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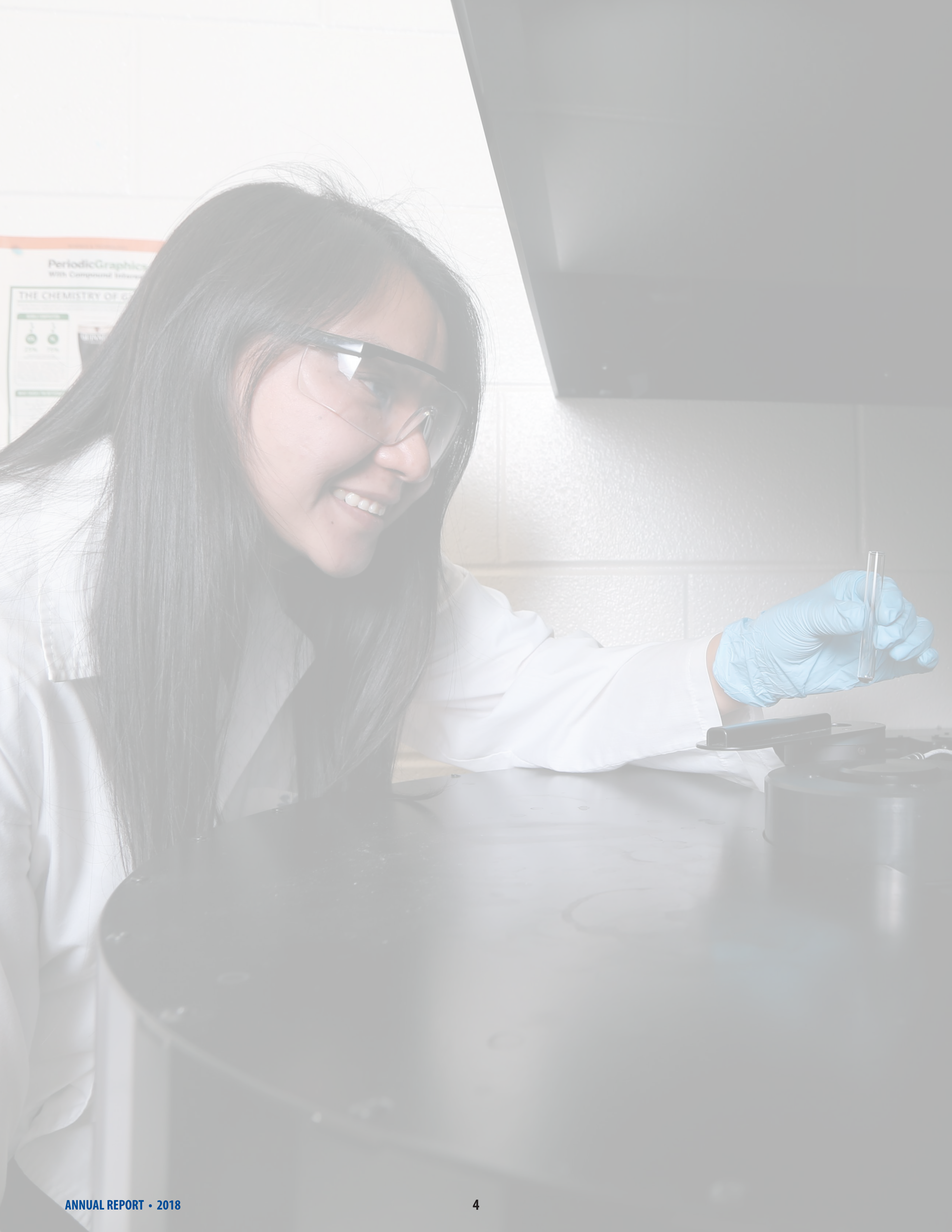
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Director’s Statement

Welcome to the 2018 Annual Report of the Whistler Center for Carbohydrate Research at Purdue University. As an industry member-based university research center, with funding from an array of grants and gifts, we work on various aspects of carbohydrates related mostly to foods, but also industrial non-food uses. Our focus is primarily on plant-based carbohydrates including starch and the wide range of non-starch polysaccharides and oligosaccharides that make up cell wall structures, gums and storage carbohydrates. Our expertise and studies span fundamental structure-function studies of carbohydrates related to nano-level assemblages with novel properties, to formation of structures affecting food texture, properties of digestion and the gut microbiome related to nutrition and health, and processing applications. In 2018, we initiated a “Big Idea” project on sugar replacement and reduction, where two research groups in the Center are studying how sugar can be better replaced with high-intensity sweeteners and carbohydrates that produce similar desirable functions of sucrose related to texture and other aspects of product quality. The groups are divided into experimental and computer modeling approaches.

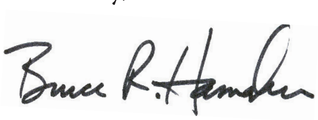
There continues to be changes occurring in the kind of foods people want to purchase and eat, and carbohydrates, as a major energy component of foods, are a part of this. At the Whistler Center, we have active programs in understanding how digestible (glycemic) carbohydrates can be fashioned to interact with the body so that a fullness feeling results and where glucose is delivered to the body over an extended period of time. We have made notable advances on this topic and published papers in 2018 showing in vivo how this could be done, and further how carbohydrate structures could be used to make slow digesting foods for this purpose. We are very active in dietary fiber and gut microbiome research with many research projects focused on understanding ultimately how dietary fibers could be used to make positive changes to the gut bacterial community for improved health.

In 2018, we expanded our Webinar research presentation series as a successful way of educating our member company scientists and non-scientists on our latest research and more broadly on implications related to our latest research. These interactive web-based sessions will be further extended in the future with opportunity for individuals who are not part of member companies to participate for a reasonable fee. Our other long-running educative function, our three-day short course held every October, continues with invited speakers and an exciting range of carbohydrate-related topics. Our short course has limited available slots for non-member participants.

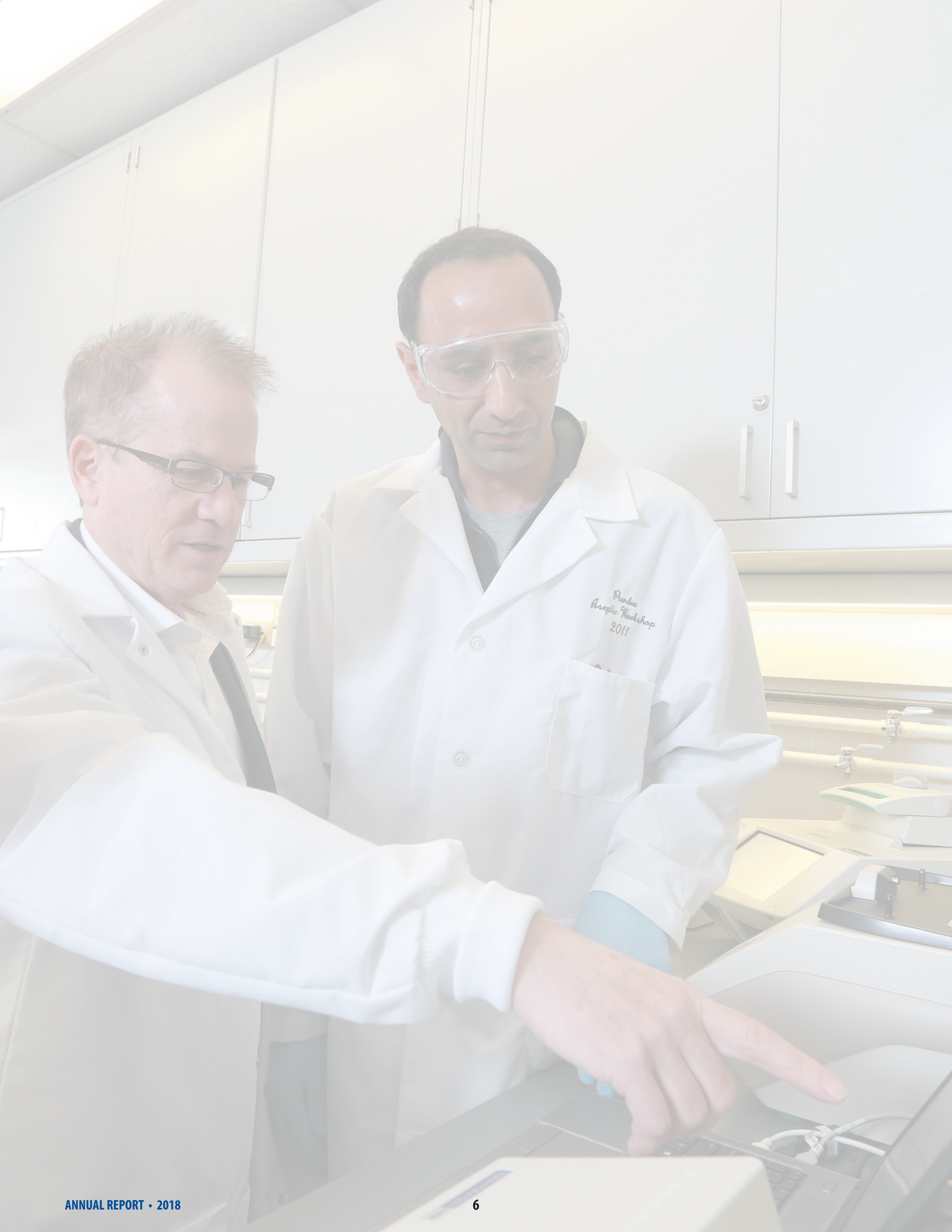
We welcomed back Pepsico Co. in 2018, and with our member companies continue to be involved with many research projects. Last year we saw one of our key faculty members, Prof. Osvaldo Campanella, moved to a Chair position at The Ohio State University. This was tough for us, but also started us thinking how we can have active faculty of the Whistler Center from other universities and institutes. In our monthly “Action Committee” meetings, initiated by Whistler Center Coordinator Katherine Fry, we are coming up with a plan to have select outside scientists from other universities or institutes be part of our core faculty. Our adjunct faculty members to the Whistler Center continue to be important to our yearly evaluation and planning exercise at our summer retreat.

I invite you to take some minutes and look through our 2018 Whistler Center Annual Report. Please feel free to contact Katherine or myself with any questions you might have.

Sincerely,



Bruce R. Hamaker
Distinguished Professor of Food Science
Roy L. Whistler Chair, Director


Purdue
Aseptic Workshop
2011

Summary of Major Research Accomplishments

Starches, Non-starch Polysaccharides and Cereals

O. Campanella and **B. Hamaker** completed work on molecular dynamics simulations on interactions between amylose and free fatty acids, including analyzing the effect of free fatty concentration (Project 4). In collaboration with **J. BeMiller**, the effects of neutral and anionic hydrocolloids on their behavioral interaction with waxy starches were studied. Naturally, waxy potato starch has a higher degree of phosphorylation when compared to other waxy starches. Therefore, it was proposed that its rheological properties would be impacted differently when mixed with charged and neutral hydrocolloids. Neutral (guar gum and konjac glucomannan) and anionic hydrocolloids (gum arabic, xanthan gum, sodium alginate, and pectin) were combined with waxy potato starch and the rheological properties of these systems were investigated when the starch was gelatinized. Results have shown that the structure and flexibility of the hydrocolloid molecules affect the rheology of those systems. In the presence of hydrocolloids having linear and flexible chains or highly-branched structures, the rheology of the material displayed a liquid-like behaviour. Conversely, in the presence of hydrocolloids having rigid chains or neutral hydrocolloids, the gelatinized waxy starch/hydrocolloid dispersion had a higher elasticity. The observed phenomenon was attributed to the formation of shear-induced double-helices in the amylopectin molecule. This research provides a new approach to study the interaction between different biomacromolecules, whereas results are pointing out new potential alternatives to promote molecular associations between starch and selected hydrocolloids by the application of moderate shear forces. These results could be used to control the quality of foods in terms of texture and nutrition.

L. Mauer's group continues to take materials science approaches to manipulate and investigate food ingredient structures and functions, water-solid interactions, and amorphization and crystallization tendencies. Ongoing studies include investigations of the roles of small molecules on the gelatinization and retrogradation of starch (Project 26), the roles of hydrocolloids in disrupting the crystallization tendencies of sugars and vitamins (Project 27), and the responses of complex ingredient blends to fluctuating storage environments (Project 28). Her scientific approaches build a framework of understanding around intermolecular non-covalent interactions and material properties.

Y. Yao's work in 2018 focused on the characterization of carbohydrate polymers using molecular rotor and new biomaterials for food and pharmaceutical applications. Individual projects included the use of molecular rotor to characterize the supramolecular structure of amylopectin and phytoglycogen (Project 33) and starch retrogradation (Project 34), continued study on using phytoglycogen and its derivatives to increase the solubility of poorly water-soluble active ingredients (Project 35), continued study on the micro-analysis of starch materials (Project 36), and strategies for pathogen biofilm removal (Project 37).

Carbohydrates, Nutrition and Health

S. Lindemann's group discovered that size-dependence in fermentation of wheat bran particles by the gut microbiota arise in particles of controlled chemical composition (Project 23). Furthermore, his group determined that size-dependent fermentation also occurs in corn brans. His group also determined that polysaccharide structure maintains stable microbial diversity over sequential transfers *in vitro*, suggesting that microbes cooperate in polysaccharide degradation in ways that avoid direct competition. Furthermore, his group determined that both the branching structure of resistant glucans and the chain length of inulins influence which microbiota are best adapted for their consumption. Finally, his group identified that subtle structural variations in sorghum arabinoxylan structure select for different *Bacteroides* genotypes in different individuals (Project 24).

B. Hamaker's group has expanded research towards modifying or fabricating dietary-fiber-based materials that could have targeted function in the gut microbiota related to health (Project 7). They continue to study relationships between dietary fiber structures and function, particularly related to the specificity of structure in support of gut bacterial groups (Project 8). On glycemic carbohydrates, they have conducted *in vitro* and *in vivo* work on slowly digestible carbohydrates and their potential to activate physiological systems related to appetite and the concept of extended energy of foods (Project 9) and on cellular and physiological responses related to obesity (Project 10).

M. Ferruzzi's group continues to pursue research on fundamental and applied aspects of both food and nutrition science disciplines. The long-term focus of his group is to identify food science strategies that will contribute to the prevention of chronic disease in humans. Working toward this goal, their work focuses on understanding the impact of the food matrix and processing on physical and chemical stability as well as bioavailability of phytochemicals. His work has focused on both traditional grains and biofortified staples (cassava, potato, maize sorghum and millet). **Dr. Ferruzzi's** group continues to explore interactions between phytochemicals (phenolics and carotenoids) with carbohydrate and protein macromolecules, including the role of these interactions in altering phytochemical bioavailability and glycemic response from foods (Project 6).

Polysaccharide and Other Biomacromolecule Structures

O. Jones's group has completed research involving the practical utilization of particulate assemblies of proteins and polysaccharides. Published findings in collaboration with **M. Ferruzzi** showed that particulate maize protein assemblies offer select advantages as controlled release vehicles in the digestive tract and within composite films when dispersed with specific stabilizers (Project 11). Whey protein particles were used to stabilize oil-water emulsions to slow release of entrapped volatile flavors, which could be readily be applied towards polysaccharide-based particles (Project 12). A third study found that chitin particles extracted from milled cricket flour also contributed towards the emulsification properties of protein-rich flours, serving as a guide for developers of insect-based ingredients (Project 13).

