Flavor Summit: Industry Perspectives

February 5-6, 2019

Rosen Plaza Hotel

Orlando, Florida, USA

UF | IFAS Extension
UNIVERSITY of FLORIDA

UF Center for Smell and Taste

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February 5-6, 2019
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www.crec.ifas.ufl.edu/flavorsummit

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Welcome

Whether it is the adventurous pursuit of novelty, the comforting embrace of familiarity, or the quest for healthful natural ingredients, today's consumers are seeking flavorful foods and drinks. Flavor science is moving quickly to keep pace. Flavor chemists are identifying unique odor and taste compounds in plants and other products from around the world. Chemosensory scientists are unlocking the molecular, physiological and psychological mechanisms underlying the detection and perception of flavor compounds. And the food, beverage and flavor industries are using that knowledge to create more flavorful and healthful products for consumers.

Flavor Summit – Industry Perspectives seeks to bring together experts from academia and industry to discuss the cutting edge of flavor science and its impact on those industries that bring flavor to the public. We would like to thank the many experts who have joined us from around the world to share their perspectives and their research. We also greatly appreciate the sponsors, Conagen, McCormick and Company, Inc., Florida Chemical Company, Treatt, Florida Foundation Seed Producers, Maine Lobster Now, and exhibitors Almendra, Sweegen, Florida Foundation Seed Producers, Inc., United Spectrum, Sunwin Stevia, Virginia Dare, and the University of Florida, without which this conference would not be possible.

And so, on behalf of the University of Florida Citrus Research and Education Center and the University of Florida Center for Smell and Taste, we would like to welcome you to Orlando, Florida for **Flavor Summit – Industry Perspectives**. We hope that you find the next two days to be interesting, valuable and fun.

Sincerely,
Yu Wang, Ph.D., UF/IFAS Citrus Research and Education Center
Steven D. Munger, Ph.D., UF Center for Smell and Taste

Social Media

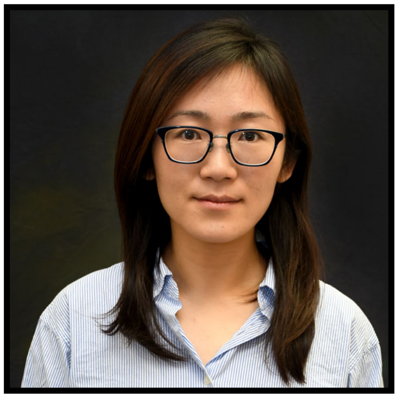
Follow workshop activities and announcements on social media.

Facebook: @industryflavorsummit

Twitter: @flavorsummit

Instagram: #industryflavorsummit

Planning Committee



Yu Wang, Ph.D.
University of Florida, IFAS,
Citrus Research and
Education Center
Lake Alfred, Florida

Steven Munger, Ph.D.
University of Florida,
Center for Smell and Taste
Gainesville, Florida

David McKeithan, Ph.D.
Florida Chemical Company
Winter Haven, Florida

Matthias Guentert, Ph.D.
Consultant
Ridgewood, New Jersey

Agenda

Monday, February 4, 2019

12:00 pm – 7:00 pm	Registration and Exhibit/Poster Setup

Tuesday, February 5, 2019

7:00 am – 5:00 pm	Registration
8:30 am – 5:30 pm	Exhibit/Poster Display
8:00 am – 9:00 am	Continental Breakfast
9:00 am - 9:20 am	Welcome and Introductory Remarks *Michael Rogers, Director, UF/IFAS Citrus Research and Education Center* *Steven Munger, Director, UF Center for Smell and Taste*

Session I
Chair: Yu Wang (University of Florida)

9:20 am – 10:00 am	A Historical Perspective of Flavor Science *Russell Rouseff, Southwest University, PRC*
10:00 am – 10:40 am	The Taste of Fruit: Sweet Taste of Nature *Julie Mennella, Monell Center*
10:40 am - 11:10 am	Coffee Break
11:10 am – 11:50 am	Discovery and Function of Flavors with Modifying Properties for Bitter Reduction *Guy Servant, Senomyx*
12:00 pm – 1:30 pm	Lunch

Session II
Chair: Steven Munger (University of Florida)

1:30 pm - 2:10 pm	Emerging Flavor Innovation Opportunities – Outlook into the Future *Birgit Schleifenbaum, Firmenich*
2:10 pm – 2:50 pm	The Key to Future Flavors Lies within Citrus Genetics *Fred Gmitter, University of Florida/IFAS Citrus Research and Education Center*
2:50 pm – 3:20 pm	Coffee Break
3:20 pm – 4:00 pm	Identification of Flavor Modulators in Natural Products *Yu Wang, University of Florida/IFAS Citrus Research and Education Center*
4:00 pm - 4:40 pm	Industrial-Scale Production of 11 Steviol Glycosides: from Reb A to Z *Oliver Yu, Conagen*
5:30 pm – 7:00 pm	Reception

Agenda

Wednesday, February 6, 2019

7:00 am – 4:00 pm	Registration
8:30 am – 4:00 pm	Exhibit/Poster Display
8:00 am – 9:00 am	Continental Breakfast

Session III
Chair: Matthias Guentert (Consultant)

