and new inspection solutions will be derived from the environment. Technologies Used: The DIS uses a real time, distributed, multitasking environment and has engines for developing MMI screens, auto-calibration and self-diagnostic tools. The DIS is TCP/IP compatible and includes heuristic rule programming, mathematical and statistical modeling, temporal reasoning and fuzzy logic. Application Examples: Some of the key-point packaging line inspection locations considered in this Paper include: after the Soaker, before the Canner, after the Seamer, after the Crowner, before the Labeler, after the Labeler and after the Packer. Conclusions: The DIS is the natural next step to the packaging line inspection automation evolution, especially with its open environment. Our efforts are very promising and a number of Brewers have shown interest in the work being done.

O-53 Development of linear FBI (filled-bottle inspector) using new inspection systems

Kazuyoshi Goto, Hiroshi Maita, Hiroshi Shibata, Shin-ichi Ogata, Kaoru Katayama and Kazuhiro Horiuchi

Previously, Kirin Brewery has introduced empty bottle inspection (E.B.I) and filled bottle inspection (F.B.I) systems to ensure glass bottle quality. Although our current F.B.I system reduced the labor that was required for visually checking filled bottles, it was more expensive and less accurate. Therefore, we tried to develop a new F.B.I system that was both cheaper and had improved inspection accuracy. First we constructed a low-cost conveyer using linear conveyer belts instead of star wheels. This instrument enabled us to reduce the time required to change to different type of bottles compared to the rotary type. We also developed a non-spinning inspection system by using a special lens and a novel optical system. This inspection system uses the next generation of image analysis technology which enabled rapid processing, and by using a new algorithm which minimises disturbance effects, we were able to obtain high inspection precision. Thus, we have successfully developed a new linear F.B.I system with improved accuracy and ability to also carry out "Level Inspection" and "Crown Inspection". In addition, the current F.B.I costs have been reduced by approximately 40% and the inspection accuracy increased by more than 20%.

O-54 Reducing glass scuffing during bottle washing

Bob Shewmake and Malcolm Graham

Scuffing of refillable glass bottles reduces consumer appeal and increases production costs through glass replacement costs. This paper discusses how Coors, Golden introduced new additive technology from DiverseyLever into their bottle washing operation and subsequent testing of returnable bottles indicates a 50% reduction in bottle degradation. Such a reduction in bottle degradation results in less scuffing and would therefore increase the useful life of the bottle. The Coors results would indicate a significant impact to the major U.S. brewers since they share the returnable bottle float. Because this new technology is a bottle washing detergent, it successfully replaced the previously used additives, providing effective detergency and scale control in the wash sections. In addition to reducing scuffing and chemical etching, the test results indicate additional benefits:- increased filling rates due to reduced friction during conveying of bottles-scale removal; improved heat transfer in the bottle washer, reduced water usage.

O-55 The key to successful brewery operations in the 21st century

Virgis Colbert

During the 20th century, brewing evolved from an art practiced by local craftsmen in a large number of small breweries to a highly sophisticated, technology-driven industry. Numerous small breweries were replaced by a smaller number of larger, more efficient breweries. Improved distribution capabilities resulted in many beers gaining popularity in markets previously dominated

by local or regional brewers. What followed was the emergence of multi-national and international brewing companies whose brands enjoyed instant recognition and wide acceptance among consumers. Success as a brewer in the 21st century will demand a totally integrated business approach characterized by the following: The ability to rapidly integrate emerging technology into all levels of the business. An engaged, highly developed workforce capable of operating sophisticated equipment and systems. Business systems that provide relevant information to decision-makers in a timely manner. Strategic alliances and partnerships with vendors and distributors. An ongoing commitment to product quality and timely action on food safety issues. A workplace that fosters collaboration and recognizes the value of everyone