The **Jones** group has continuing research interests in the role of protein structures and how they interact with polysaccharides in complex materials. A new project has been initiated on how protein glycosylation affects interactions with polysaccharides (Project 14). **O. Jones** and **O. Campanella** have also continued their research on fibrous aggregates prepared with maize proteins as a physical stand-in for wheat glutenin (Project 15), which is a natural fibrous protein assembly responsible for desirable viscoelastic behaviors in baked products. Both electrospinning and extrusion processes are being investigated as means to prepare improved gluten-free dough systems with low-cost and reduced ecological impact.

J. Kokini's group studies nanocomposites, their fabrication and properties, and new methods of detection of discrete components in complex food materials. Antibodies for glutenins were developed and conjugated to quantum dots for detection of location in wheat doughs (Project 16), and biodegradable protein-based Surface Enhanced Raman Spectroscopy platforms were fabricated for detection of food allergens and toxins (Project 17). Nanofibers were made from kafirin protein to encapsulate essential oils for packaging applications (Project 18). His lab successfully analyzed the effects of crosslinking and plasticization on dispersive and polar surface energy (Project 19), and zein and kafirin-based nanocomposites for biodegradable packaging (Project 20). They also worked on non-linear rheology and protein secondary structures of doughs (Project 21).

Rheology and Physico-chemical Properties

Research performed by the group **O. Campanella**, **B. Reuhs** and **O. Jones,** in collaboration with Prof. Avtar Handa from the Department of Horticulture and Landscape Architecture, determined rheological properties of tomato products and found the association of these properties with the structure and mechanical properties of the tomato particles. Results of this research challenge the long-held idea that pectin in the continuous water phase is responsible for viscosity and texture (Project 1). Other ongoing studies are demonstrating alternative processes capable of producing tomatoes with better organoleptic properties with reducing energy expenditure.

Interfacial Phenomena

G. Narsimhan's group continues to work on fundamental aspects of interfacial phenomena in food and biological systems. They are investigating the prediction of swelling behavior of crosslinked starch and elastic behavior through modeling (Projects 29 and 30) and pore formation and properties using antimicrobial peptides (Projects 31 and 32).

Chemical Structures and Functions of Polysaccharides

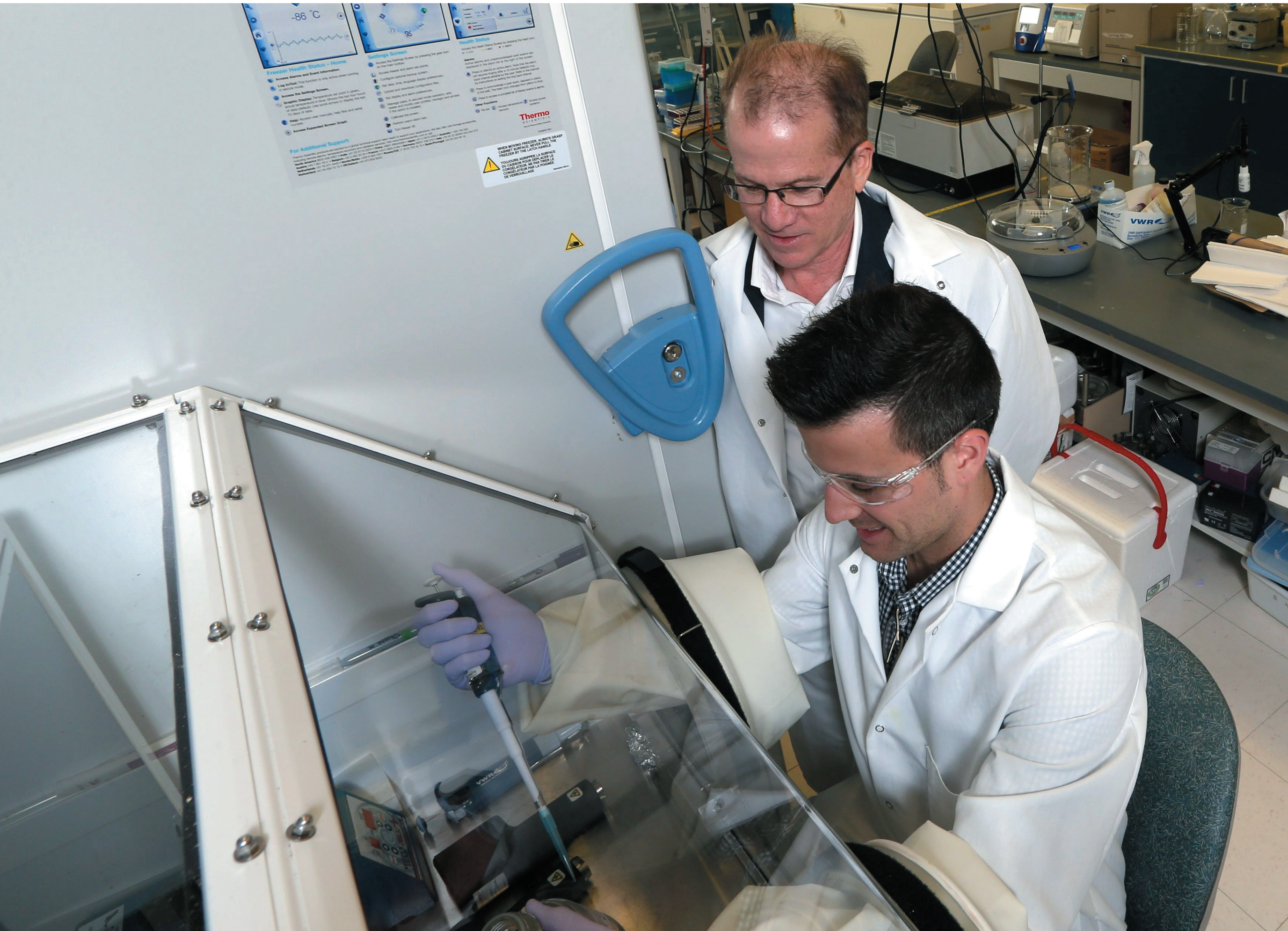
B. Reuhs and **A. Terekhov** run the analytical core facility at the Whistler Center dedicated to complex carbohydrate structural analysis. With **O. Campanella** and **B. Hamaker**, the group studies non-starch polysaccharide structures and their physical functionality (described under Campanella), as well as colon fermentation (described under Hamaker).

With **O. Jones** and **O. Campanella**, the **Reuhs** group also researches the structure and functionality of polysaccharides in processed foods, such as tomato products (Project 1).

Analysis typically involves monosaccharide profiling using the alditol acetate or TMS-methyl-glycoside analysis by GC, and linkage analysis by partial methylation using GC-MS, as well as 2D-NMR, MS, and FT-IR. Other chromatography methods are used to profile molecular size, and as preparative tools. All of these research efforts are related to understanding the role of polysaccharides in structure-function relations in various biological and food systems.

Emerging Food Processes

O. Campanella's group has been working on the processing of foods with the aim of optimizing conditions to achieve good quality and safe foods. Thermal and non-thermal processes are being studied. Thermal processing of foods involves the use of Microwave, whereas non-thermal processes have involved research on Cold Plasma Processing and Pulsed Electric Fields (PEF) (Project 2). In collaboration with Dr. Fernanda San Martin and graduate student **Gabriella Mendes-Oliveira,** the team was able to develop a model that takes into account transient changes in product temperature before achieving the final sterilization temperature. The study is relevant to the food industry because it provides a quantitative tool to predict survival characteristics of pathogens with microwave or other processing conditions to enhance food product quality and keep food safe. Results recently published in the Journal of Emerging Technologies demonstrate the capacity to estimate the efficacy of cold plasma processes with consideration of varying concentrations of reactive ions species. Predictive models are also being assembled for reduction in *Escherichia coli* O157:H7 and *Salmonella* Typhimurium during Pulsed Electric Field (PEF) pasteurization of fruit juices, which are frequently causes of food poisoning outbreaks. This study will build predictive models describing the inactivation of those pathogens under more realistic PEF conditions, i.e., conditions that include varying voltage, frequency and processing time. For the first time, survival parameters including critical electric field strength, repetition rate, and the shape of the survival curve under PEF treatments are included into the description of the microbial inactivation curves and can be used as technical support to optimize novel food processing technologies.



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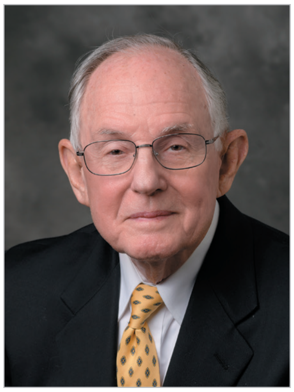


James N. BeMiller

General Research Areas
- Starch
- Carbohydrate chemistry

Specific Research Areas
- Starch granule structure, reactivity, and behavior
- Chemical and biological modifications of starch
- Structure-functional property relationships of polysaccharides

Osvaldo H. Campanella

General Research Areas
- Process modeling
- Rheology
- Material structure and texture
- Extrusion

Specific Research Areas
- Application of rheology to food science and food engineering
- Mathematical modeling of food process operations
- Online rheological techniques
- Rheology of biomaterials
- Dough rheology
- Rheology of dairy products
- Characterization of material structure and texture; relationship to rheological properties
- Effect of glass transition on product texture
- Extrusion: role of rheology in the extrusion process

Mario G. Ferruzzi

General Research Areas
- Phytochemical and botanical chemistry with focus on food pigments and flavonoids
- Development of methodologies for determination of phytochemicals in food and biological matrices
- Investigation of food processing effects on phytochemical profiles, bioavailability, and ultimate bioactivity
- Development of strategies for incorporation and stabilization of phytochemicals in food systems

Bruce R. Hamaker

General Research Areas

- Carbohydrates and health
- Starch, chemistry and function
- Dietary fiber, chemistry and function

Specific Research Areas

- Glycemic carbohydrate digestion for slow digestion/low glycemic response, physiological response
- Dietary fiber, modifications in functionality and gut fermentability, gut microbiota and metabolites
- *In vitro, in vivo*, cell culture studies
- Cereal starch and protein functionality
- Textural properties influenced by starch fine structure
- Interactions between starch and other food components
- Appropriate methods of improving cereal utilization in developing countries

Owen G. Jones

General Research Areas

- Physical interactions between food biopolymers, such as milk proteins and fibrous polysaccharides
- Assembled structures through physical interactions and environmental changes, such as pH, temperature and dielectric constant
- Assembled structures for the purpose of controlled release, textural mimetry or modulated interactivity within food or pharmaceutical products

Jozef Kokini

General Research Areas

- Food materials science
- Linear and non-linear rheology
- Computational fluid dynamics
- Food nanotechnology and fabrication of nano-biosensors
- Phase behavior and compatibility of ingredients in food mixtures
- Food structure and texture during extrusion, mixing processes and computational fluid dynamics

Stephen Lindemann

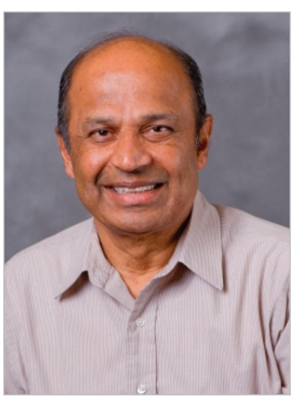
General Research Areas
- Gut microbiome
- Genomics and metabolism

Specific Research Areas
- Dietary fiber impacts on gut microbiome diversity
- Genomic mechanisms of polysaccharide fermentation
- Carbon, nitrogen and energy cycling by gut microbiota and host interfaces

Lisa J. Mauer

General Research Areas
- Food chemistry
- Water-solid interactions
- Food materials science

Specific Research Areas
- Structure-function relationships of food ingredients
- Solid state characterization
- Glass transitions
- Moisture sorption
- Deliquescence
- Crystallization and amorphization



Ganesan Narsimhan

General Research Areas
- Emulsions and foams
- Biopolymer interactions

Specific Research Areas
- Pore formation by antimicrobial peptides in cell membranes and lipid bilayers
- Pasting behavior of starch
- Stability and texture of food emulsions and foams
- Adsorption of proteins and protein-polysaccharide complexes at interfaces
- Functional properties of proteins and protein-polysaccharide complexes
- Physical and chemical modification of proteins for use as food stabilizers
- Rheology of polysaccharide solutions and gels

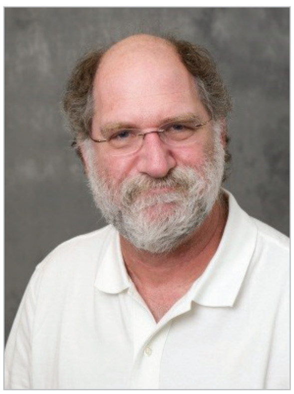
Bradley L. Reuhs

General Research Areas

- Polysaccharide analysis
- Bacterial and plant cell wall compositions, structures and functions
- Sugars and polysaccharides in nutrition and food systems

Specific Research Areas

- Extractions and purification of acidic polysaccharides from cell walls of plants (including food products) and bacteria
- Pectin, hemicellulose, capsule, gum and lipopolysaccharides analysis
- Application of HPLC, MS, GC, GC-MS, FT-IR and NMR to structural studies of carbohydrates, including polysaccharides



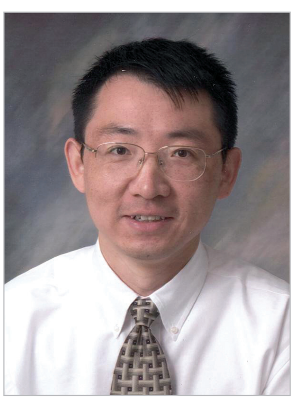
Clifford F. Weil

General Research Areas

- Plant classical and molecular genetics
- Protein structure and function
- Gene expression
- Large-scale forward and reverse genetics screening
- Genome maintenance and organization
- Genomics of starch digestion, composition and architecture

Specific Research Areas

- Rational redesign of corn starch composition
- Computer modeling of starch synthases
- Mutational analysis of starch biosynthesis in corn and *E. coli*
- Genetic modification of corn starch properties



Yuan Yao

General Research Areas

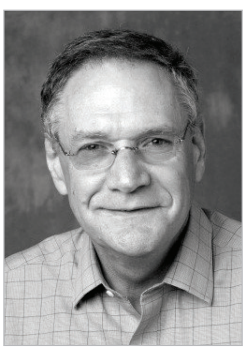
- Novel biomaterials for food and health
- Chemistry and genetics of carbohydrate polymers
- Nanotechnology for foods and drugs
- Coating of active ingredients

Specific Research Areas

- Construction and characterization of nano-biomaterials
- Stabilization, solubilization and delivery of active ingredients
- Genetic, enzymatic and chemical modifications of starch
- Functional food ingredients
- Carbohydrate microanalysis
- Evaluation and removal of pathogen biofilms
- Roll-to-roll coating of active ingredients

Adjunct Faculty

Yonas Gizaw, Ph.D. is Principal Scientist at The Procter and Gamble Co. Currently, he is technical leader for Advanced Cleaning Transformative Platform Technologies in Corporate R&D. Dr. Gizaw is a 20-year veteran of P&G with broad experience in biopolymers, nanotechnology, polymers physical chemistry, surfactants and colloids. He spent about eight years in Snack and Beverages, where he supported technology development for beverages (Sunny D) and Snacks (Pringles), then moved to the Fabric Care Strategic and Innovation division, where he was responsible for development of strategic technologies Downy/Lenor & Tide/Ariel, etc. In 2012, he joined Corporate Research – Transformative Platform Technologies. Prior to joining P&G, Dr. Gizaw received his doctoral degree from Purdue University in synthetic carbohydrate chemistry.