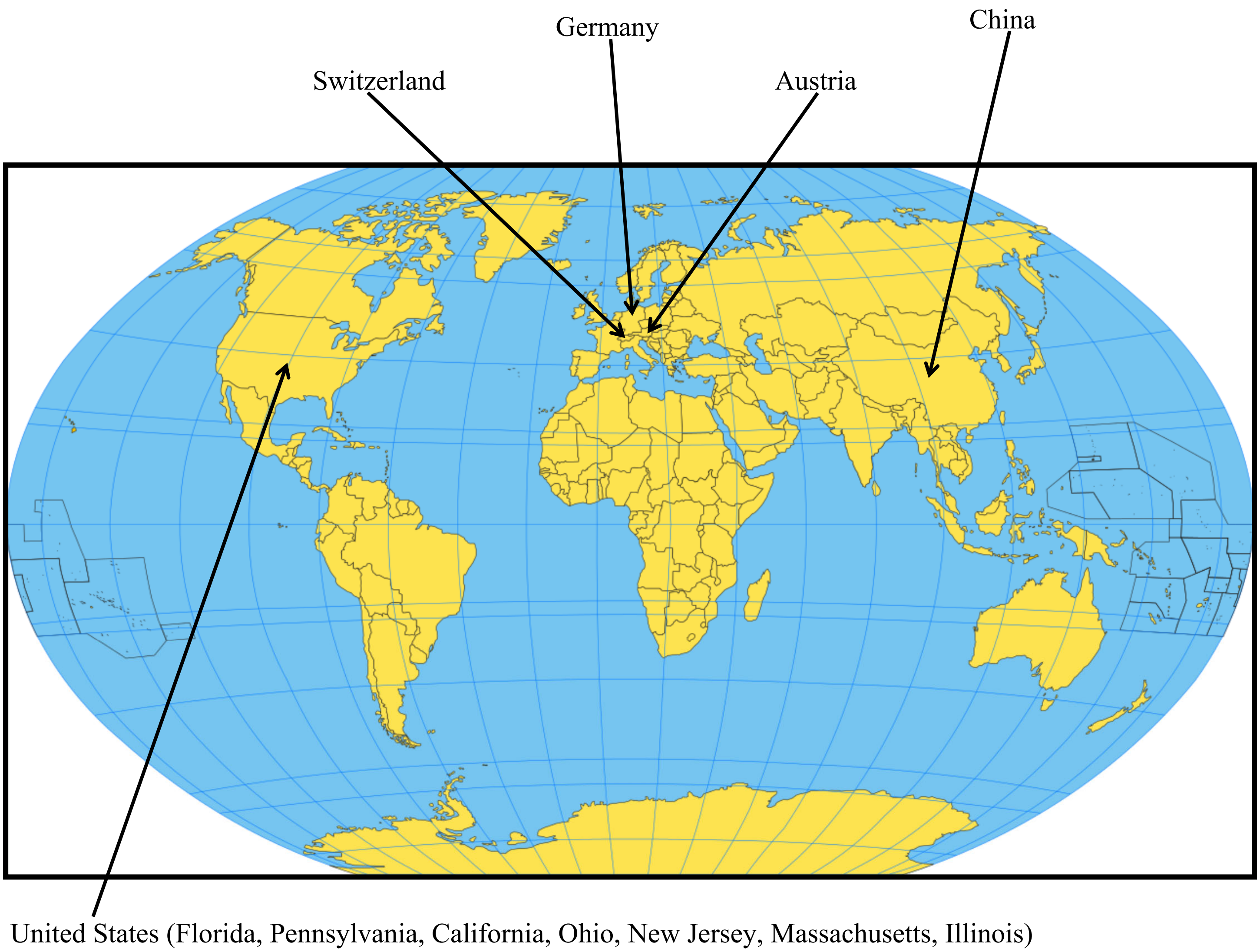
9:00 am – 9:40 am	Bitterness Perception: Can We Discriminate Between Bitter Compounds? *Wolfgang Meyerhof, University of Saarland*
9:40 am – 10:20 am	Contextualizing Context: The Use of Immersive Technology in Consumer Sensory Testing *Christopher Simons, The Ohio State University*
10:20 am – 10:50 am	Coffee Break
10:50 am – 11:30 am	Conquering the Inner Carnivore *Adam Janczuk, International Flavors and Fragrances*
11:30am – 12:10 pm	High-Throughput Screening of TRPM8 for Discovery of Novel, High-Intensity Cooling Agents *Jay Slack, Givaudan*
12:10 pm – 1:30 pm	Lunch

Session IV
Chair: David McKeithan (Florida Chemical Company)

1:30 pm - 2:10 pm	Flavor Beyond Taste: Identification of Taste Active Food Constituents that Help to Maintain a Healthy Body Weight *Veronika Somoza, University of Vienna, Symrise*
2:10 pm – 2:50 pm	Clean Label Sugar Reduction: How to Get It Done with Plant-Based Sweeteners and Sweetness Modulators? *Alex Woo, W2O*
2:50 pm – 3:30 pm	Innovative Flavor & Food Product Development – Influence of Regulations and Guidelines *Matthias Guentert, Consultant*
3:30 pm – 4:00 pm	Coffee and Wrap-up

Speaker Abstracts

The planning committee extends their deepest gratitude to each of the speakers willingness to travel and speak at the Flavor Summit. The speakers have traveled from around the world to bring the latest research available in flavor science. Each speaker is greatly appreciated and words cannot express our gratitude. Thank you!



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A Historical Perspective of Flavor Science

Russell Rouseff, Ph.D.
Southwest University, PRC
Chongqing, China

Russell Rouseff is a Professor and Doctoral Supervisor at the National Research Center for Citrus, Southwest University, Chongqing, China specializing in citrus flavor chemistry and technology. He is also an Emeritus Professor of Food Chemistry with the University of Florida and former Co-Director of the UF/ IFAS Juice & Beverage Center. Professor Rouseff has over 40 years experience in the Florida citrus industry. The first years were with the Scientific Research Department of the Florida Department of Citrus before moving to the University of Florida in as a full professor. He retired in 2012 as an emeritus professor. He has written or edited seven books, 55 book chapters and over 200 scientific papers and published abstracts. During his 25 years with the university he has graduated 17 Masters and Ph.D. students, mentored 8 post docs and numerous visiting scientists. His areas of interest include citrus pigments, flavor changes during processing and storage, off-flavors as well as flavor models. His most recent interest has involved potent, trace concentration sulfur volatiles in fruits, leaves, coffee, rice and wines. Professor Rouseff has been elected as a Fellow of the Agricultural and Food Division of the American Chemical Society (ACS). He served on the editorial advisory board of the ACS Journal of Agricultural and Food Chemistry from 1985-2010. In 2000 he received the Research and Development Award from the Institute of Food Technologists, Citrus Products Division. In 2009 he received the American Chemical Society's Award for the Advancement of Food and Agricultural Chemistry and in 2014 he was selected in the 10000 Talent Plan for High-Level Foreign Experts, China.

Abstract: The development of flavor science was the result of people wondering why flowers smelled the way they do and what makes various foods taste different. Early chemists, using fractional distillation and open column chromatography, were able to identify about 500 flavor substances up to the 1950's. After the development of capillary GC, NMR and coupled GC-MS the number of identified flavor molecules had increased to 3,500 by1990 and continued to increase exponentially because of more advanced analytical techniques such as GC-olfactometry. With improved analytical separation and identification tools, sample sizes could be decreased from hundreds of Kg to less than a gram in some cases. With the development of chiral chromatography, it was found that nature often produced flavor molecules in predominantly one optically active form. Furthermore, it was often found that only one form was flavor active or the two optical forms had different thresholds or even different sensory properties. As chemists were determining the structures of molecules that exhibited flavor activity, biologists were seeking to determine the neural processes responsible for the perception of flavor from the receptor to the brain. Flavor is a combination of smell (olfaction) and taste (gustation) whose receptors are found in the nose and mouth respectively. There were several competing theories as to the exact nature of the olfaction receptors until Axel and Buck showed there were about 350 odorant protein receptors for smell and that different volatiles could trigger more than a single receptor. Similar progress for taste receptors has shown that humans possess over 40 receptor genes for bitterness alone.

Human sensory confirmation is the ultimate test of any flavor study. Sensory science has evolved from simple liking scales to quantitative descriptive analyses of perceived flavor attributes. Chemical models of flavor systems are best validated using a trained sensory panel.

The Taste of Fruit: Sweet Taste of Nature

Julia Mennella, Ph.D.
Monell Chemical Senses Center
Philadelphia, Pennsylvania, USA

Dr. Julie A. Mennella obtained a Ph.D. from the Department of Behavioral Sciences at The University of Chicago in Chicago, IL. She joined the faculty at the Monell Chemical Senses Center in Philadelphia, PA in 1990 where she is now a Member. Her major research interests include investigating the timing of sensitive periods in human flavor learning and growth; uncovering how children are living in different taste worlds than adults and their vulnerabilities to the current food environment as well as medication adherence; and the development of psychophysical tools to study individual variation in taste and flavor perception. She is the recipient of several grants from the National Institute of Deafness and Other Communication Disorders and the Eunice Kennedy Shriver National Institute of Child Health and Human Development; the author or co-author of numerous peer-reviewed research papers and an internationally recognized speaker on the ontogeny of flavor preferences and its implications for health and nutritional programming.