O-56 Streamlining of Asahi's state-of-the-art brewery

Nobutoshi Imaizumi

Asahi's Shikoku brewery is our ninth brewery and the first in the Shikoku region. It was completed in June 1998 in Saijo City, Ehime, to respond to the growing demand for our Super Dry in that area. The brewery was at first designed to be operated with fewer personnel by adopting a central control layout, central monitor system, emergency stop system, and other systems that can help the streamlining of operations. Furthermore, in the brewing section, one-person-per-shift operations from brewhouse to aging tank has become possible this year without cutting out necessary steps for quality checks, by implementing measures to lessen the regular operations, such as (1) automatization and modification of the software, (2) reduction of nonregular operations through performance improvement activities, and (3) process irregularity detection using cellular phones in the brewery and establishment of a safety control system. In the packaging section, an area control system was introduced this year that enabled the operation control with 3 persons/shift for bottling line and 3 persons/shift for canning and keg line. Through these efforts we have achieved a more efficient operation with fewer staff members than the number of personnel expected to be required at the beginning of the brewery construction.

O-57 Brewing industry in Brazil, evolution and perspectives

André Nothaft and Kátia Jorge

This presentation is intended to give an overview of the brewing industry in Brazil, discussing changes that happened on the marketplace and tendencies for the future, as well as technological aspects. We will be discussing opening and closings of breweries, acquisitions and fusions and their influence on the market, as well as the perspectives these changes generate to the future. The driving forces for the foreseen growth on this market will also be presented. Technology will be focused through flavour characteristics of the beer produced in our country and new tendencies, the evolution of the brewing sites, and the perspectives of new players on the market.

O-58 Addressing sensitive consumer issues. An Australian view

Terry Kavanagh and Jill Hollingworth

The sensitivities of the consumers worldwide to food safety and health related issues has been heightened by the debate over the use of gene technology to develop crops which have enhanced agronomic or other characteristics. These sensitised consumers have not only placed considerable pressure on regulatory authorities to establish robust systems for protection from contaminants but also are demanding increased information about food products, their ingredients and their production processes. Protecting and even enhancing the image of beer in this environment demands a pro-active approach. Preparing the responses in advance can reduce the likelihood that such issues will be mishandled. To address this, the Australian brewing industry has sought links with corresponding industry groups internationally to put in place an early warning system. This combined with monitoring the technical environment has been useful in maintaining an awareness of both the risks to and opportunities for enhancing the image of beer.

O-59 Beyond the gate – A study of in-trade quality

Sarah Bennett and Jim Murray

Beer quality can suffer at all stages from production through to the point of sale if insufficient attention is given to its maintenance. Perhaps the weakest links in the chain occur where the product passes out of the hands of the brewer. Good quality beer can be ruined by lack of care on the part of the distributor, retailer or licensee. Brewers can take steps to remedy this situation but must first understand the nature of the problem. In response to this need BRI initiated an in-trade audit service seven years ago; its popularity has increased and it has graduated now to the international scene. This paper describes in-trade auditing of both small-pack and draught beers as presented to the consumer. Factors considered include appearance, aroma, taste, serving temperature, pack or font presentation and glass cleanliness. A key feature of this system is our new consumer-friendly descriptive language. This successful brand "quality health check" tool will be described with reference to case studies.

O-60 Alternative fermentation beverages – Functional drinks

C. Tenge and E. Geiger

The idea is to produce new, fermented beverages with existent biotechnological know-how and equipment in breweries. These alternative fermentation beverages, are produced on the basis of cereal extracts, especially beerwort. They contain a high physiological nourishment value. The goal is to create a technology which maximizes the physiological valuable contents already existent in the substrate and which are produced through the fermentation. These bioactive substances, like organic acids, mineral extracts and phytochemicals, contain beneficial health potential. To create this technology, the first step is a suitable selection of microorganisms. Particular lactic acid- and acetic acid bacteria have proven to be invaluable here. A definite genotypical characterization must follow to secure a culture. Herefore a molecular biological method on the basis of RFLP has been created, presented on the poster.The poster shows also the optimization of the substrate, for a maximum yield of the physiological contents and in view of the culture demands of the individual microorganisms. Besides, the optimal fermentation conditions, which are pH, temperature and biomass have been researched by different experiments and will be presented as well. As next steps, further technological measures, such as filtration of these beverages, substrate variations and combined fermentations with more organisms, are planned. At the end a complete technology for the production of alternative fermentation beverages is supposed to be available in breweries.