Akiva Gross, Ph.D. is President of A.T. Gross Consulting, Ltd. Dr. Gross received his doctoral degree in Organic Chemistry from the Weizmann Institute of Science in Israel and then continued his scientific training in Applied Enzymology in the chemistry departments of Massachusetts Institute of Technology and Harvard University. Before starting his consulting business, Dr. Gross served as a Vice President of Global Product Development at Corn Products International. Prior to joining the company, Dr. Gross held several R&D leadership positions at CP Kelco and Monsanto. He was also a co-founder, Senior Vice President of R&D and a member of the Board of Directors of Opta Food Ingredients, Inc. Opta Food Ingredients was established as a spinoff of Enzytech, Inc., where Dr. Gross was a co-founder and Vice President of R&D.

Sakharam K. Patil, Ph.D. is President of S.K. Patil and Associates. Dr. Patil was awarded a Ph.D. degree in Cereal Science by Kansas State University in 1973. He held several positions at American Maize Products Co., later Cerestar, from 1978 until his retirement in 2002. The positions included VP Marketing and Commercial Development (1994-1995), Vice President of Research and Development (1995-2000), Vice President of Research and Development and Director, Global, Technology Transfer (2000-2001), and VP Quality and Technology Transfer (2002). His expertise includes cereal chemistry, ingredient technology (food and industrial), technology transfer, marketing/commercial development, training/coaching, cross-functional team development, global business development and strategic management.

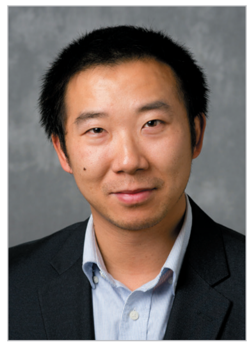
Bernhard Van Lengerich, Ph.D., Former CSO and VP Technology Strategy at General Mills, Inc. After more than 20 years of service, Bernhard retired from General Mills in March 2015. He is a strategic advisor and serves as a board member of several companies and nonprofit organizations. He is founder of the Seeding the Future Foundation, Vice Chair of Feeding Tomorrow (IFT's nonprofit organization) as well as Compatible Technology International, a nonprofit organization in Minnesota, focusing on post-harvest loss reduction in SSA. Bernhard completed his Ph.D. in Food/Biotechnology at the Technical University of Berlin, Germany. His work experience includes Unilever Germany, RJR Nabisco, New Jersey, and Buehler AG in Switzerland. In 1994, Bernhard joined General Mills, Inc., in Minneapolis. He led the development of numerous technologies and capabilities resulting in major product innovations. Bernhard authored/co-authored over 100 patents, established and led a Game Changer program, and created a novel "Cashless Venturing" initiative, enabling faster and more disruptive innovations.

Visiting Professors

Dawei Chang earned his B.S. in Food Science and Technology from HeBei Agriculture University in 2004 and his M.S. in Food Science from Shanghai Ocean University in 2007, respectively. He obtained his Ph.D. degree in food science from School of Food Science and Technology of Jiangnan University in December 2010. He started working in School of Food and Biological Engineering in Shaanxi University of Science and Technology from December 2010. He has been a visiting professor in Dr. Campanella's group at Purdue University since August 2017. His research focuses on the area of molecular properties of starch that allows the interaction with protein molecules.

Hanqing Chen earned his B.S. and M.S. degrees from the Department of Animal Science and Technology of Anhui Agricultural University in July 1991 and July 1998, respectively. He obtained his Ph.D. degree from the Department of Food Science and Technology of Jiangnan University in July 2005. Now he is a professor in the College of Food Science and Engineering of Hefei University of Technology. He joined Dr. Campanella's group as a visiting professor in September 2016, researching the structure and rheological properties of starch.

Carmen Silvia Favaro-Trindade visited Dr. Hamaker and Dr. Jones' labs from January to June 2018. She has a Food Engineering undergraduate degree from the Universidade Estadual Paulista, a master's degree in Food Science and Technology from Universidade Federal Rural do Rio de Janeiro and a Ph.D. in Food Science and Technology at Universidade Estadual de Campinas.



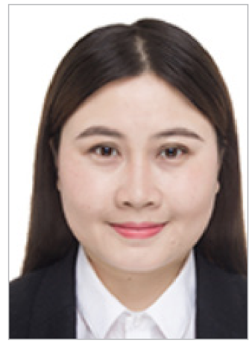
Tao Feng earned his Ph.D. in Food Science from Jiangnan University of China in June 2007. He is an associate professor of Shanghai Institute of Technology in China. He arrived at Purdue University in May 2012 as a visiting scholar in Food Science and is co-advised by both Drs. Hamaker and Campanella. His research focuses on molecular dynamics simulation of triplex soluble nanoparticles self-assembled by amylose, beta-lactoglobulin(dimer) and free fatty acids.

Mi Hongbo earned her B.S. degree from the Department of Food Science and Engineering of Tianjin University in July 2009. She obtained her Ph.D. degree from the Department of Food Science of Zhejiang University in June 2014. Now she is a faculty member at the College of Food Science and Engineering, Bohai University. She joined Dr. Narsimhan's group as a visiting professor in September 2016 with research focused on preparation and characterization of starch-lipid complexes.

Hu Hou joined Dr. Narsimhan's group in December 2016 as a visiting scholar and is working on antimicrobial peptides. He obtained a B.E. degree from the Department of Food Science and Engineering in Yantai University in June 2006, and he earned his Ph.D. degree from the Department of Food Science in Ocean University of China in June 2011. He became an Associate Professor at Ocean University of China in December 2014, and he teaches Principles of Food Engineering for undergraduate students and Food Protein Theory and Technology for graduate students. His research focused on Food Protein and Peptides.

Bin Li earned his B.S. and Ph.D. degrees from the Department of Food Science and Technology of Huazhong Agricultural University in July 1994 and July 2002, respectively. Now he is a professor in the College of Food Science and Technology of Huazhong Agricultural University. He joined Dr. Campanella's group as a visiting professor in January 2017 researching molecular stimulation and molecular docking of carbohydrates.

Xingfei Li earned his B.S. degree from the Department of Biotechnology at Shandong University of Technology in July 2008, and M.S. degree from the Department of Botany of Zhejiang Normal University in July 2012. He obtained his Ph.D. degree from the Department of Food Science and Technology of Jiangnan University in January 2017. He joined Dr. Kokini's group as a visiting scholar in January 2017. His research focuses on the complex interaction between polysaccharides and proteins.



Jie Long earned her B.S. and M.S. degree from the Department of Food Science and Technology of Nanjing Agricultural University in July 2009 and January 2012, respectively. She obtained her Ph.D. degree from the Department of Food Science and Technology of Jiangnan University in January 2016. Now she is a visiting scholar in Dr. Campanella's group at Purdue University in August 2017. Her research focuses on the characterization of the interaction of different starches with gums.

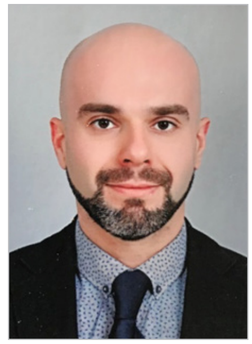
Xiaoyuan Ma earned her B.S. in Bioengineering from the College of Chemistry and Chemical Engineering – Nanjing University of Science and Technology, China in 2006. She received her Ph.D. in Applied Chemistry at Southeast University, China in 2011, advised by Dr. Weiping Qian. She joined Dr. Kokini's group as a visiting professor in December 2017, with financial support from the China Scholarship Council (CSC). Her research focuses on the fabrication of nanomaterials and their SERS application in food safety detection.

Jae-Hoon Shim is an Associate Professor in the Department of Food Science and Nutrition at Hallym University. Jae graduated with his M.S. and Ph.D. degrees from the Department of Food Science & Biotechnology, Seoul National University. His research focuses on food enzymology and food microbiology. He was a sabbatical visiting professor and has ongoing research collaboration with Dr. Hamaker.

Viridiana (Viri) Tejada, visiting scholar at the Whistler Center with Dr. Campanella, received her B.S. degree in Food Engineering (2010), M.S. degree (2013) and doctorate degree in Biotechnology, from Tecnológico de Monterrey, Mexico. In the Summer of 2007 and Fall of 2009, she attended internships at the University of British Columbia and Cornell University, respectively. Viri has worked as part-time lecturer at Tecnológico de Monterrey, teaching courses in the biotechnology department. She is now a Postdoc fellow focused in dietary fiber obtained from agro-industrial residues, mainly fruit peels, and gut microbial mathematical modeling. Viri's expertise extends to non-thermal technologies, such as high hydrostatic pressure, and their use for enzyme inactivation and dietary fiber modifications.

Secil Turksoy completed her B.S. degree in Food Engineering at Ankara University in 2001 in Turkey. She also completed her M.S. and Ph.D. degrees in the same department, in which she focused on functional properties of fruit- and vegetable-based dietary fibers. After receiving TUBITAK Scholarship in 2018, she joined Dr. Jozef Kokini's group as visiting scholar. Her research focuses on rheological properties of viscoelastic food materials.

Enbo Xu obtained his Bachelor degree from Zhejiang University of Technology in July 2013 in Food Science and Technology. Then, he studied in Jiangnan University to pursue his M.S. and Ph.D. degree in Food Science and Technology. He is now a visiting scientist with Dr. Campanella. His research focuses on the extrusion processing of cereals.



Tuncay Yilmaz holds a Ph.D. in Food Engineering from Celal Bayar University. Tuncay was a Visiting Professor who worked with Dr. Kokini researching the role that previously unstudied protein components play on rheological properties of wheat flour doughs. He joined Kokini's group in August 2016.

Genyi Zhang is a Professor of Food Science at Jiangnan University, mainly focusing on the carbohydrate chemistry and nutritional properties of starch, and related to this, nutritional interference to prevent or delay the incidence of chronic diseases (diabetes) using functional food components. He also works on soft matter nanotechnology for functional component encapsulation and delivery. He was a visiting professor in the summer of 2018 with Dr. Hamaker.

Haining Zhuang earned her Ph.D. in Food Science from Jiangnan University of China in June 2011. She arrived at Purdue University in May 2012 as a postdoc research associate in Food Science and was advised by Dr. James N. BeMiller. Her research focused on interactions between crosslinked starch and various hydrocolloids. She worked in the Institute of Edible Fungi, Shanghai Academy of Agricultural and Sciences, as an assistant researcher from 2014 to 2018. She rejoined Dr. Hamaker's group as a visiting scholar in August 2018.

Visiting Scientists

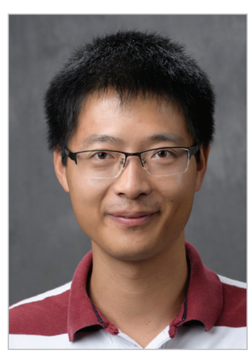
Iram Ashfaq earned her undergraduate degree in Bioinformatics in 2011, and completed her M.S. in Biotechnology in 2014 from Government College University, Faisalabad, Pakistan. She is enrolled in Ph.D. Biotechnology at National Institute for Biotechnology and Genetic Engineering (NIBGE), Pakistan. Now Iram is a visiting scholar in Dr. Stephen R. Lindemann's group at Purdue University in the area of prebiotics linking to human gut microbiome health. She joined Lindemann's lab in February 2018.

Neslihan Bozdogan completed her B.S. degree in Food Engineering from Hacettepe University in 2011 in Turkey. She earned her M.S. degree in Food Engineering from Ege University in 2015 and began her Ph.D. degree in the same department, advised by Dr. Seher Kumcuoglu. She joined Dr. Kokini's group as a visiting scholar in October 2017 with financial support from the Scientific and Technological Research Council of Turkey (TUBITAK). Her research focuses on the numerical simulation and noninvasive 3D imaging of bubble dispersion during mixing.

Thais Brito-Oliveira earned her B.S. in Food Engineering from the College of Animal Science and Food Engineering - University of São Paulo (USP) in 2014. She began her M.S. in Food Engineering at University of São Paulo in 2015, advised by Dr. Samantha Cristina de Pinho. She joined Dr. Campanella's group as a visiting scholar in July 2016 with financial support from the São Paulo Research Foundation (FAPESP). Her research focused on the rheological characterization and mathematical modeling of cold-set, emulsion-filled gels produced with soy protein isolate and polysaccharides.

Matilde Caressa earned a bachelor's degree in Food Science and Technology from the University of Parma in October 2016. In March 2018, she joined Dr. Campanella's group as a Visiting Scholar for a six-month internship. Her current research is focused on the characterization of gluten-free bread made with extruded zein and different starches.

Nanci Castanha received her B.S. degree in Food Engineering from University of Campinas (2014) and her M.S. degree in Food Science and Technology from University of São Paulo (2017), both in Brazil. She started her Ph.D. in Food Science and Technology at University of São Paulo in 2017. Currently, she is a visiting scholar at the Whistler Center, working jointly with Dr. Jones and Dr. Reuhs, and formerly with Dr. Campanella. Her research focuses on the evaluation of the structure and properties of modified starches using different technologies.



Lilin Cheng earned his B.S. in Food Safety and Quality from Shihezi University in 2011 and went to Jiangnan University to pursue his M.S. and Ph.D. degree in Food Science and Engineering. He bypassed his M.S. in 2012. He was a visiting student at Purdue from 2015 to the summer of 2017 and was co-advised by Drs. Campanella and Hamaker. His research focused on a three-component interaction and molecular dynamic simulation of the nanocomplex.

Ashwana D. Fricker received her Ph.D. degree in Microbiology from Cornell University in 2015. Before coming to Purdue, Ashwana completed a postdoctoral fellowship in the University of São Paulo, Brazil. Her research has focused on cellular pathways involved in how bacteria internalize information from their environment. She joined Dr. Lindemann's group in March 2017 and is working on analyzing causative agents and biomes of various disease states.

Fanny Gozzi is a registered dietitian and an undergraduate working to obtain her Bachelor of Applied Nutrition in France. In March 2018, she joined the Whistler Center in Dr. Hamaker's laboratory for a four-month internship as a Visiting Scholar. She worked with Ph.D. student Anna Hayes on the in vitro and in vivo slow digestion property of pearl millet. Upon completion of her bachelor's degree, she plans to pursue a master's degree in a related field.

Fangting Gu came to Dr. Hamaker's lab in August 2018 as a visiting scholar from Yangzhou University with funding from both the Chinese government and Yangzhou University. Her M.S. research focuses on the relationship between fiber and microbiota.