Abstract: From the age of two years, an American is more likely to eat a manufactured sweet than a fruit on a given day. In this talk, I will highlight the scientific evidence regarding the biology of taste preferences that makes children especially vulnerable to our current food environment of processed foods high in salt and refined sugars. Also highlighted with be recent evidence on children's perception of the taste of fruits, particularly whether they are the same or different from the adult. In a collaboration between Monell and the University of Florida, we discovered that children are more sensitive to smaller variations in sugar content of blueberries than are adults. Because a diet insufficient in fruits is the top dietary risk factor contributing to both global burden of disease and mortality, the time is ripe to focus on children. Research is needed to determine what types of experiences and for how long the taste experience needs to last to develop evidence-based strategies that foster the liking of the varying sweetness and textures of whole fruit.

Discovery and Function of Flavors with Modifying Properties for Bitter Reduction

Guy Servant, Ph.D.
Senomyx
California USA

Guy Servant joined Senomyx Inc. in 2000 as a scientist working on taste and olfactory receptors. Over the last 18 years he took on additional responsibilities, and since 2016 he leads the overall biology research effort at the company with a focus on the discovery of new flavors, flavor modulators and natural high intensity sweeteners.

Abstract: Humans detect bitter and poisonous substances with 25 different bitter taste receptors expressed in taste receptor cells located in taste buds on the surface of the tongue. These receptors belong to the vast family of Class A G protein-couple receptors and, using cell based assays, at least 22 of these receptors have now been functionalized. Surprisingly a single bitter taste receptor can be activated by several chemically diverse ligands and, conversely, a specific bitter ligand can activate several bitter receptors. Senomyx followed a classical discovery paradigm for the identification and development of potent bitter receptor antagonists that could potentially serve as FMPs for the food, beverage, OTC and pharmaceutical industries. High throughput screening was performed on 13 different receptors using a library of diverse structures. Hits were then analyzed for potency, specificity and selectivity. Several lead series were then evaluated for attenuation of bitterness of representative tastants. Based on its potency, positive effects in sensory studies and physical properties, BB68 (3-(1-((3,5-dimethylisoxazol-4-yl)methyl)-1H-pyrazol-4-yl)-1-(3-hydroxybenzyl)imidazolidine-2,4-dione(S6821, CAS 1119831-25-2) was promoted as a development candidate. Following a battery of safety and toxicological studies, BB68 received FEMA GRAS status in 2010 followed by additional regulatory approvals by JECFA, China, Japan, Korea, Mexico & Indonesia. BB68 now being commercialized in several countries to effectively attenuate the bitterness of pharmaceutical and consumer products.

Emerging Flavor Innovation Opportunities – Outlook into the Future

Birgit Schleifenbaum, Ph.D.
Firmenich
Geneva, Switzerland

Birgit is a passionate and experienced innovation management leader with a 25 years' track record in large high-tech Food & Flavor companies. Sixteen years ago, Birgit joined Firmenich. Swiss and family-owned for the last 120 years, is Firmenich the largest private company in its industry of flavors & fragrances.

Birgit's current responsibility covers the management of the "front-end" of innovation.

Her entrepreneurial spirit is driven by new business explorations that are part of a courageous vision and include "outside the box" approaches.

Abstract: Consumers make food choices based on many factors and these are constantly evolving with emerging lifestyles. The role of our senses as a preference driver is a significant one. This talk will connect dots between future food trends and the role a flavor could play.

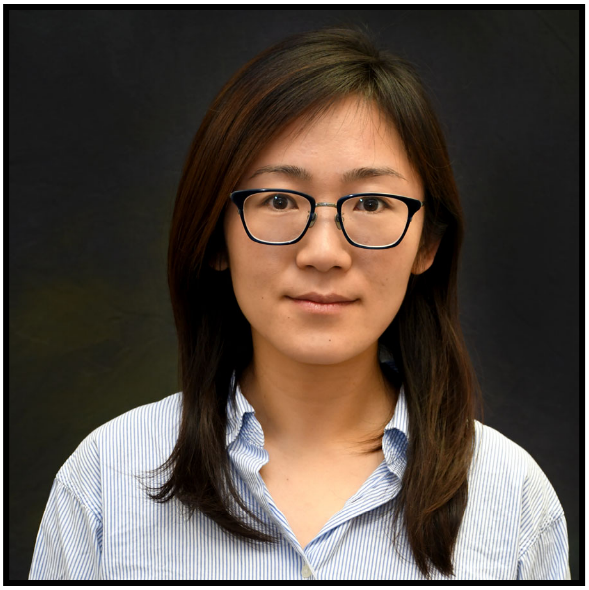
The Key to Future Flavors Lies within Citrus Genetics

Fred Gmitter, Ph.D.
UF/IFAS Citrus REC
Lake Alfred, Florida, USA

Prof. Fred G. Gmitter, Jr. is a University of Florida (UF) Research Foundation Professor in the Horticultural Sciences Department, located at the UF Citrus Research and Education Center in Lake Alfred, Florida. He received BA and MS degrees from Rutgers University and the PhD degree from UF. His research focuses on citrus breeding and cultivar development, with specific emphasis on more fundamental studies of host-pathogen interactions (particularly Huanglongbing tolerance), development and application of genomics-based breeding approaches, and unravelling the complex genetic basis of fruit quality attributes while tying these traits to consumer preferences. He has published well over 150 refereed manuscripts in international scientific journals, including Nature, Nature Biotechnology, Food Chemistry, BMC Plant Biology, Plant Science, among others. He has served as an Associate Editor for three different scientific journals. The Florida Fruit and Vegetable Association recognized him as Researcher of the Year in 2011. He led the International Citrus Genome Consortium, which made the first citrus genome sequences publicly available in 2011. With colleagues at UF, he has released more than 30 new scion and rootstock cultivars in the past 10 years. More than 1.6 million trees of UF-CREC cultivars have been planted since 2015, many of which demonstrate enhanced levels of HLB-tolerance.

Abstract: Genome sequencing studies have revealed that modern citrus species evolved from ancestral forms through the course of several million years. Great diversity in adaptation to multiple climatic and environmental conditions was directly linked to a wide range of genetic diversity, as well as a substantial palate of potential flavor molecules. However, the commercially important cultivar groups that currently support the world's citrus industries, including the flavor industry, are of more recent lineage, and because of human selection their genetic diversity has been reduced. In the past several decades, citrus breeders have developed new cultivars based on new genetic combinations; these cultivars provide the potential for new and unique flavor opportunities to attract consumers and to support the industry. This breeding effort has been more random than directed, but new genetic tools now enable a much more focused approach to the manipulation and improvement of citrus fruit quality attributes, including color, flavor and aroma, and even phytonutrient content. This presentation will discuss some of the underlying genomic and genetic research, and describe how that can lead to specifically designed new flavor opportunities in citrus.