Fei Jia earned his B.S. degree from the College of Food Science and Nutritional Engineering in China Agricultural University. He obtained his M.S. degree from the Department of Food Science and Technology of Jiangnan University. He started his Ph.D. study in Processing and Storage of Agriculture Products in China Agricultural University in September 2014. He joined Dr. Kokini's group as a visiting scholar in November 2016. His research focuses on the development of rapid detection method for allergens and foodborne pathogens.

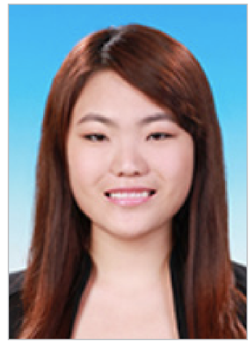
Nida Kanwal is a native of Faisalabad, Pakistan, where she was born and raised. She graduated with a BS and MS in Food Technology from University of Agriculture, Faisalabad, Pakistan. She is earning her Ph.D. from University of Agriculture, Faisalabad. She joined Purdue University as Visiting Scholar for 6 months beginning October 2018. Her research focuses on characterization of Pakistani-grown barley varieties for their nutritional attributes and for preparation of value-added baked products using wheat barley composite flour.

Dandan Li received her B.S. in Food Science and Engineering from Northeast Forestry University in 2013. Then she went to Jiangnan University to pursue her M.S. and Ph.D. degrees in Food Science and Engineering. The research topic of her M.S. and Ph.D. is continuous-flow, electro-assisted degradation of polysaccharides with different charges. She joined Dr. Jones's group as a visiting scholar in August 2017 to study the interaction between polysaccharides and proteins.

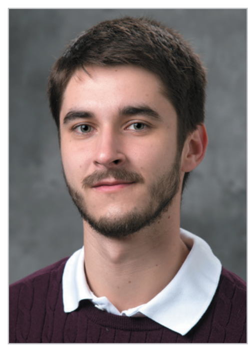
Jingpeng Li received a M.S. in Food Engineering from Guizhou University in 2015, and she is now a Ph.D. candidate in Jiangnan University under Professor Zhengyu Jin. She studied the extrusion technique of coarse cereal particles for UHT milk as a master before working on the orientation degree and instant cooking methods of enzymatic extruded noodles during her doctoral period. Additionally, part of her work is about to model and quantitatively determine cooking doneness and rapid fermentation process of vegetables. Jingpeng is currently a visiting scholar in Dr. Campanella's lab to conduct research related to molecular dynamics simulation and rheology of carbohydrate.

Santiago Ramirez Lopez visited Dr. Jones' lab from March through June 2018 from Lund University. He is currently a Doctoral student in the Department of Food Technology.

Mickael Martins is a registered dietitian and an undergraduate working to obtain his Bachelor of Applied Nutrition in France. He joined Dr. Hamaker's lab group in March 2018 for a four-month internship as a Visiting Scholar. He works with Ph.D. student Jongbin Lim on effects of galloyl groups on starch digestibility and its physico-chemical property. Upon completion of his bachelor's degree he plans to pursue a master's degree in a related field.



Zhang Mengke earned her B.E. degree from the Department of Food Science and Engineering at Fujian Agriculture and Forestry University in July 2011. She obtained her M.S. degree from the Department of Food Science and Nutrition Engineering of China Agriculture University in June 2013. She started Ph.D. study in Food Science at Jiangnan University in September 2013. The research topic of her Ph.D. study is the preparation of a cyclodextrin supramolecular nanoparticle based on click chemistry as a drug delivery system. She joined Dr. Narsimhan's group as a visiting scholar in August 2016 to conduct molecular dynamics simulation of complexation of alamethicin with cyclodextrin.



Hans Muller visited Dr. Campanella's lab from January through June 2018 during his post-graduate studies in food engineering at Universidade de São Paulo.

Anam Nasir joined Dr. Lindemann's lab in February 2018 as a Visiting Scholar with support from International Research Support Initiative Program (IRSIP), Pakistan. She is a Ph.D. candidate at National Institute for Biotechnology and Genetic Engineering (NIBGE), Pakistan. Her interests focus on the production of prebiotics and their health benefits. She obtained her master's and bachelor's degrees from Government College University, Faisalabad (GCUF), Pakistan. Her project at Purdue focuses on the structural differences in microbial glycans and their effect on human colonic microbiota.

Selvin Gerardo Artica Ortega was a Zamorano intern with the Department of Food Science in Dr. Yao's lab from January through April 2018.

Marianna Tagliasco earned her bachelor's degree in Food Science and Technology in July 2016 from the University of Parma. In March 2018, she joined the Whistler Center with Dr. Campanella's group for a six-month internship as a Visiting Scholar. She is currently an M.S. student with research focusing on the rheological characterization of gluten-free dough made with extruded zein and different starches.

Denisse Lorena Rosales Velasco visited Dr. Lindemann's lab from January through April 2018. She studies Industrial Engineering at Central American University Jose Simeon Canas.

Shangyuan Sang received a B.S. (June 2012) and a M.S. (June 2015) in Food Science and Engineering from Jiangnan University under Dr. Bo Jiang. In September 2015, he started his Ph.D. study in Food Science and Engineering at Jiangnan University under Dr. Xueming Xu. The research topic of his Ph.D. is about the function of hen egg components during dough processing. He joined Dr. Narsimhan's group as a visiting scholar in August 2018 to conduct molecular dynamics simulation of complexation of egg yolk lipids with amylose.

Danli Wang is a visiting scholar from the Department of Food Science and Nutrition with the College of Biosystems Engineering and Food Science at Zhejiang University in China. She works in Dr. Hamaker's lab on starch modification and the measurement of its structures, properties and applications.

Lijie Zhu earned his B.S. degree from the College of Food Science at Shenyang Agricultural University in June 2009 and his Ph.D. degree there in June 2014. Now he is a faculty member at the College of Food Science and Engineering, Bohai University. He joined Dr. Narsimhan's group as a visiting scholar in September 2017, researching the effect of the structure of adsorbed protein layer in emulsion droplets on the loss of flavor.

Graduate Students

Miguel Alvarez Gonzales completed his B.S. in Food Science and Technology from the Department of Food Science and Technology at PanAmerican Agricultural School, Zamorano University. He is an M.S. student supervised by Dr. Yuan Yao. Previously, he worked on designing bioactive packaging materials for roll-to-roll manufacturing. Currently, he works on the characterization of carbohydrate polymers.

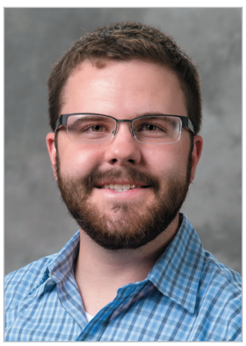
Ingrid J. Aragón Gallego earned her B.S. in Chemistry from Universidad del Valle, Cali, Colombia in 2009. Her undergraduate thesis was on the validation of in vitro methodology for evaluation of iron bioaccessibility in foods. Afterward, she joined the Nutritional Quality Laboratory (NQL) of the International Center for Tropical Agriculture (CIAT) (Palmira, Colombia) as a research assistant in 2009. In addition, she participated in the development of different research projects in the cassava and bean breeding programs at CIAT, focused on carotenoids and Fe/Zn biofortification of cassava and beans, respectively. In 2014, she joined Dr. Ferruzzi's lab as a Ph.D. student via a scholarship received through the Colombian government. She graduated in 2018 with her thesis on the nutritional and bioactive value of biofortified staple crops and native foods of Colombia.

Seda Arioglu-Tuncil received her B.S. in the Food Engineering Department at Ataturk University in Turkey in 2010. She was awarded a scholarship for her M.S. and Ph.D. degrees in the USA by the Turkish Government and joined Dr. Mauer's lab in January 2013 for her M.S. studies. Her project focused on the crystallization inhibitor properties of different polymers in bioactive amorphous solid dispersions. She completed her M.S. in December 2014 and earned her Ph.D. in December 2018.

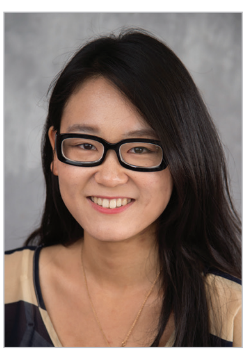
Emmanuel Ayua graduated from Moi University in December 2011 with a B.S. in Food Science and Nutrition, and M.Sc. in Community Nutrition from the University of Eldoret (both in Kenya). He joined Dr. Bruce Hamaker's lab in 2016 and is working toward a Ph.D. degree in Food Science. His research focuses are in effects of extrusion on fermentation of dietary fibers by the gut microbiome and extrusion processing in Kenya.

Emma Barber received her B.S. in Chemical and Biomolecular Engineering with a minor in Food Science from North Carolina State University in 2014. She joined Purdue in 2014, and completed her M.S. in Food Science with Dr. Kokini in 2018. Emma's research focused on optimizing a biodegradable corn protein platform for the spectroscopic detection of allergens and toxins.

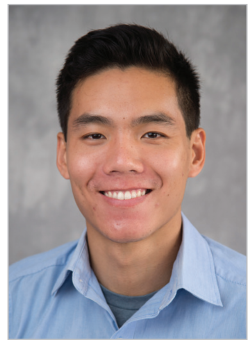
José Bonilla earned his B.S. in December 2014 from the Food Science Department at Zamorano University in Honduras. During the spring of 2014, he worked as Visiting Scholar in Dr. Yao's lab, using polysaccharides from starch to improve thymol solubility. In January 2015, he began studies for his doctorate in Dr. Kokini's lab. His Ph.D. research focuses on the use of inorganic fluorescent nano-probes (quantum dots) as an in situ labeling technique to study the distribution and rheological properties of cereal proteins.



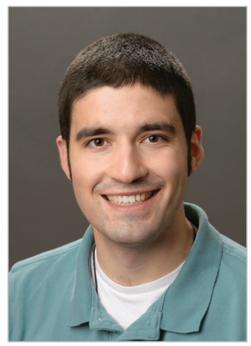
Nathaniel Brown received his B.S. in Biological and Agricultural Engineering and minor in Food Science from Kansas State University in May 2018. He has had various internships with companies like Bimbo Bakeries USA as a process engineer (2016) and McCormick & Company in Technical Innovation (summer, 2017 & 2018). He joined Dr. Campanella's lab in August 2018 in pursuit of a M.S. in ABE, conducting research on the interactions between rheology and interface science with microbubbles and applications in cleaning and sanitization.



Jingfan Chen graduated from the Food Science Department in 2015 is currently an M.S. student in Dr. Yao's lab. Her research primarily is on carbohydrate applications to improve the efficacy and bioavailability of active ingredients.



Christopher Cheng received a B.S. in Food Science from Purdue University in 2012. He then received an M.S. degree from North Carolina State University in Food Science in 2014, and his Ph.D. under Dr. Jones in 2018. His research focused on developing applications for zein, a protein derived from corn.



Dennis Cladis earned his B.A. in Chemistry and Mathematics from DePauw University in 2009. He completed his M.S. in synthetic inorganic chemistry at Purdue in 2012. From there, he discovered a passion for food science as a practical application of his chemistry and subsequently earned his M.S. in Food Science at Purdue in 2014, with his research focusing on fatty acid profiles and mercury content in fish. Currently, he is pursuing his Ph.D. under the direction of Drs. Ferruzzi and Weaver. His research examines the absorption, distribution, metabolism and elimination of natural plant polyphenols as well as screening toxicity of natural products.

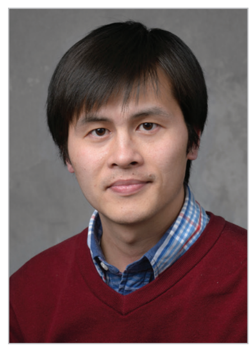
Sarah Corwin received her B.S. in Nutrition from Case Western Reserve University in Cleveland, Ohio, in 2013. She worked in Dr. Nathan Berger's laboratory in the Genetics Department at Case Western Reserve University after graduation, examining the effect of dietary fats on prostate malignancy, and then for Jenny Craig as a Personal Consultant in 2014. Sarah completed her dietetic internship through Indiana University-Purdue University, Indianapolis, with a capstone in Food Service Management. As a registered dietitian, she worked as a clinical dietitian for Hooverwood Home in Indianapolis. Sarah bypassed her M.S. degree and joined Purdue under Dr. Hamaker's advisement in 2016. She is working toward her Ph.D. in the area of slowly digestible carbohydrates.

Hawi Debelo earned her B.A. degree in Biochemistry from Manhattanville College, New York, in 2012. Following her undergraduate career, Hawi worked at PepsiCo Global Research and Development Center as a Product Development Technician. She spent two years at PepsiCo conducting research with Product Developers in innovation, formulation, and commercialization of Pepsi products. Hawi Debelo joined Dr. Ferruzzi's lab in 2014 as a Ph.D. student, where she works on a project to evaluate the stability, bioaccessibility and bioavailability of bioactive compounds from native African plant materials.

Gnana Prasuna Desam earned her B.Tech. degree in the Department of Agricultural and Food Engineering from Indian Institute of Technology, Kharagpur, in July 2014. She joined Dr. Narsimhan's group in June 2015 to pursue a Ph.D. degree in the Department of Agricultural and Biological Engineering and is working on prediction of swelling kinetics of waxy cornstarch and modified waxy cornstarch.

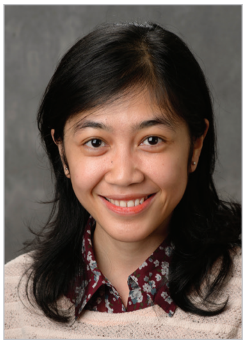
Aminata Diatta received a B.S. in Natural Sciences in 2002 and a pre-doctorate diploma in Chemistry and Biochemistry of Natural Products in 2006 from Cheikh Anta Diop University, Dakar, Senegal. She worked on the theme: "Characterization of three varieties of sorghum (S. bicolor), composition and aptitude to form rolled flour products." She joined Dr. Hamaker's group in fall 2015 and successfully defended her M.S. in May 2018.

Enrico Federici earned his B.S. degree in food science and technology in July 2014 from University of Parma. During work on his master's in food science and technologies at the University of Parma, he joined Dr. Campanella's lab as a visiting scholar for six months, working on a collaborative research project between Purdue University and the University of Parma. This contributed to the completion and defense of his M.S. thesis in October 2016. After working for 6 months as a research assistant at the University of Parma, Enrico joined Drs. Jones and Campanella's lab in August 2017 as a Ph.D. student. His research focuses on improvement of gluten-free products with the use of novel protein preparations and assemblies.

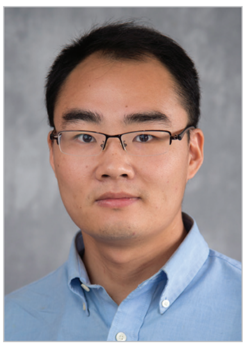


Xing Fei earned his B.S. in 2006 from Huazhong Agricultural University and his M.S. in Food Science from Guangdong Ocean University, China, in 2009. Xing earned his Ph.D. in Agriculture and Biological Engineering at Purdue in spring 2018. His research was on the mechanical properties of single molecules.

Collin Felten graduated from Brown University in 2015 with a B.S. in Chemical and Biochemical Engineering. He joined the Mauer lab in 2016 to pursue a M.S. in Food Science, which he earned in December 2018. His research dealt with screening for different salt forms of thiamine and characterizing the physical and chemical stability of amorphous thiamine in foods.



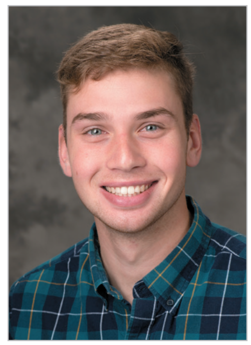
Maya Fitriyanti completed her B.S. in Microbiology from Bandung Institute of Technology, Indonesia, in 2008 and M.S. degree in Chemical Engineering from Bandung Institute of Technology, Indonesia, in 2012. She began her Ph.D. in the Agricultural and Biological Engineering Department at Purdue University in fall 2015 and joined Dr. Ganesan Narsimhan's research group. Her research focuses on development of a process for production of antimicrobial peptides (AMPs) from soybean.



Yezhi Fu received his B.S. degree in Food Quality and Safety and M.S. degree in Food Engineering, both from China Agricultural University, Beijing. He started his research in Dr. Yao's group as a visiting student in 2014 and now is pursuing his Ph.D. degree. His research focuses on designing antimicrobial coating to improve the safety of fresh and fresh-cut produce, using cantaloupe as a model.

Anna Hayes received her B.S. in Food and Nutrition Science and her B.A. in Spanish from Saint Catherine University (Saint Paul, Minnesota) in May 2014. Anna arrived at Purdue University in August 2014 and is studying for her Ph.D. Her research focuses on elucidating the locational delivery of carbohydrates in the small intestine and on determining the effects of particle size and viscosity on carbohydrate metabolism.

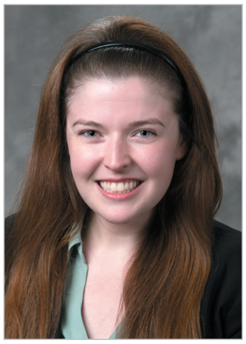
Marwa El Hindawy is from Cairo, Egypt. She obtained her Ph.D. degree with Dr. Hamaker in December 2018, and is now a post-doctoral research associate in his laboratory.



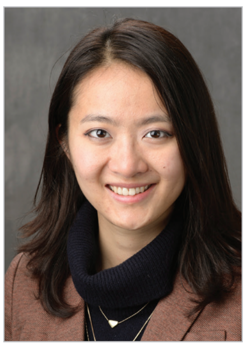
Drew Hirsch received a B.S. in Food Science from Purdue University in 2017. He then joined Dr. Jones' lab to continue his research and pursue an M.S, which he earned in December 2018. His research focused on the functionality of protein and chitin from crickets as ingredients for emulsion-based food products.

Rachel Jackson joined the Hamaker lab in 2016 to pursue an M.S. in Food Science. Her work focuses on technologies to increase gut fermentability of insoluble fibers and that relationship with microbiota and metabolite changes related to health.

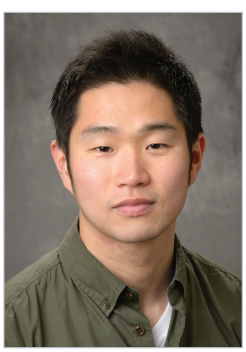
Enosh Kazem received his B.S. in Food Science from Purdue University in 2011. After graduation, he spent two years in medical school at Indiana University, and is now studying in Dr. Hamaker's group, where his research focuses on the role of fiber and microbiota in colon health.



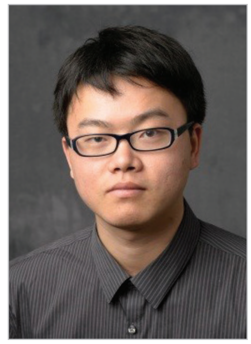
Alyssa Kelley received her B.S. in Nutritional Sciences from the University of New Hampshire in 2016. Subsequently, she completed a two-year research fellowship at the U.S. Army Research Institute of Environmental Medicine in Natick, Massachusetts. In 2018, she joined Dr. Jones's laboratory to pursue her M.S. in Food Science. Her research focuses on the glycosylation of zein as a method of improving its functionality and for incorporation into gluten-free doughs.



Jinsha Li completed her B.S. in Biosystem Engineering at Michigan State University in 2013. She joined Dr. Engelberth's group in August 2013. In July 2015, she successfully defended her M.S. thesis in Agricultural and Biological Engineering, titled "Adding value to bio-ethanol production: quantification and recovery of lutein and zeaxanthin from DDGS." In the same year, she started Ph.D. study with Dr. Narsimhan and has been working on the project "Prediction of swelling kinetics of waxy native maize starch." Jinsha is the recipient of the Fredrick N. Andrews Fellowship.



Jongbin Lim earned his M.S. degree in Food Science and Technology from Sejong University in South Korea. He joined Dr. Hamaker's lab group in August 2014 to begin his doctoral work. His research is on the moderation of starch digestion rate by inhibition of digestion enzymes and the development of glycemic carbohydrates to digest in the ileal region of the small intestine for stimulation of physiological feedback systems.



Dongdong Ma received a B.S. degree in Food Science from Purdue University in 2013. He is currently completing his M.S. in Agricultural and Biological Engineering. Dongdong is characterizing the rheology of complex materials and in particular its effects on the processing of these materials, including baking and drying. He is also specializing on numerical methods to characterize phenomena of heat and mass transfer through viscoelastic materials such as biofilms.

Luis Maldonado received his B.S. degree in Food Science and Technology from Zamorano University, Honduras. His undergraduate research focused on the evaluation of the pasteurization temperature and final acidity on the stability of calcium and vitamin D in yogurt. Before coming to Purdue, he worked for 3 years as a technical advisor for food processing companies in Honduras. He joined Dr. Kokini's lab in fall 2013 and completed his Ph.D. research focused on the characterization and encapsulation of bioactive compounds with nanomaterials in August 2018.

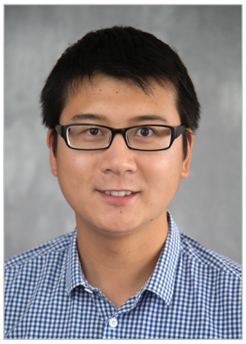
Morgan Malm received her B.S. degree in Food Science from Purdue University in May 2016. She first joined Dr. Kokini's group as an undergraduate student in August 2014 and focused on the characterization of proteins. In June 2016, she transitioned into the Purdue Food Science M.S. program to continue her work with Dr. Kokini's group and has since received approval to bypass to the Ph.D. program. Morgan will continue her research on functionalizing proteins for the application of a platform for the detection of allergens and toxins.

Moustapha Moussa rejoined Dr. Hamaker's group in June 2016 to pursue his Ph.D. in Food Science. His research areas focus on grain chemistry and processing with the objective of use extrusion and nutrition-related technologies to better utilize and expand markets of local-based sorghum and millet grains. He received his M.S. in Food Science from Purdue University in 2007. Along with Dr. Hamaker, he successfully helped to implement the Food Processing Incubation Concept to backstop grain-based food technology development and scaling-up with nutrition and market emphasis in urban and rural areas in Niger and West Africa.

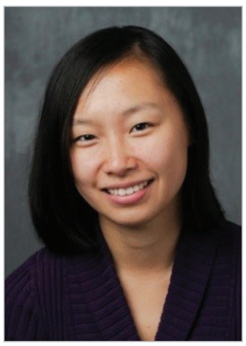
Cheikh Ndiaye received a B.S. in Physics and Chemistry from Cheikh Anta Diop University, Dakar, Senegal. A pre-doctorate diploma in Chemistry and Biochemistry (equivalent to M.S.) was obtained from the same university in 2004. In 2009, an M.S. in Food Science and Technology was obtained from Jiangnan University, China. He has worked for the Institute of Food Technology (ITA) in Dakar since 2003, and is a member of the Cereals and Leguminous Vegetables Department. He joined Dr. Ferruzzi's lab after receiving a fellowship from the ERA USAID project to study biofortification of extruded cereal products using native African plant materials as biofortification agents. He is now part of the USAID Food Processing Innovation Lab and finished his Ph.D. in May 2018.

Smith G. Nkhata completed his B.S. in Nutrition and Food Science from Bunda College of Agriculture, University of Malawi, in 2007 in Malawi. He later joined the Government of Malawi through the Ministry of Agriculture and Food Security in 2009 as a Food and Nutrition Specialist, a post he holds to date. In 2011, he was admitted at Michigan State University, where he completed his M.S. degree in Food Science in 2013. He joined Drs. Ferruzzi and Hamaker's groups in August 2015 to pursue his Ph.D. in Food Science. His research area is in part on provitamin A stability during processing, in vitro bioaccessibility and bioavailability of provitamin A from maize-based products.

Gabriella Mendes Candido de Oliveira received a B.S. in Food Engineering (five-year degree) from the University of São Paulo, Brazil, in 2013. She has been a recipient of several scholarships from the Brazil government and the Exchange Program between the University of São Paulo, University of Illinois, and Purdue University. In fall 2011, she attended classes at the Food Science and Human Nutrition Department, University of Illinois. In 2013, she was selected for placement in a Ph.D. program in the United States under the program Science Without Borders. She arrived at Purdue in fall 2014. Her research focuses on novel processing technologies from an experimental and modeling standpoint. She works with Dr. Campanella.



Xingyun Peng received his B.S. degree in Food Science and Engineering from China Agricultural University, Beijing, in 2011 and his M.S. degree in Cereal, Oil and Vegetable Protein Processing from the same university in 2014. He studied protein-oil interactions in soymilk processing during his M.S. program. He obtained his Ph.D. at Purdue in fall 2018 under the direction of Dr. Yao, with his research focusing on novel properties of starches associated with food applications.



Elizabeth Pletsch received her B.S. in Food Science and Human Nutrition from the University of Illinois at Urbana-Champaign in December 2011. She worked for Hillshire Brands Co. (formerly known as Sara Lee) until coming to Purdue University in August 2012. She bypassed her M.S. degree and completed her Ph.D. degree under Dr. Hamaker on physiological effects of glycemic carbohydrates.

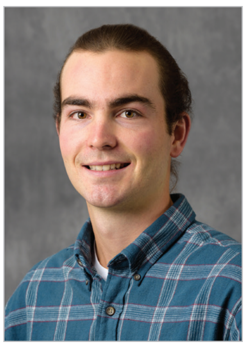
Angarika Rayate received her bachelor's in Chemical Engineering from University of Mumbai in 2015. She started the M.S. program in spring 2016 at Purdue University and graduated in August 2018. Her research focused on the interaction between dairy proteins and polysaccharides in dilute and concentrated systems.

Rándol Rodríguez obtained his B.S. degree from the Food Science Department of Zamorano University, Honduras. He worked with Dr. Yao on the structure and function of carbohydrate particulates, and obtained his Ph.D. degree in August 2018.

Arianna Romero Marcia joined Dr. Lindemann's lab in January 2018. She is working to obtain her M.S. in Food Science. Her interests focus upon interaction of starch and starch-derived carbohydrates with the gut microbiota and overall health. She obtained her bachelor's degree from Zamorano University, Honduras. Her project at Purdue aims to uncover how the structure of resistant dextrins influences the community structure and metabolic output of fermenting microbiota.

Tahrima Binte Rouf completed her B.S. in Chemical Engineering from Bangladesh University of Engineering and Technology (BUET) in 2012 in Bangladesh. After graduation and before joining Dr. Kokini's group in August 2014, she was a lecturer in the department of Chemical Technology at Ahsanullah Institute in Bangladesh. She is now pursuing a Ph.D. degree in Food Science. Her research mainly is on the functionalization of biopolymers using different nano-materials.

Leigh Schmidt earned her B.S. in Food Science from Purdue in 2003 and her M.S. in Food Science from UC Davis in 2009. She joined Dr. Hamaker's lab group in August 2013 as a USDA National Needs fellow for Foods and Health. Between degrees, Leigh worked in the food industry in quality and product development roles. Her Ph.D. research is on food protein matrices as a method to slow starch digestion.



Patrick Sweet graduated from Saint Mary's University of Minnesota in May 2015 with a B.A. in Biochemistry. He joined the Weil Lab in May 2016 and earned his M.S. degree in the fall of 2018. His research focused on cell wall composition in sorghum.

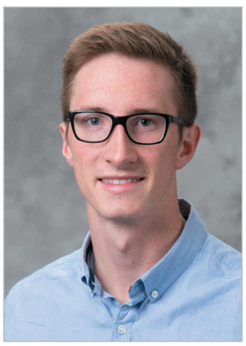
Geraldine M Tembo completed her B.S. degree in Food Science and Technology at Botswana College of Agriculture (now Botswana University of Agriculture and Natural Resources) in 2015. In 2018 she received a Fulbright scholarship to join Dr. Josef Kokini's lab to pursue her master's degree.

Riya Thakkar is a graduate student working to obtain her M.S. in Food Science. Her area of interest is Food Microbiology. She obtained her undergraduate degree, Bachelor of Technology in Biotechnology, in May 2016 from D.Y. Patil University, India. She worked as a research intern at Bhabha Atomic Research Center toward her thesis as an undergrad. Her research there was related to finding the effects of natural food compounds on tuberculosis. She has also worked as a Research Assistant at the Indian Institute of Technology, Bombay, where her study was related to nanoparticles on post-operative bone infections. She started her master's degree under Dr. Stephen Lindemann's laboratory at Purdue University in January 2017. Her work here focuses on the effect of particle size of food on the colonic microbiota.

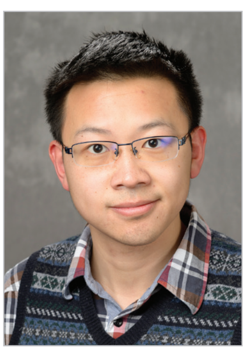
Pablo Torres-Aguilar received his M.S. in Nutritional Sciences from the University of Illinois at Urbana-Champaign, where his research focused on food insecurity and the impact of environmental factors on the diet of underserved groups, both in the U.S. and internationally. He joined Dr. Hamaker's group in the fall of 2014 and is working toward completing his Ph.D. degree.

Hazal Turasan completed her B.S. degree in Food Engineering at Middle East Technical University in 2011 in Turkey. She completed her M.S. degree in the same department. She focused on encapsulation of rosemary essential oil. After receiving a Fulbright scholarship in 2014, she joined Dr. Kokini's group for her Ph.D. studies.

Adrienne Voelker graduated from the University of Notre Dame in 2016 with a B.S. in Chemistry. She joined Dr. Lisa Mauer's lab group in 2016 to pursue her M.S. in Food Science and has since received approval to bypass to the Ph.D. program. Adrienne's current research focuses on improving thiamine delivery in foods by studying its physical and chemical stability in its amorphous form in different formulations, and she has taken a leading role in a project exploring the use of sucrose crystallization inhibitors.

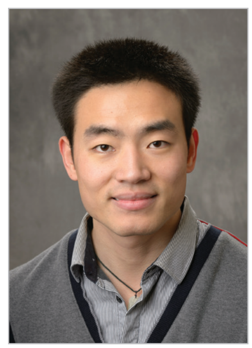


Travis Woodbury received his B.S. in Food Science from Brigham Young University-Idaho. He's had internships working QA for a gourmet dip company, production for a dairy manufacturer, and QC for an onion distributor. He previously worked as a lab assistant for Dr. Kerry Huber, a Ph.D. alumnus from Purdue and the Whistler Center. He's currently working on his M.S. in Dr. Mauer's lab researching the effects of various oligosaccharides on starch structure-function.