Identification of Flavor Modulators in Natural Products



Dr. Wang is an assistant professor at the University of Florida, IFAS, Citrus Research and Education Center. Her research focuses on food chemistry and quality, emphasizing the flavor (aroma and taste) of fruits, herbs, and other agricultural commodities. She also finds the usage of citrus by-products for flavor modulation and health benefit an interest. Her extension responsibilities include working with growers and processors to improve quality, particularly flavor of citrus products.

Yu Wang, Ph.D.
UF/IFAS Citrus REC
Lake Alfred, Florida, USA

Abstract: The great majority of consumers indicate that flavor is the most important factor impacting their preferences and purchases. In order to keep pace with the market and consumer expectations, a newly developed flavor program at UF/CREC provides fundamental information on flavor monitoring and improvements through pre- and post- harvest practices as well as flavor addition/removal. This talk will focus on use of omics" techniques and bioactivity-guided compound identification to improve flavor quality and to enable high throughput and reproducible production of consumer-liked products in large scale to match the expected increased demand markets.

Industrial-Scale Production of 11 Steviol Glycosides: from Reb A to Z

Oliver Yu, Ph.D.
Conagen Inc.
Boston, Massachusetts, USA

Dr. Yu has a B. Sc. from Dept. of Biophysics at the Fudan University in Shanghai, and a Ph. D. from Department of Biology at the University of South Carolina, Columbia, SC. His postdoctoral training was at the DuPont Company in Wilmington, DE. He joined the Donald Danforth Plant Science Center in 2001, serving as a Principal Investigator until 2012. During that time, he was also an adjunct professor at the Washington University in St Louis and University of Missouri-Columbia. Dr. Yu has published more than 70 manuscripts and patents in the area of metabolic engineering in plants and synthetic biology in microbes. In 2010, Dr. Yu co-started a biotech company, Conagen Inc, currently located at Bedford, MA. Conagen has more than 180 scientists and engineers in three cities, focusing on pathway engineering and microbial platform development. Conagen has become a full-spectrum service provider for the synthetic biology industry, providing services ranging from novel pathway constructions, scale-up and process engineering, and pilot and large-scale fermentation production. Dr. Yu is currently also an affiliate staff at Massachusetts Institute of Technology (MIT), and serves on the editorial board of several academic journals and the review panels of several federal funding agencies. He is also a principal investigator for a 863 Project of China.

Abstract: Steviol glycosides are natural products isolated from Stevia rebaudiana leaves, and are widely used as high intensity, low-calorie sweeteners. Naturally occurring steviol glycosides have the same base structure (steviol) and differ in the content of carbohydrate residues (e.g. glucose, rhamnose, and xylose residues) at the C13 and C19 positions of steviol. Stevia rebaudiana extracts are commercially available, which typically contain stevioside and rebaudioside A as the primary compounds. The other steviol glycosides, which demonstrate many desirable properties, typically are present in these extracts at much lower concentrations. The majority of the steviol glycosides are formed by several glycosylation reactions of steviol, which typically are catalyzed by the UDP-glycosyltransferases (UGTs) using uridine 5'-diphosphomonosaccharide (UDPglucose or UDP-rhamnose) as a donor of the sugar moiety. In plants, UGTs are a very divergent group of enzymes that transfer a glucose residue from UDP-glucose to steviol. In order to identify the key UGTs in the biosynthesis pathway of steviol glycosides, bioinformatics analysis was performed and selected UGT candidate genes were enzymatically characterized. Our work identified several UGTs that demonstrated 1, 3-13- O-glucose, 1, 3-19-O-glucose, 1, 2-13-O-glucose, 1, 2-19-O-glucose and/or 1, 6-13-O-glucose, and O-rhamnose glycosylation activity to produce 11 steviol glycosides including 6 known steviol glycosides (rebaudioside G, rebaudioside KA, rebaudioside A, rebaudioside E, rebaudioside D and rebaudioside M) and 5 novel steviol glycosides. Some of the enzymes were crystalized and their structures resolved. Extensive protein structure-based enzyme engineering has been carried out. And high-throughput screening methods for identify targeted enzymes have been developed. Furthermore, we can produce these 11 steviol glycosides in large scale by using engineered UGT proteins and recombinant yeast cells. This recombinant yeast system has produced yields as high as 93%, providing a new approach to produce these desirable minor steviol glycosides at an industrially relevant scale.

Bitterness Perception: Can We Discriminate Between Bitter Compounds?

Dr. Meyerhof is retired from the positions of Professor of Molecular Genetics, Potsdam University, and Head of the Department of Molecular Genetics of the German Institute of Human Nutrition Potsdam-Rehbrücke. Currently, he is a guest professor at the Center for Integrative Physiology and Molecular Medicine, Saarland University, Germany. He explores the influence of taste perception on the nutritional behavior and the health as well as their genetic basics. He characterized various human bitter taste and sweet receptors and discovered taste modulating substances. He emphasized the importance of genetic variability for sensitivity differences in taste perception in the population. He also engineered various strains of mice to investigate the representation and processing of taste signals in the brain.

Wolfgang Meyerhof, Ph.D.
Saarland University
Hamburg, Germany

Abstract: Numerous and structurally diverse natural or synthetic chemicals elicit bitterness which is usually associated with danger and innately avoided. Yet we can overcome the innate aversion and learn to enjoy some bitter foods and beverages. This differentiation suggests that the bitter sensing system is organized to enable animals to sort harmful from harmless or healthy bitter substances. In mice and men expression of distinct subsets of the bitter taste receptor gene repertoires generates oral sensor cells with overlapping but distinct molecular receptive ranges, which are indispensable for bitter discrimination. The functional diversity of the peripheral bitter sensing cells is propagated by peripheral neurons to the central nervous system. Genetic manipulation of central gustatory neurons alters the behavioral responses of mice to some but not all bitter substances further supporting the possibility that mice distinguish between some bitter substances. In taste discrimination tasks we used bitter substances that activate different receptors in different sets of bitter-dedicated taste cells. The results demonstrate that wild type mice are able to discriminate arbutin from chlorhexidine and papaverine. The data propose that bitter recognition is mediated by functionally distinct gustatory pathways that enable mice to discriminate between some bitter compounds. The data also raise the question of how the complex cellular organization of the bitter sensing system affects acceptance and intake of foods that differ in their content of bitter compounds.

Contextualizing Context: The Use of Immersive Technology in Consumer Sensory Testing

Christopher Simons, Ph.D.
The Ohio State University
Columbus, Ohio, USA

Christopher Simons earned his undergraduate degree in Biology from the University of Oregon, his M.S. degree in Physiology from Portland State University in Portland, OR and his Ph.D. in Sensory Science from the University of California, Davis. Subsequently, Chris completed post-doctoral fellowships in the Laboratoire de Neurobiologie Sensorielle [Sensory Neurobiology Laboratory] at the Ecole Pratiques des Hautes Etudes in Massy, France and the Unités de Formation et Recherche de la Odontologie [Dental School] at the Universite Paris 7. From 2004 through 2012 Chris led the Sensory Research function at Givaudan Flavors Corp. and joined the faculty in the Department of Food Science and Technology at the Ohio State University in 2013. Chris' research interests use a multidisciplinary approach to understand the perception of foods and how they are processed to influence reward and ultimately behavior. One outcome of this research is to identify the neural and physiological correlates associated with perception, liking, and food choice through the use of a variety of methodologies including human sensory testing or psychophysics, electrophysiology, and behavioral measurements. Another outcome is to leverage the knowledge gained from these types of investigations into the development of new methodologies that assist in the creation of better foods. In 2017, Chris was awarded the Barry Jacobs Memorial Award for Research in the Psychophysics of Human Taste and Smell by the Association for Chemoreception Sciences and in 2018 he received the Educator Award from the North American Colleges and Teachers of Agriculture association.