Tianming Yao obtained his B.S. in Food Science and Technology from Shanghai Jiao Tong University, China. His undergraduate research was on the OSA modification of small granule starches. He joined Dr. Janaswamy's group in August 2015 as a master's student with support from China Scholarship Council (CSC). His research focused on the interaction between polyphenols and starches. Tianming is now a Ph.D. student with Drs. Lindemann and Hamaker and works on dietary fiber and the gut microbiome.

Ximena Yepez received a B.S. degree in Food Engineering from Escuela Politécnica del Litoral, Guayaquil, Ecuador. In 2012, she joined the Food Technology and Development Laboratory under Dr. Keener in the Department of Food Science. She focused on the effect of high voltage atmospheric cold plasma (HVACP) treatment in modifying vegetable oil chemistry. She obtained her M.S. degree in Food Science from Purdue University in 2014. She joined Dr. Kokini's research laboratory in Food Science, where her research is focused on the study of HVACP as a catalyst in chemical reactions. She earned her Ph.D. in December 2018.



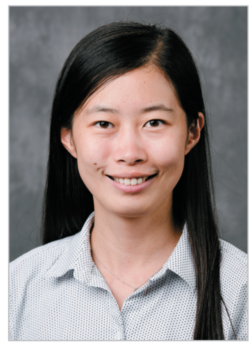
Xiaowei Zhang received B.S. and M.S. degrees from the Department of Food Science and Engineering at Shanghai Jiao Tong University, China. He joined Dr. Hamaker's group as a Ph.D. student in August 2014. Xiaowei's research project focuses on dietary fiber structure-function relationships with the colon microbiota and health.

Ph.D. Post-Doctoral Research Associates

Matthew Allan received a B.S. in Food Science from Washington State University in 2012 and received a M.S. (2014) and a Ph.D. (2018) in Food Science from Purdue University under Dr. Lisa Mauer. His graduate research focused on deliquescence, developing crystal hydrate phase diagrams, and investigating the effects of sugars on gelatinization. He was also the recipient of the James and Pari BeMiller Graduate Scholarship. Matthew is currently a Postdoctoral Research Associate in Dr. Lisa Mauer's lab, funded by a NIFA grant to research the effects of sugars and salts on starch retrogradation.

Thaisa Cantu-Jungles received her B.S. in Nutrition from the Pontificia Universidade Católica do Paraná (Brazil). She earned her M.S. and Ph.D. in Biochemistry at Federal University of Paraná (Brazil). In 2015 she joined Dr. Hamaker's group as a visiting scholar for a year to conduct part of her Ph.D. research. Her research has focused on the structural characterization of dietary fibers from fruits and its applications in the biological field. In 2018 she rejoined Dr. Hamaker's group as a postdoctoral researcher in the area of dietary fiber fermentation by the gut microbiota.

Ming-Hsu Chen received his Ph.D. degree in Agricultural and Biological Engineering from the University of Illinois in 2015. His research has focused on bioactive carbohydrates manufacturing as well as characterization and elucidation of structural-functional relationships. Before coming to the U.S., Ming-Hsu obtained his M.S. and B.S. degrees in Microbiology and Biochemistry from National Taiwan University. Additionally, he had one year of work experience at Academia Sinica studying fungal secondary metabolites, carbohydrate recognition proteins and lymphocyte maturation. He joined Dr. Lindemann's group in August 2017 and is interested in exploring the interactions among carbohydrates, gut microbiota and human health.



Fang Fang received her Ph.D. in 2017 with Drs. Campanella and Hamaker on starch amylopectin thickening and molecular aggregation properties with shear. She rejoined their groups in the fall of 2018 as a Postdoctoral Research Associate and works on industrial projects related to carbohydrate structure and function.

Alpana Thorat received a Bachelor of Pharmacy degree from Pune University in 2006, and Masters of Technology in Pharmaceutical Technology–Biotechnology from National Institute of Pharmaceutical Education and Research (NIPER Mohali, India) in 2008. She worked in the pharmaceutical industry for one year (senior research chemist in Sai Life Sciences, Pune-India). In 2010, she joined the Ph.D. program in Chemical Engineering at the Indian Institute of Technology, Gandhinagar, India. Her thesis work focused on crystallization and polymorphism of curcumin. She joined Dr. Mauer's lab (jointly working with Dr. Lynne Taylor from IPPH, Purdue University) in September 2015 and worked on understanding the amorphization of sugars.

Whistler Center Staff

Katherine Fry joined the Whistler Center as the Center's coordinator in February 2018. Before joining the Center, Katherine worked in supply chain management with Purdue's Strategic Sourcing Department, and in content marketing and sales management at a locally owned retail store. She received her bachelor's degree in foods and nutrition in business from Purdue University in 2015.

Bhavesh Patel received a B.S. degree in Dairy Technology from Gujarat Agricultural University, Anand, India, and an M.S. degree in Food Technology from Central Food Technological Research Institute (CFTRI), Mysore, India. His Ph.D. in Food Science is from Pennsylvania State University, where his research involved study of starch and polysaccharide structures and the effect of processing conditions on thermal and physical properties. Bhavesh joined Drs. Campanella and Hamaker's groups in 2008 and has worked on the development of processes for isolation of corn fiber polysaccharides and enhancing their functional properties. He also has worked on fiber rheology and incorporation into processed foods and gel formation kinetics. Dr. Patel worked on a project related to enzymatic conversion of complex polysaccharides into useful industrial and food products. Currently he conducts short-term research projects for the Whistler Center member companies.

Anton Terekhov is proficient in analytical chemistry, molecular biology techniques and analytical instruments such as NMR, GCMS, LCMS and FTIR. Anton has more than 10 years of experience in an interdisciplinary laboratory environment, including the fields of analytical chemistry, microbiology, genetics, geology and chemical and civil engineering. His main research area is carbohydrate analysis using above-mentioned analytical instruments. He is Director of Analytical Services for the Whistler Center.

Our People, Our Projects

Campanella

1. Industrial Processing Properties of Tomato Products
2. Modeling Inactivation Parameters of Spore Cells Subjected to Cold Plasma and Other Non-Thermal Processes
3. Modeling the Microbial Community in the Gut: The Basics
4. Using Molecular Dynamic (MD) Simulation to Understand the Stability of Amylose-Free Fatty Acid Complex
5. Innovative Green Clean-in-Place Technology with Micro-bubbles

Ferruzzi

6. Impact of Phytochemicals on Starch Digestion and Intestinal Glucose Transport

Hamaker

7. Fabrication of Dietary Fibers for Novel Functions in the Gut
8. *In Vitro* Gut Fermentation Studies on Dietary Fibers and their Modification
9. Investigations on Slowly Digestible Glycemic Carbohydrates
10. Cellular and Physiological Response Studies of Glycemic Carbohydrates with Slow Digestion Profiles

Jones

11. Physical Stability of Suspensions Containing Polysaccharides and Colloidal Proteins
12. Stabilization of Oil-in-Water Emulsions by Whey Protein Microgels
13. Emulsification Properties of Polysaccharide and Protein Fractions of Crickets
14. Effect of Protein Conjugation on Protein-polysaccharide Interactions
15. Protein Fibrous Structures as Physical Simulacrums of High-MW Glutenin

Kokini

16. Simultaneous Fluorescent Detection of Gliadins, LMW, and HMW Glutenins in Wheat Dough Samples Using Antibodies-Quantum Dots Complexes as Imaging Tools
17. Fabrication of Biodegradable Protein-Based Surface Enhanced Raman Spectroscopy Platforms for the Detection of Food Allergens and Toxins Characterizing the Surface and Mechanical Properties of Zein Films
18. Fabrication of Antimicrobial Kafirin Nanofibers Encapsulated with Essential Oil Phenols for Food Packaging Applications
19. Effect of Contact Surface, Plasticized, and Crosslinked Zein Films are Cast On, on the Distribution of Dispersive and Polar Surface Energy Using the Van Oss Method of Deconvolution Effect of Aging Time and Temperature on the Non-Linear Rheological Properties and Secondary Structure of Different Flour Dough Samples
20. Zein- and Kafirin-Based Nanocomposites for Biodegradable Packaging
21. Effect of Aging Time and Temperature on the Non-Linear Rheological Properties and Secondary Structure of Different Flour Dough Samples

Lindemann

22. Establishment of Model Dietary Fiber-Consuming Gut Microbial Communities for Generalizable Fiber-Microbiota Research
23. Particle Size Effects on Bran Fermentation by Gut Microbiota
24. Bran Arabinoxylan Chemical Structure Effects on Fermentation by Gut Microbiota
25. Differential Fermentation of Resistant Dextrins by Gut Microbiota

Mauer

26. Starch Properties in Different Environments
27. Amorphous Solid-State Dispersion (Amorphization) of Crystalline Ingredients
28. Water-Solid Interactions and Phase Diagrams

Narsimhan

29. Prediction of Swelling Behavior of Crosslinked Maize Starch Suspensions
30. Volume Fraction Dependence of the Elastic Behavior of Starch Suspensions
31. Synergistic Effect of Low Power Ultrasonication on Antimicrobial Peptide Action
32. Pore Formation in Phospholipid Bilayers by Antimicrobial Peptide
33. Nucleation and Growth of Pores in 1,2-Dimyristoyl-sn-glycero-3-phosphocholine (DMPC) / Cholesterol Bilayer by Antimicrobial Peptides Melittin, its Mutants and Cecropin P1

Yao

34. Using Molecular Rotor to Detect the Supramolecular Structure of Amylopectin and Phytoglycogen
35. Visualization of Starch Retrogradation using Molecular Rotor
36. Phytoglycogen and its Derivatives to Improve the Solubility of Poorly Water-Soluble Active Ingredients
37. Micro-Analysis of Starch Materials
38. Pathogen Biofilm Reduction at the Surface of Fresh Produce

Project Summaries

1 Industrial Processing Properties of Tomato Products

P.I.: O. Campanella, B. Reuhs

Researcher: Xing Fei, Ph.D.

Collaborators: O. Jones

Objectives: The central hypothesis of this study is that the rheological properties of cell wall suspensions are determined by the properties and interactions between plant derived particles forming those suspensions. Two important variables are considered to affect the rheology of these suspensions. One is the particle concentration in the suspensions and the other is the physical properties of the particles. Results of this research are challenging a long-assumed hypothesis concerning the processing of tomatoes and other plant-derived products and have demonstrated that products with better sensory characteristics and suitable viscosities can be produced without the need of using high energy demanding processes. In these processes, although the product viscosity is maintained the sensory characteristics of the products are negatively affected. Four specific objectives were pursued in this research:

1. Determine the effects of soluble pectin on the viscosity of serum and suspensions.
2. Determine the effects of pectin on the tomato particle properties.
3. Determine the effects of processing conditions on the tomato particles and the rheological properties of the tomato suspensions.
4. Determine the rheological behavior of industrially processed tomato suspensions under different processing conditions and analyze the causes why the viscosity of tomato products is reduced upon concentration and reconstitution.

Progress: Understanding the relationship between structure and rheological properties of plant-cell-wall derived foods has become a growing interest to both academia and industry. Rheological properties of vegetable suspensions, a key functional attribute of these products, depend on both the serum and the particle phases of the suspensions. Although recent studies on other plant-based materials have suggested that the particle phase is the dominant factor, the relationship between fundamental particle properties and the bulk rheology of the suspension is still unclear. This research evaluated systematically the contributions of soluble pectin and particle phase on the rheology of tomato suspensions and identified that the structure of the particle and its physical properties are crucial in determining the rheology of such systems. Alteration of these particle properties either by processing conditions or by internal enzymatic activity could cause a significant change in the rheology of tomato products. Tomato products consist of suspensions made of tomato particles in a medium composed by a water solution of soluble carbohydrates, such as pectin and simple sugars. In order to study the influence of the main parameters affecting these systems, the rheology of reconstituted suspensions of tomato pulp in different solutions of pectin with different concentrations was determined. Specifically, the focus of the research investigated the influence of the pectin content and the pectin chemical properties, including its degree of methoxylation (DM) on the rheological properties of the suspensions. The rheological properties of the reconstituted suspensions were characterized by the technique commonly used in the industry such as Bostwick instrument and by rotational rheometry. The different pectin solutions, i.e., the suspension media, exhibited simple Newtonian behavior and their viscosities increased with increasing DM and pectin content. However, all reconstituted tomato suspensions revealed shear thinning behavior and that the amount of soluble pectin in the medium has practically no effect on the suspension viscosity whereas the concentration of particles and the mechanical properties of the particles were the dominant factor. Other results obtained in this work concerned with the methods used to characterize the suspensions. Tomato suspensions are complex systems that require extreme care when tested using standard rheometry. For example, use of standard geometries such as cone and plate and parallel plates geometries, significant wall slip was observed due to phase separation in the suspension. The phenomenon was even more noticeable when the pectin content was low. Results found allowed us to conclude that pectin plays an important role on their stabilization by increasing the interaction between particles. By using the vane geometry, which is able to reduce slippage effects, the consistency index k was highly correlated to industrially employed measurements such as the Bostwick test

(R^2=0.91). The effects of thermal breaking and physical treatments such as ultrasound and high shear were employed at the laboratory scale. Part of this work also involves industrially processed products. The effects of the concentration process to produce tomato paste from tomato juice at an industrial scale was also investigated to elucidate the effects of the concentration process on the properties of the particles and the rheology of the suspensions when they are reconstituted from paste to juice. Ultrasound and high shear treatments reduced significantly the particle size of the treated tomato suspensions, the former leading to an increase in their viscosities whereas the latter to a significant decrease in their viscosities. Results were explained by formation of particles with structural differences which were provoked by these two different treatments. Ultrasound treated suspensions contained more intact particles, and a large strength, which was evaluated by a compression test on a limited number of particles. Conversely, high shear treated suspensions resulted in mostly ruptured particles that lost mechanical strength. The water-soluble pectin (WSP) fraction increased after ultrasound and shear treatments. However, as discussed above soluble pectin is not the direct cause for the changes in the rheology of the suspensions; instead these changes are a consequence of changes in the particle properties.

2 Modeling Inactivation Parameters of Spore Cells Subjected to Cold Plasma and Other Non-Thermal Processes

P.I.: O. Campanella

Researcher: Gabriella Mendes Candido de Oliveira, Ph.D. student

Collaborators: F. San Martin, A. Deering (Food Science), A. Garner (Nuclear Engineering)

Objectives: Previous work has focused on the use of plasma technology to inactivate spores in model liquids. A model was developed considering the variable concentration of the sterilizing gas species, and the model was validated with experimental results on spore inactivation. Microwave also offers a potential alternative to pasteurizing fruit juices with minimum deterioration of physicochemical and sensory qualities. The following objectives in the microwave area were:

1. To investigate the effect of microwave pasteurization on the inactivation of target microorganisms in apple juice. More specifically, *Escherichia coli* O157:H7 and *Salmonella* Typhimurium were the target microorganisms under investigation, because they are well-known foodborne pathogens and frequently cause food poisoning outbreaks;
2. to describe the inactivation kinetics of these microorganisms using microwave heating to pasteurize apple juice achieving temperatures of 80° to 90°C for 30s as these process conditions are like the reported heating protocols for conventional pasteurization methods for apple juice;
3. to develop a reliable model that enables describing the kinetics of inactivation of these microbial cells under realistic microwave pasteurization conditions in real apple juice, and
4. to compare the ability of the proposed modeling approach to predict the resistance of the reference microorganisms to achieve 5 log10 reduction in both commercial and fresh apple juices.

Progress: Application of microwave, an appealing alternative technology to conventional pasteurization, is being considered. Microwave heating differs from conventional heating due to its capacity to dissipate energy inside the product through the interaction of microwave radiation with water molecules. This interaction heats the food rapidly due to the internal heat generation that takes place in parallel with convection and conduction phenomena. Conventional processing relies on heat transferred from external heat sources, which often requires a long heating time resulting in deleterious effects of food qualities and nutritional attributes. Work on microwave heating of fruit juices and the resulting microbial inactivation was conducted during the period October 2017 through December 2017. During 2018 most of the work focused on completing the work in microwave and the start and experimental completion of Pulsed Electric Field (PEF). The latest work was completed at Eastern Regional Research Center USDA, Wyndmoor, PA.

The microwave study involved the inactivation kinetics of Escherichia coli O157:H7 and Salmonella Typhimurium under microwave pasteurization at temperatures between 80 to 90°C, i.e., at conditions similar to conventional pasteurization. Inoculated juices were treated at different power levels (600W, 720W) and treatment times (5s, 10s, 15s, 20s, 25s). Time-temperature profiles were obtained by fiber-optics sensors in contact with the samples allowing continuous data collection. The log-logistic and Arrhenius equations were used to quantify the impact of the temperature history; thus, yielding two modeling approaches that were compared for validation purposes. The survival ratio under non-isothermal conditions was estimated by the numerical solution of a non-linear ordinary differential Experimental runs were performed on fresh apple juice and validated on commercial apple juice. Results indicated that inactivation increased with power level, temperature, and treatment time reaching up to 7 Log10 cycles. The study is relevant to the food industry because it provides a quantitative tool to predict survival characteristics of pathogens at other processing conditions.

3 Modeling the Microbial Community in the Gut: The Basics

P.I.s: O. Campanella, J. Welti-Chanez (Tecnologico de Monterrey, Mexico)

Researcher: Viridiana Tejada Ortigoza, visiting postdoc (Tecnologico de Monterrey, Mexico)

Collaborators: Bruce Hamaker

Objectives: To understand the nature of microbial communities' interactions and how these might impact the host's health (or disease).

Progress: An article is being written that revises some of several approaches being considered to model microbiota dynamics; they include:

1. the microorganisms, where individual parameters (such as growth rate), species present in the community and the interactions between the microorganisms (mutualism, commensalism, neutral) are considered.
2. the molecular, where the metabolite production (e.g. SCFA and vitamins) and consumption, as well as their physical parameters such as diffusion of nutrients through the microbial species or vice versa are considered, and
3. the host, by considering the environment provided to the microbial community (diet) and how this affects the presence or absence of specific species, and the nutrient production and diffusion through the host.

The use of several mathematical models involving computational analyses are being reviewed. These methods are based on parameters obtained experimentally through *in vitro* or *in vivo* studies. More recently, the *in-silico* perspective has taken advantage of metagenomics to extend the analysis of the microbiota dynamics using a genomic view by using GEMs (Genome-Scale Metabolic Models), but also through dynamic models to reconstruct biological networks. The work of different modeling groups has been identified and is being reviewed. The use of very complex models also requires the input of many parameters which would complicate their application in a practical way. The main goal of the review is to identify general model(s) where general rules might be applied to gain practicality to model the microbial community in a pragmatic way by simplifying the use of this information not only for the scientific community but also for the industry.

4 Using Molecular Dynamic (MD) Simulation to Understand the Stability of Amylose-Free Fatty Acid Complex

P.I.s: O. Campanella, X. Zhu (Research Computing, Rosen Center for Advanced Computing, Purdue University)

Researcher: Lilin Cheng, completed

Collaborator: B. Hamaker

Objectives: The main objective of this project was to study the complexation of an amylose fragment and linoleic acid molecules and to monitor conformation changes of the amylose fragments and the location of the different linoleic acid molecules in the amylose fragment hydrophobic cavity.

Progress: Given its importance in food and pharmaceutical applications, the complexation of amylose with amphiphilic molecules (ligands) such as linoleic acid was theoretically investigated using Molecular Dynamics (MD). Most of MD studies have involved only single molecules as the guest. In this work, MD simulation was utilized to study the complexation process when more than one linoleic acid molecule is complexing with an amylose fragment. Results showed that the amylose fragment complexed with linoleic acid to form a V-type structure, and more glucose residues participated with an increasing number of linoleic acid molecules. Intra-molecular hydrogen bonds were the main interactions stabilizing the formation of the amylose helical structure. The preferred location of the linoleic acids molecules was in the central region of the amylose fragment, which favored the fluctuation of the two terminal regions of the complex in a larger extent than the central region. In addition, like when a single linoleic acid molecule is considered, the aliphatic tails of the linoleic acid molecules complexed with the hydrophobic cavity of the amylose fragment and the carboxyl heads were exposed to the polar water molecules.

5 Innovative Green Clean-in-Place Technology with Micro-bubbles

P.I.s: O. Campanella, C. Corvalan

Collaborator: J. Lu

Objectives: The general objective of this project is to use microbubbles to clean fouled surfaces of processing equipment. A model is being developed to further understand the mechanisms of fouling material detachment and separation by microbubbles. Work is being also done to study the coalescence and stability of the microbubbles. Specific objectives are the following:

1. Modeling
    - Validate model with experiment
    - Investigate bubble coalescence in a Non-Newtonian fluid
    - Investigate bubble coalescence involving surfactant
2. Experiments
    - Perform experiments to explore interactions and cleaning by microbubbles on a micro scale

Progress: It is important to understand the different mechanisms of bubble coalescence in cleaning. These mechanisms are affected by the outer-fluid rheology, bubble size ratio, and bubble interfacial surface tension gradient. A model has been developed using the Finite-Element Method (FEM). FEM results compared with data from the literature have shown that closely follows experimental values for bubble neck, r_b (meniscus joining coalescing bubbles) radius growth over time. Experimental data found in the literature were determined by a high-speed camera. The model follows experiments done with both inviscid and viscous materials and confirmed the scaling experimentally determined by Paulsen et al. as $r_b \sim t^{1/2}$. By investigating bubbles coalescing in a Non-Newtonian outer-fluid it was found the growth of the coalescing neck radius followed a scaling of $r_b \sim t^{n/2}$. Where n is the flow index of the non-Newtonian fluid. Knowing this scaling allows for further understanding of the phenomena and provides tools to predict coalescence time based on the flow index of the outer-fluid. With the addition of a surfactant to bubble coalescence there is an added Marangoni stress caused by the gradient of surface tension. The interactions between micro bubbles with and without surfactant that are associated with cleaning are being further investigated in the project.

6 Impact of Phytochemicals on Starch Digestion and Intestinal Glucose Transport

P.I.s: M. Ferruzzi, B. Hamaker

Researcher: Min Li, Post-doc

Objectives: To define the chemical nature of interactions between phenolic constituents and starch in model food systems and their impacts on product quality, digestibility and intestinal glucose transport.

Progress: We have over the years made use of a coupled in vitro digestion/Caco-2 intestinal cell culture models adapted using a combination of brush boarder enzymes and labeled glucose (d7-glucose) to model both glucogenesis and glucose transport from model food systems containing phenolics. Application of this model to whole food systems and mixed meals has allowed us to explore the potential for interactions between phenolic and starch in select foods including fruits, vegetables, grains and potatoes as well as model systems including waxy maize and potato starch. In parallel we continue to expand our understanding of the interactions between polyphenolics, phenolic acids with starch by characterizing the chemical and physical nature of these interactions as well as their impacts to both product physical quality as well as bioaccessibility of phenolics and digestibility of starch/protein. In this regard we have reported on changes in starch structure as a result of complexation with simple phenolic acids [Li et al., Food Hydrocolloids. 2018;77:843-52.]. Apparent amylose content and amylose leaching was discovered to be a result of the development of amylose-like structures in the case of phenolic acid complexation with amylopectin and V-type amylose in potato starch-phenolic complexes. The nature of these interactions appears to be primarily physical as minimal alteration was observed in monosaccharide compositions and glycosidic linkages by GC-MS analysis. These structural changes were negatively associated with pasting temperature, peak viscosity, hot paste viscosity and cold paste viscosity. Furthermore, digestibility was modestly lower (resulting from increase in resistant starch) for starch-phenolic acid complexes than for native starch and starch-phenolic acids mixtures. Relative glucose transport through highly differentiated Caco-2 human intestinal monolayer was reduced for maize amylopectin-phenolic complex compared to native amylopectin but higher for potato starch-phenolic complex. Interestingly, the level of cellular phenolic uptake was lower for amylopectin-phenolic complex and higher for potato starch-phenolic complex. These observations suggest that physical phenolic-starch interactions might be a factor modulating functionality and nutritional values of both starch and phenolics.

In the past year we also finalized our assessment of processed potato products in order to understand the potential for similar complexes to form in commercial potato processing relative to fresh in-home preparation [Li et al., Food & Function. 2019]. Commercial products forms including French fries, shredded (hash browns) and diced (home fries) were found to have had significantly higher concentrations of resistant starch compared to freshly prepared counterparts, and this did translate to a reduction in in vitro glucose release and intestinal transport. However, clinical assessment of glycemic response with the three commercial products showed only a subtle but discernable ascending trend (French fry ≥ home fry ≥ hash browns) for incremental area under the curve at 2 h post breakfast suggesting that while potato phenolics may interact with potato starch, they only have a modest influence on acute glycemic response.

7 Fabrication of Dietary Fibers for Novel Functions in the Gut

P.I.s: B. Hamaker, B. Reuhs

Researchers: Xiaowei Zhang, Ph.D. Nusebye Bulut, M.S. student

Collaborators: A. Keshavarzian (Rush Medical School, Chicago); S. Lindemann (Purdue University)

Objectives: Fermentable dietary fibers have the potential to produce positive short chain fatty acid (SCFA) changes in the colon, such as elevated levels of butyrate or propionate, and desired changes in microbiota composition by favoring certain bacteria or bacterial groups. Our interest in these studies is in finding ways to either improve fermentability and function of fibers through use of food technology methods or to fabricate new fiber materials with targeted function.

Progress: Our laboratory takes a food scientist's view on dietary fibers as materials that can be used directly, modified, or fabricated to achieve targeted function in the gut for improvement of localized and whole-body health. In the studies reported here, fibers were physically modified or fabricated with hypotheses to improve their function in the gut, and tested using *in vitro* human fecal fermentation or an *in vivo* model. Our interest is to test material properties related to their function and, if possible, to find ways to improve fiber functionality in the gut.

A previously done study illustrates this point that was *in press* at the end of 2018 (Kaur et al., Physical inaccessibility of a resistant starch to Bacteroidetes shifts mouse gut microbiota to butyrogenic Firmicutes. 2019. *Molecular Nutrition and Food Research*). In this work, starch was covered with a porous alginate matrix that was hypothesized to disfavor utilization by the Gram [-] Bacteroidetes, due to their requirement to physically attach to the starch to degrade it. In this way, the entrapped starch, which was mostly resistant to upper gastrointestinal tract enzymes, would favor Firmicutes bacteria such as *Ruminococcus spp*. that have amylosomes to digest into matrices. These acetate-producing bacteria are known to promote some butyrogenic species. In a mouse study, 2-week feeding of the starch-entrapped alginate microspheres as part of a chow diet caused a 2-3-fold increase in mol% buyrate in the distal colon over resistant raw potato starch. Thus, fabrication of a fiber was used to test a hypothesis on how to promote a certain group of gut bacteria, but also to provide clues regarding how fiber fabrication or modification might be done to improve function in the gut.

In this year, Ph.D. student Xiaowei Zhang reported on the making of a novel soluble fiber matrix that promoted butyrate production and increased certain butyrogenic gut bacteria (Zhang et al., Fabrication of a soluble crosslinked corn bran arabinoxylan matrix supports a shift to butyrogenic gut bacteria. Submitted). Low arabinose/xylose ratio CAX was extracted with two concentrations of sodium hydroxide to give soluble polymers with relatively low and high residual ferulic acid (CAX-LFA and CAX-HFA). After laccase treatment to make diferulate crosslinks, soluble matrices were formed with average size of 3.5 to 4.5 mer. *In vitro* human fecal fermentation of CAX-LFA, CAX-HFA, soluble crosslinked ~3.5 mer CAX-LFA (SCCAX-LFA), and ~4.5 mer SCCAX-HFA revealed that the SCCAX matrices had slower fermentation property and higher butyrate proportion. 16S rRNA gene sequencing showed that SCCAX-HFA promoted OTUs associated with butyrate production including Unassigned Ruminococcaceae, Unassigned *Blautia*, *Fecalibacterium prausnitzii*, and Unassigned *Clostridium*. This is the first work, to our knowledge, showing the fabrication of a soluble dietary fiber that favors growth of butyrogenic bacteria.

In another study, M.S. student Nusebye Bulut fabricated a plant cell wall-like material and tested it for *in vitro* human fecal fermentation response, with the hypothesis that insoluble fermentable matrices of certain compositions are more or less favorable to support butyrogenic Clostridia group bacteria. Solubilized CAX from corn bran, with higher arabinose/xylose ratio than mentioned above, and with higher residual bound ferulic acid, was formed into a crosslinked insoluble film. Work was then done to successfully incorporate nanofibrillated cellulose and nanosized pectin into the film matrix, so that on exposure to water such as in an *in vitro* fecal fermentation slurry, the material and its constituents remained insoluble. Fermentation results are currently being evaluated.

8 *In Vitro* Gut Fermentation Studies on Dietary Fibers and their Modification

P.I.s: B. Hamaker, B. Reuhs, S. Lindenmann

Researchers: Enosh Kazam, M.S. student; Emmanuel Ayua, Ph.D. student; Rachel Jackson, M.S. student; Thaisa Jungles, Post-doc

Collaborators: A. Keshavarzian and A. Landy (Rush Medical School, Chicago); M. Tuinstra (Purdue University)

Objectives: Fermentable dietary fibers have the potential to produce positive short chain fatty acid (SCFA) changes in the colon, such as elevated levels of butyrate or propionate, and desired changes in microbiota composition by favoring certain bacteria or bacterial groups. Our interest in these studies is in understanding the specificity of dietary fiber chemical and physical structures to utilization of gut bacterial groups, and to explore how physical and enzymatic modification of fibers might be used to improve functionality.