Abstract: Immersive technologies can restore relevant contextual information that improves the ecological validity of consumer testing paradigms and enables the assessment of consumer responses or behaviors in pertinent, but controllable conditions. We have recently undertaken a unique series of experiments in which immersive technologies were used to manipulate the testing environment and assessed the impact of context on product perception, preference, and acceptability. We have found that product preference and liking is context dependent and that inclusion of relevant contextual information improves product discriminability and test reliability. Potential mechanisms underpinning these results will be reviewed and the specific environmental cues that are most impactful will be discussed.

Conquering the Inner Carnivore

Adam Janczuk, Ph.D.
Re-Imagine Modulation™
Dayton, New Jersey, USA

Adam Janczuk is IFF's Global Innovation Program Director for Re-Imagine Modulation™ responsible for pioneering technologies that balance and elevate taste experiences in the pursuit of a healthy lifestyle.

Adam Janczuk holds a Ph.D. in Chemistry from Wayne State University, with over 15 years of experience in both R&D and business leadership. With over 35 patents and publications, Adam has proven track record of leading innovation and developing new technologies focused on consumer experiences and expectations.

Outside of his professional life, he routinely volunteers his time and talents for non-profit, cultural, and youth focused organizations such as scouting. Adam organizes outdoor adventure programs, youth oriented training programs and consults on policy.

Abstract: Since the landmark discovery of human taste receptors in 2002, there has been extensive research to better understand the mechanism of action and identify novel ligands. From an industry perspective, the objective was to develop tastants that impact the perception of sweet, umami and suppress bitterness in consumer products. The importance of understanding how taste helps to identify toxins, maintain nutrition, and regulate appetite, has gained traction given the emergence of alternative food sources. The talk will review key qualitative and quantitative aspects of umami taste as it relates to non-meat protein sources.

High-Throughput Screening of TRPM8 for Discovery of Novel, High-Intensity Cooling Agents

Jay Slack, is a research fellow at Givaudan, leading long-term research efforts in the area of chemosensory biology. Discoveries enabled by his research team are now in commercialization as proprietary taste molecules and they have received several patents, providing a sustainable competitive advantage for Givaudan. His lab also studies how chemosensory signaling pathways affect other aspects of human health and behavior. In addition, he oversees research activities with key external partners to enable strategic collaborations that will benefit both parties.

Jay Slack, Ph.D.
Givaudan
Cincinnati, Ohio, USA

Abstract: Menthol is commonly used in the food and flavor industry for its cooling properties, but its use is limited by other unwanted sensory properties as well as the short duration of cooling that is elicited by menthol. *In vivo* menthol stimulates TRPM8, which is a nonselective, cation channel that is robustly activated by cold and other chemical stimuli such as icilin. We created a stable mammalian cell line expressing the human TRPM8 receptor to use in a high-throughput screening campaign using a high-diversity library of small molecules, resulting in the identification of hit compounds that stimulate TRPM8 activity. Potent and selective TRPM8 agonists derived from the screen were used *in vivo* to assess oral cooling efficacy in human subjects. When tested in common consumer applications such as toothpaste, some TRPM8 agonists elicited cooling sensations for up to 2 hours after brushing compared to only 15 minutes for the menthol reference. Two novel compounds were selected as a development candidates, evaluated in safety studies, and determined to be Generally Recognized as Safe (GRAS) by an expert panel of the Flavor and Extract and Manufacturers Association. Our proprietary coolants are one of the first commercial examples of using bioassay screening approaches to identify high-impact flavoring materials.

Flavor Beyond Taste: Identification of Taste Active Food Constituents that Help to Maintain a Healthy Body Weight

Veronika Somoza, Ph.D.
University of Vienna
Vienna, Austria

Veronika Somoza, neé Faist, earned her Master‘s degree in Human Nutrition from the University of Gießen, Germany, and her Ph.D. in Food Science from the University of Vienna, Austria. Afterwards, Veronika finished her habilitation program at the University of Kiel, Germany, to achieve the *venia legendi*. During this time, she also completed a post-doctoral fellowship at the Department of Chemistry and Biochemistry, University of South Carolina, USA. After another five years of research as Vice Director of the German Research Center for Food Chemistry, an Institute of the Leibniz Community (WGL), Veronika accepted an offer from the University of Madison / WI as Associate Professor (tenured) at the Food Science Department. In 2009, she decided to relocate back to Europe to hold a full professorship for Bioactive Food Constituents at the University of Vienna / Austria. Since 2011, Veronika chairs the Department of Physiological Chemistry and is vice dean of the Faculty of Chemistry since 2014. Her main research interests are bioactive food constituents involved in regulatory processes of digestion, satiation and body composition. For her work on bioactive tastants, Veronika was awarded the FEMA Excellence in Flavor Science Award in 2016.

Abstract: Health effects of aroma- and taste active compounds are gaining more and more scientific interest. Although most studies report effects in rodents, evidence for beneficial effects in humans is growing as well. Terpenes, for example, have been found to reduce the progression of experimentally induced skin cancer in rodents, and to exert anti-inflammatory effects in humans. Among taste active compounds, bitter compounds such as caffeine, but also the pungent constituents of hot chilli pepper, capsaicin and nonivamide, have been demonstrated to modulate digestion and satiation.

While human intervention trials and animal studies are suitable for providing data on health benefits *in vivo*, cell culture studies may prove mechanisms of cellular uptake and action. However, pharmacokinetics, including intestinal degradation, absorption, transport and metabolic transformation in response to a given dose cannot be investigated in one cell systems, but are necessary for evaluating a compound’s efficacy. Here, quantitative analysis of the parent compound and its metabolites not only in the preparation administered but also in target tissues plays a pivotal role in identifying *in vivo*-representative cell culture conditions.

Combining chemical-analytical techniques with appropriate biochemical outcome measures will help to unravel the bioactivity and possible health beneficial effects of aroma- and taste-active compounds. The lecture will present strategies for the identification of taste active food constituents that help to maintain a healthy body weight.

Clean Label Sugar Reduction: How to Get It Done with Plant-Based Sweeteners and Sweetness Modulators?

Alex is the founder and CEO for W2O, a food technology firm for the past ten years. He specializes in applying niche expertise in taste & smell neuroscience and plant based sweeteners & flavors to create "Better Food". Prior to that, Alex had held various R&D leadership positions in companies including Pepsi, Starbucks, and Wrigley. He led technical teams to achieve business results. Alex holds a PhD in Food Science from the University of Wisconsin-Madison.

Alex Woo, Ph.D.
W2O
Chicago, Illinois, USA

Abstract: We can reduce sugars in foods and beverages with found-in-nature high potency sweeteners including stevia and monk fruit extract, and non/low caloric bulk sweeteners such as allulose and erythritol. Furthermore, we can make these reduced sugar foods and beverages sweeter with sweetness modulators under six different mechanisms. These have been made possible through recent advances in taste and smell neuroscience and crossmodal correspondence. Taste and smell neuroscience of today, is the flavor technology of tomorrow".

Innovative Flavor & Food Product Development - Influence of Regulations and Guidelines

Matthias Guentert holds a Ph.D. in food chemistry from the University of Karlsruhe, Germany. Since retiring from his executive leadership position with Symrise he has been a consultant for food ingredients, fragrances and food. During his career of almost 30 years with Symrise he held various important technical and commercial leadership positions. From July 2008 until July 2014 he was the president of the flavor and nutrition division in North America. He also served for two terms as a member of the scientific advisory board of the German Institute for Food Chemistry in Freising, Germany (2005 – 2014). From May 2012 until May 2015 he was also elected to the FEMA Board of Governors in Washington, DC.

Matthias Guentert, Ph.D.
Consultant
Ridgewood, New Jersey, USA

Abstract: Modern innovative flavor and food product development is strongly impacted by a multitude of influences. Ultimately, it is in the widest sense the preferences, wishes and fears of the consumer that are reflected by product safety, nutritional and flavor considerations. Those drive the composition, labeling and appearance of final market products. Regulations and guidelines are typically issued to inform the consumers about safety, quality and nutritional issues as well as to protect them from any fraud or misrepresentation. It will be discussed here how some of these regulations and guidelines or also their non-existence can drive product development. Affected are the final food and beverage products as well as the ingredients that are used in their compositions. Among the food ingredients a strong focus will be on flavors. Areas such as organic, taste modulation, GMO-free, natural and clean label will be discussed.

Poster Session

Exploration of Volatile Targets to Enhance Strawberry Flavor

Zhen Fan, University of Florida

Strawberry is popular for its unique aroma. Although there have been many papers profiling volatiles in strawberry, there is a need to link chemical compounds to sensory responses. Over seven years, 158 strawberry samples from 48 varieties and breeding selections were subject both to consumer sensory panels and chemical analysis. These strawberry genotypes represent the University of Florida breeding program, some varieties from California and Europe, and a small sample of proprietary varieties. Volatile hierarchical cluster and network analysis revealed a highly intertwined network and strong correlations within volatile classes. Advanced statistics were used to connect the first two years of sensory data and chemical data (all chemical data not yet available for last five years) in order to identify volatiles with highest impact on sensory ratings. Multivariant analysis showed that sweetness was driven by total sugar, mainly sucrose, but was also enhanced by specific volatiles. Relatively weak correlations were found between total volatile content and sensory ratings, in contrast to previous studies. Important ester compounds such as butanoic acid derivatives had high PLS index scores in predicting sweetness and high partial correlations with sweetness. Alcohols, which are precursors for esters, were found to have negative correlations with sweetness.

Volatile's Role in Blueberry Flavor: What Compounds are Responsible for Novel Aromas?

Haley Sater, University of Florida

To improve fruit quality, it is necessary to understand the volatile composition, and identify which molecules impart preferred flavors, and increased perceived sweetness. This study focuses on blueberries (Vaccinium corymbosum). In 2016, individual plants were selected from the University of Florida's early stage breeding nurseries for their aroma and henceforth referred to as volatile aromatic parents (VAPs) with three objectives 1. Utilize sensory panels to understand how consumers respond to the unique aromatic volatile trait in VAP blueberries. 2. Identify specific volatiles, found in VAP berries selected for their distinct, aromatic flavor, originally noted in the cultivars 'Snowchaser' and 'Kestrel'.

Results from taste panels in 2018 indicated that a significant number of panelists could detect a novel flavor or flavors in the VAPs compared to non-aromatic genotypes. However, VAPs selected were not preferred in terms of 'overall liking' or 'overall flavor liking' by panelists.

Volatile analysis from GC-FID quantitation identified 84 volatile compounds among all genotypes surveyed. When volatiles present in VAPs were compared to non-aromatic genotypes the aromatic genotypes were found to have significantly higher levels of specific terpenes and esters. Aromatic genotypes were also found to have significantly lower levels of other compounds. Additionally, the aromatic genotypes had significantly higher levels of soluble solids and higher soluble solids to titratable acid ratios.

Poster Session

Differentiation between Orange Flavor and Mandarin Flavor

Shi Feng[1] , Joon Hyuk Suh[1], Frederick G. Gmitter[2], Yu Wang[1]
[1]Department of Food Science & Human Nutrition and [2]Department of Horticulture Science, Citrus Research and Education Center, University of Florida, Lake Alfred, FL

Citrus fruit flavors, specifically flavors of orange and mandarin, have been intensively investigated in the last decades. Relevant studies have primarily focused on the characterization of flavor profiles in different orange and mandarin fruits. However, the characteristic flavor difference between orange and mandarin has not been defined. In the current study, sensory analysis demonstrated the significant role of aroma in the discrimination between orange flavor and mandarin flavor. Then valencia orange and LB8-9 mandarin were used for the investigation of representative orange and mandarin aroma profile respectively. The most aroma-active compounds of Valencia orange and LB8−9 mandarin were preliminarily identified by aroma extract dilution analysis (AEDA) while quantitation of key volatiles followed by calculation of odor activity values (OAVs) further detected potent components (OAV $\geq$ 1) impacting their overall aromatic profiles. Follow-up aroma recombination and omission studies revealed that ethyl butanoate, ethyl 2-methylbutanoate, octanal, decanal, and acetaldehyde were essential for orange-like aroma, whereas linalool, octanal, α-pinene, limonene, and (*E,E*)-2,4-decadienal were considered key components for mandarin-like aroma. On the basis of a better understanding of orange versus mandarin flavor, it might be possible that some new HLB-tolerant cultivars have the potential to be used as supporting information in orange juice products.

Role of mineral nutrition on citrus fruit quality and postharvest storage life of HLB-affected mandarin cv. LB8-9 (Sugar Belle)

Faisal Shahzad, Jeffrey K. Brecht, Yu Wang, Mark A. Ritenour, and Tripti Vashisth

Huanglongbing (HLB; citrus greening) is a serious endemic citrus disease thought to be caused by the bacterium *Candidatus* Liberibacter asiaticus (CLas). About 80-90% of citrus trees in Florida are estimated to be infected, resulting in >70% decline in citrus production over the last decade. Fruit from CLas-infected trees are of poor quality showing blotchy peel color, lopsided shape, and small size. In addition, fruit with HLB symptoms have an off flavor and higher acidity, which makes these fruit less desirable or even unmarketable. A preliminary comparative study was conducted to evaluate the effect of preharvest mineral nutrients (potassium, calcium, boron and its combinations) on postharvest storage life and fruit quality of HLB-affected LB8-9 (RCBD, n=4). Right after harvesting, fruit were stored at 25 °C with 85% relative humidity (RH) for 21 days. With potassium and boron in combination treatment, fruit weight, diameter, peel color ‘a’ and ‘hue’ values were increased as compared to control. Fruit compression force and peel color ‘b’ value were higher with calcium treatment than other treatments. Sensory evaluation on gLMS scale showed higher scoring for mandarin flavor intensity and sweetness, lower sourness scoring in potassium and boron treated-fruit. Overall, potassium and boron separately and in combination improved the fruit quality attributes of HLB-affected LB8-9.

Poster Session

Candidate Genes of Blueberry Branched Chain Flavor Volatile Biosynthesis

Lorenzo Bizzio, University of Florida

Flavor volatiles derived from the degradation of branched chain amino acids have been found to be very important to the flavor profiles of several fruits. These volatiles are known to impart distinctly "fruity" aromas and often find use as artificial flavorants. However, the specific genes responsible for the biosynthesis of these volatiles remain uncharacterized in many fruit crops. Here we report several likely candidate genes possibly involved in branched chain volatile biosynthesis from a blueberry draft genome. Identifying such genes lays the groundwork for future research into the validation and functional characterization of the biosynthetic enzymes thought to be encoded by them.

Characterization of Aroma-active Compounds in Four Tuo Tea by GC-MS and GC-O Analysis

Xueying Nie[a], Shihong Mao[a], Xu Wei[b, c], Frederick G. Gmitter Jr.[c], Huarong Tong[a]
[a]College of Food Science, Southwest University, Chongqing, China; [b]College of Horticulture and Landscape, Southwest University, Chongqing, China; [c]Citrus Research and Education Center, University of Florida, Lake Alfred, USA

Tuo tea is named after the bowl shape. HS-SPME was adopted to extract the volatile compounds from 4 types of Tuo tea, including T1 from Fengqing, Yunnan; T2 from Banan, Chongqing; T3 and T4 from Dali, Yunnan. In total, 61 volatile compounds were identified by GC-MS and RI. 28 of them presented in all the four tea samples, mainly composed of alcohols and ketones. 32 of them were identified by GC-O as aroma active compounds. The accumulation of all compounds was presented as relative quantification. The scented features of tea samples mainly presented floral, fruity, woody, and spicy odors, which might be attributed to the volatile compounds with high odor intensity including Mesityl oxide, hexanoic acid, benzaldehyde, α-terpineol, nonanoic acid, linalool, linalool oxide II. These aroma-active compounds were supposed to be the characteristic active aroma composition of Tuo tea. Further reconstruction experiments are needed to verify the combination of active aroma components.

Poster Session

The Molecular Mechanism Underlying the Valencene Deficiency Observed in Mandarin Hybrids

Qibin Yu[1], Ming Huang[1], Hongge Jia[1] Yuan Yu[1], Anne Plotto[2], Elizabeth A. Baldwin[2], Jinhe Bai[2], Nian Wang[1], Frederick G. Gmitter Jr.[1]
[1]University of Florida, Institute of Food and Agricultural Sciences, Citrus Research and Education Center, Lake Alfred, FL 33850, USA; [2]USDA-ARS Horticultural Research Laboratory, Fort Pierce, FL 34945, USA

Valencene is a major sesquiterpene in citrus oil and biosynthesized by valencene synthase (EC: 4.2.3.73) from the 15-carbon substrate farnesyl diphosphate. It is abundant in some mandarins e.g. Fortune, however, it is undetectable in others e.g. Murcott. In this study, valencene production in fruit exhibited an Mendelian inheritance ratio of 1:1 in a segregating F1 population of Fortune × Murcott. We found only one dominant locus associated with valencene content detected on the linkage group 3 of the genetic map. A clear relationship between presence or absence of valencene synthase gene (*Cstps1*) expression, and presence or absence of valencene among randomly selected mandarin hybrids, was observed. A 12-nucleotide deletion at approximately -270 bp from the *Cstps1* coding region was only found in Murcott. Transient over-expression of the Fortune *Cstps1* promoter in sweet orange showed notable GUS activity, but the Murcott *Cstps1* promoter did not. In addition, by re-inserting the 12-nucleotide fragment, the activity of the Murcott *Cstps1* promoter was mostly recovered. The deficiency of valencene production in some mandarins is probably due to a 12-nucleotide deletion in the promoter region of the *Cstps1*, which could be a crucial switch of *Cstps1* transcription. These results further enhanced the understanding of valencene biosynthesis in citrus.

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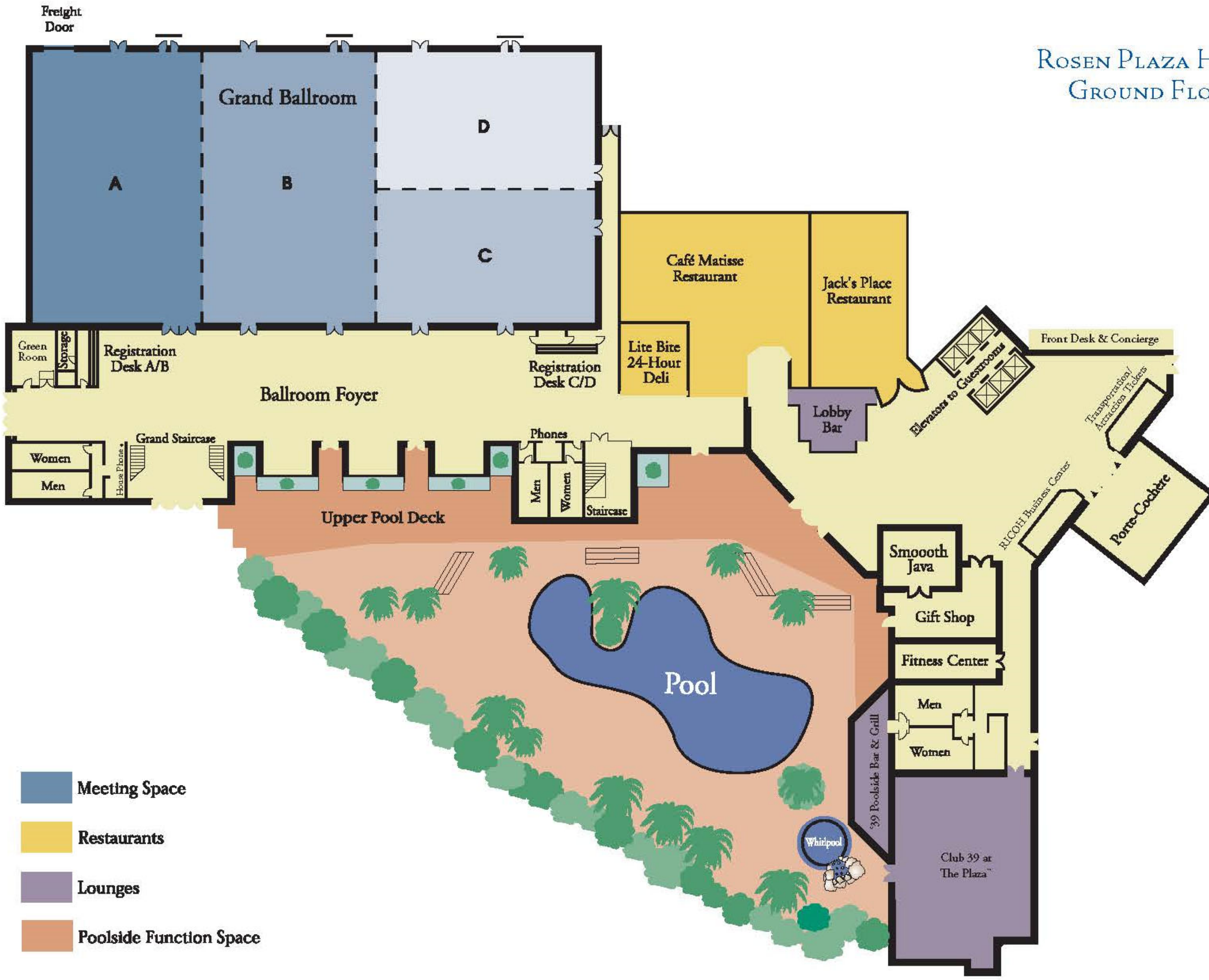
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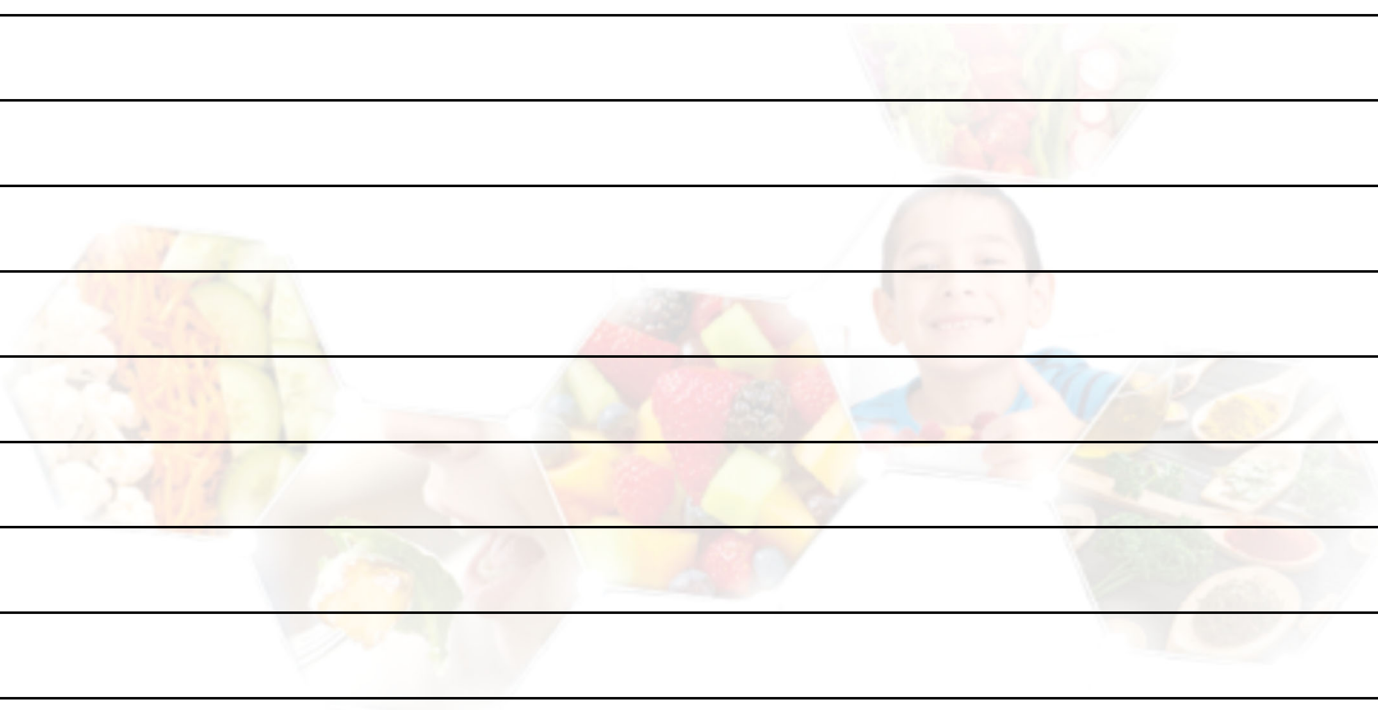

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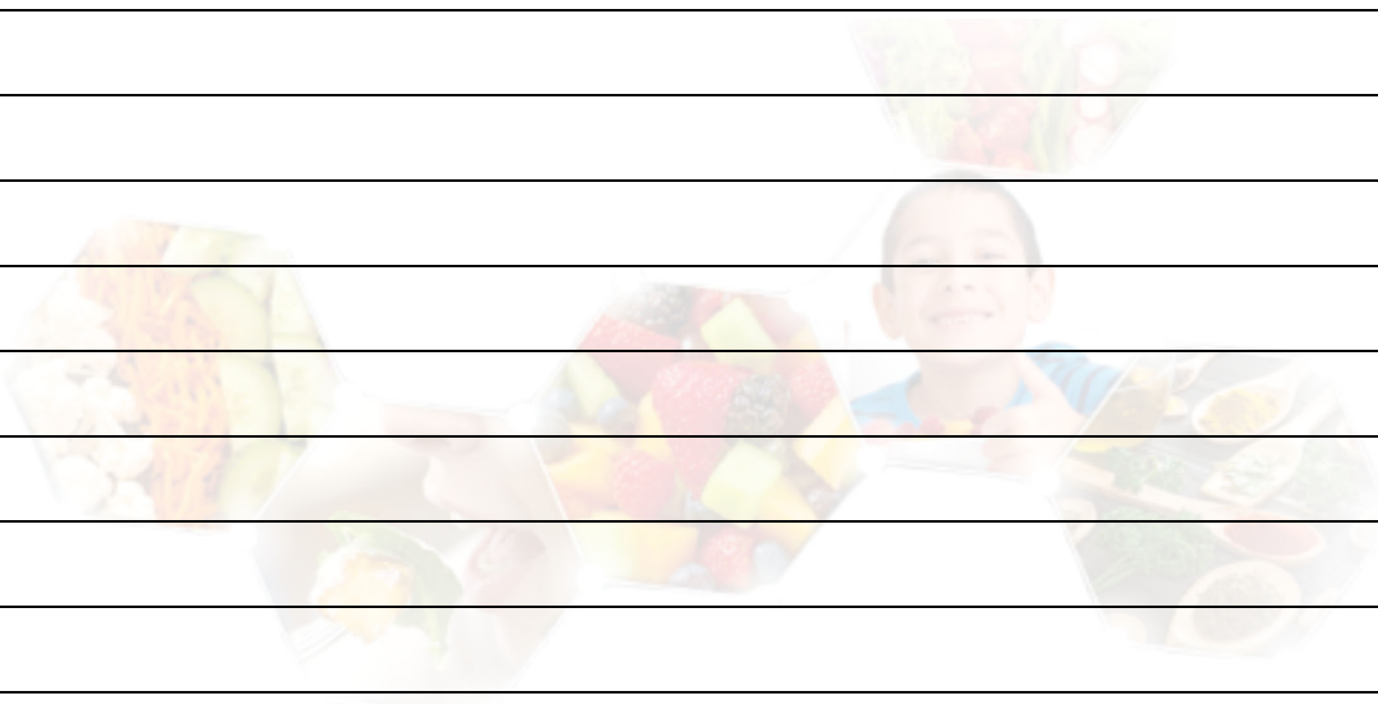

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