Progress: The link between the gut microbiota and localized gut and whole-body health is now established. At a basic level, a healthy microbiota is one that ferments fibers well to produce substantial levels of short chain fatty acids (acetate, propionate, butyrate) and low endotoxin for reduction of gut inflammation and maintenance of good barrier function. High inflammation and poor gut barrier function are directly related to non-communicable chronic diseases such as those associated with obesity and metabolic syndrome diseases. Dietary fibers that ferment in the gut and make favorable changes to the microbiota are encompassed in the concept of prebiotics. Although early work focused more on certain oligosaccharides and their promotion of bifidobacteria and lactobacilli, prebiotics now cover a broader range of fermentable fibers that promote beneficial gut bacteria. The challenge confronting scientists is to understand how to use prebiotic fibers (oligo- and polysaccharides) to generate predictable changes in the gut microbiota for improved health.

Work previously done by sandwich Ph.D. student Thaisa Jungles (Federal University of Parana, Brazil), and who is now a post-doc in our laboratory, was published (Cantu-Jungles et al., *In vitro* fermentation of insoluble D-glucans from the edible mushroom *C. speciosa* stimulates the growth of the butyrogenic *Clostridium* cluster XIVa in a targeted way. 2018. *Carbohydrate Polymers* 183:219-229). This work shows that an insoluble □-glucan from a mushroom, and its debranched analog, are highly butyrogenic *in vitro* and have high specificity for promotion of a single *Anerostipes spp.* OTU that increased from less than 1% abundance to about 25% in a 24-hour fecal fermentation. *Anerostipes spp*. are known to be butyrogenic. This was interesting as the fiber did not markedly increase another Firmicute acetate producer, like *Ruminococcus spp*., which in resistant starch studies increase butyrogenic bacteria through crossfeeding, and it seems it directly promotes this species. In another work *in press* at the end of 2018, Cantu-Jungles et al. (Soluble xyloglucan generates bigger bacterial community shifts than pectic polymers during in vitro fecal fermentation. 2019. *Carbohydrate Polymers*), showed that a less common structure of xyloglucan caused larger changes to the bacterial community structure than the common pectic polymers. The paper hypothesizes that more commonly consumed fibers may be less perturbing to the bacterial community structure.

Xiaowei Zhang completed a genotype x environment study on corn bran arabinoxylan (CAX) extracted from 4 genotypes by 3 growing years at the Purdue Agronomy Farm. CAX samples were compared in human fecal fermentations to test the hypotheses that, 1) CAXs extracted from brans from different corn genotypes and grown over different years (environments) show distinct structures, and 2) these cause differences in gut microbiota response and fermentation metabolites. Monosaccharides and linkage analysis revealed that CAXs had different structures and that the differences were genotype-specific, and not significantly due to environment. PCA analysis revealed that both short chain fatty acid production and the microbial community shifted also in a genotype-specific way. Thus, small structural changes, in terms of sugar and linkage compositions, cause significant changes in fermentation response showing high specificity of structure to gut microbiota function.

9 Investigations on Slowly Digestible Glycemic Carbohydrates

P.I.s: B. Hamaker, M. Ferruzzi

Researchers: Jongbin Lim, Ph.D. student; Leigh Schmidt, Ph.D. student; Anna Hayes, Ph.D. student; Sarah Gafter Corwin, Ph.D. student

Collaborators: B. H. Lee (Gachon University, South Korea); A.H.M Lin (University of Idaho); M. Ferruzzi; S. H. Yoo (Sejong University, South Korea); G. Zhang (Jiangnan University); B. Nichols (Baylor College of Medicine, Houston); R. Quezada-Calvillo (University of San Luis Potosi, Mexico); D. Rose (University of Waterloo, Canada)

Objective: To design slowly digestible glycemic carbohydrates for low glycemic response and with a degree of small intestine ileal digestion for the purpose of targeting physiologic response (i.e., ileal brake and gut-brain axis); and related to ways to manipulate starch digestion rate, including a better understanding of natural inhibitors and their effect on starch digestive enzymes.

Progress: Our current interest in glycemic carbohydrate research is to understand how to achieve slowly digestible carbohydrates that have both moderated glycemic response and the potential to effect physiological changes through ileal triggers to influence appetitive response and slow gastric emptying for a sustained energy effect (see Hasek et al. 2018. *Molecular Nutrition and Food Research*; Cisse et al. 2018. *Nutrition Research*). We have continued to study ways to prolong glycemic response, to reduce the glycemic spike, and to locationally digest starch and other glycemic carbohydrates into the ileum.

Anna Hayes, Ph.D. student, conducted a human study to investigate different aspects of millet-containing foods, particularly *couscous*, that we had previously shown to have very slow gastric emptying rate (~4-5 hours half-emptying time) in West Africans (Cisse et al., *Nutrients*, 2018). Interestingly, in U.S. subjects, we did not find a similar slow digesting effect for millet *couscous*, but did find a somewhat moderated and extended glycemic response compared to wheat-based *couscous*. We hypothesize that this may be related to whether a person normally consumes foods containing slowly digestible carbohydrates and if this conditions a person to respond by activating the ileal brake for slowly digestible millet products. This is currently being tested in a study by Ph.D. student Pablo Torres Aguilar, who is obtaining diet recall data from U.S. and African subjects and testing for their response to slowly digestible carbohydrates.

Jongbin Lim, Ph.D. student, studied natural phenolic inhibitors of mammalian carbohydrate digestive enzymes (α-amylase and the α-glucosidases) and the enterocyte glucose transporter with the goal of understanding how food-based inhibitors might be used to effectively modulate glycemic response and, related to our own work, to be digested more distally in the small intestine. In 2018, he designed a method to measure flavonoid inhibition that avoids the confounding effect of the phenolic compounds on the standard colorimetric tests commonly used. An accurate high-performance anion-exchange chromatography (HPAEC) method was used to measure the inhibition property of flavonoids against mammalian starch digestive enzymes, because flavonoids interfere with the 3,5-dinitrosalicylic acid (DNS) and glucose oxidase/peroxidase (GOPOD) methods. Eriodictyol, luteolin, and quercetin increased absorbance values (without substrate) in the DNS assay and, with substrate, either overestimated or underestimated values in the DNS and GOPOD assays. Using the HPAEC measurement method, flavonoids showed inhibition properties against α-amylase and α-glucosidases that were different from the colorimeteric data, including different inhibition constants (K_i) and mechanisms. Structurally, the double bond between C2 and C3 on the C-ring of flavonoids appeared particularly important in the inhibition of α-amylase, while the hydroxyl group (OH) at C3 of the C-ring was related to inhibition of the α-glucosidases. Starch digested product analysis by HPAEC revealed structural specificity of flavonoids in the inhibition of mammalian α-amylase and α-glucosidases. He is currently conducting a mouse study to investigate the inhibition property of flavonoids toward starch digestive enzymes.

Leigh Schmidt, Ph.D. student, was finishing her studies on the food matrix effect on starch digestion rate. Sorghum products contain naturally slowly digested forms of carbohydrate, as the starch portion is less readily digested than many other cereals. We have evidence that the matrix of sorghum porridges contains kafirin protein bodies and other proteins which are highly crosslinked around gelatinized starch is the cause of the slow digestion property. Developing matrices in other cereals tend to aggregate and collapse. The 3-deoxyanthocyanidin pigments, present in all sorghums, may account for the difference in matrix formation and stability that reduces overall starch digestion. In order to assess the contributions of 3-deoxyanthocyanidin compounds to matrix formation and associated changes in digestion, a 3-deoxyanthocyanidin found in sorghums, apigeninidin, was added to a yellow corn flour slurry and heated to a porridge, then subjected to *in vitro* α-amylase digestion. The porridge microstructure was examined by confocal microscopy using double-labeling with fluorescence markers for carbohydrate and protein. Additionally, the association between apigeninidin (0-50 μM) and a model protein, ovalbumin (5 μM), was assessed utilizing native tryptophan fluorescence quenching spectroscopy from 25-95°C. Addition of apigeninidin produced a significant reduction in the rate of initial starch digestion compared to the untreated starch control. Microstructure of apigeninidin-treated samples was significantly altered, as the zein-containing protein bodies demonstrated areas of extensive web-like structures. Through 30 min. of α-amylase digestion, the protein matrix of treated corn porridges remained largely intact. Fluorescence quenching provided binding information between ovalbumin and apigeninidin, with static quenching determined as the main quenching mechanism. Increasing temperature increased the number of binding sites (from 0.585 to 0.907) and the association constant K_A (1.60 x10^2 to 8.12 x10^3 M^{-1}), indicating stability of the complex increased above the ovalbumin melting temperature. Thus, apigeninidin addition to corn flour porridge increased protein matrix formation, likely due to increased stability from hydrophobic interactions.

10 Cellular and Physiological Response Studies of Glycemic Carbohydrates with Slow Digestion Profiles

P.I.: B. Hamaker

Researchers: Marwa El-Hindawy, Ph.D. student; Beth Pletsch, Ph.D. student

Collaborators: H. Naim (University of Veterinary Medicine Hannover, Germany); B. Nichols (Baylor College of Medicine, Houston); Roberto Quezada-Calvillo (University of San Luis Potosi, Mexico)

Objectives: To understand the cellular and physiological responses to slowly digestible carbohydrates that might have value in the area of controlled glycemic response, satiety and the concept of sustained or extended energy release.

Progress: Our interest in this area is based on two findings from our group: 1) slowly digestible carbohydrates (SDCs) that locationally digest in the small intestine ileum activate the gut-brain axis to reduce food intake in obese animals (see Hasek et al. 2018. *Molecular Nutrition & Food Research* doi:10.1002/mnfr.201700117), and 2) that starch digestion products of α-amylase are sensed by intestinal cells (Caco-2) to mobilize and activate the α-glucosidases (sucrase-isomaltase) to the apical membrane for their efficient digestion (Chegeni et al. 2018. *The FASEB Journal* doi.org/10.1096/fj.201701029R). The first finding led us to the study reported below by Marwa El-Hindawy showing that fabricated ileal-digesting starch-entrapped microspheres reduce weight gain in normal mice fed on a high-fat diet and, in diet-induced obese mice, causing faster weight reduction than a rapidly digestible carbohydrate-based diet. The second study has led to investigations on enteroendocrine L-cell culture showing that maltooligosaccharides, similar to α-amylase degradation products of starch, stimulate secretion of glucagon-like protein-1 (GLP-1) and in higher amounts than the well-studied similar effect on L-cells of short-chain fatty acids (separately tested as acetate, propionate, butyrate) produced by fiber fermentation by the gut microbiota. The overall goal of this research is to design SDCs that can be used in processed foods to activate the gut-brain axis for appetite control and weight management.

Marwa El-Hindawy completed her Ph.D. in December. In a previous study from our laboratory, carbohydrate-based foods with slow digestion rate and locational digestion in the ileum had the beneficial effect of reducing food intake that was associated with stimulation of the gut-brain axis. The hypothesis was tested whether activation of the gut-brain axis using the same fabricated slowly digestible starch (SDS) microspheres would increase weight loss of diet-induced obese (DIO) mice transferred to a low-fat diet and/or would reduce weight gain of lean mice placed on a high-fat diet. It was hypothesized that the distal release of □-amylase degradation products of starch by the digestion of SDS along the course of the small intestine contributes to the stimulation of the gut-brain axis. Alginate-entrapped starch microspheres with slow digesting rates were used to investigate the role of SDS in the intervention and prevention of obesity in C57BL/6J DIO and lean mice models over 12 weeks of feeding. Results showed that 20% SDS and pregelatinized starch in low-fat diets significantly improved weight loss, body fat reduction, and food intake reduction in DIO mice converted to low-fat diet for 12 weeks. Similarly, 15% SDS in high-fat diets showed significant reduction in weight gain rate and food intake in lean mice fed on 45% of calories high-fat diet. The intricate role of dietary carbohydrates on gut physiological response, related to satiety and food intake, could be a new approach in the design of foods for health applications.

11 Physical Stability of Suspensions Containing Polysaccharides and Colloidal Proteins

P.I.: O.G. Jones

Co-P.I.s: M. Ferruzzi

Researcher: Chris Cheng, Ph.D. student

Objective: Determine the impacts of structure and interactive components on zein particle stability in gastrointestinal conditions and physical contribution to films.

Progress: Zein nanoparticles were shown to improve the mechanical behavior of cellulosic films at lower concentrations, yet incompatibility with the cellulose at higher concentrations induced clustering and reduced mechanical performance. Plasticizers, surfactants, and interactive polysaccharide components were utilized to improve compatibility with the modified cellulose matrix. An article has been accepted in *Journal of Food Engineering* that relates the inability to use higher concentrations of zein nanoparticles to improve the elastic properties beyond those of the original cellulose film; however, interactive carbohydrates and uncharged surfactant improved the distribution and contribution of particles within the film. In a parallel study, digestion studies indicated that zein nanoparticle digestion was relatively rapid in intestinal conditions but greatly reduced during gastric conditions due to the combined effect of acid and physiological ion concentrations, wherein aggregation of particles reduced access of the enzyme. After digestion of particles in intestinal conditions, digested zein components reduced bioaccessibility of a bioactive isoprenoid, which could indicate specific associations between digested peptides and either isoprenoids or bile salts. This work was published in *Food Hydrocolloids.*

12 Stabilization of Oil-in-Water Emulsions by Whey Protein Microgels

P.I.: O.G. Jones

Co-P.I.: G. Narsimhan

Researchers: Lijie Zhu, visiting scholar (2017-2018), Ryan Murphy, Ph.D. student (2013-2017)

Objective: Determine the interfacial activity and physical stability of oil-in-water aqueous emulsions using (a) microgels of whey protein with or without pectin; determine influence of

particle size, particle swelling ratio, and environmental conditions on interfacial properties.

Progress: Effects of the relative size and deformability of protein-based microgels on flocculation and Ostwald-ripening (dispersed molecule entrapment) of emulsion droplets stabilized by the microgels were determined by use of emulsion stability and interfacial characterization techniques. A publication was released in *Gels,* in which it was shown that larger microgels with greater deformability reduce the rate of volatile release (relative release, however, was not convincingly greater than unstructured protein interfaces and is not necessarily recommended as a viable strategy for beverage emulsions).

13 Emulsification Properties of Polysaccharide and Protein Fractions of Crickets

P.I.: O.G. Jones

Researcher: Drew Hirsch, M.S. student

Objective: Determine the surface activity and emulsifying capability of protein and chitin fractions from ground crickets.

Progress: Protein and chitin fractions were isolated from ground cricket flour. While only protein-rich fractions provided significant surface pressure to model oil-water interfaces, emulsions could be prepared with either fraction. Stability was likely contributed only by the smallest particles within the chitin-rich fractions via a Pickering-stabilization mechanism, and these emulsions work highly prone to flocculation and creaming within 1-2 days of room temperature storage. Protein-rich fractions provided a bimodal distribution of stabilized emulsion droplets at studied concentrations, limiting their stability to less than a day without agitation but approximately 15-20 days if redispersed. A manuscript is in preparation.

14 Effect of Protein Conjugation on Protein-Polysaccharide Interactions

P.I.: O.G. Jones

Researcher: Alyssa Kelley, M.S. student

Objective: Determine the effect of protein glycosylation on the associative or segregative interactions with common polysaccharide materials.

Progress: Building upon the work of a prior student (Juan Du) in which a non-interactive component conjugated to the polysaccharide fraction restricted interactions with proteins, a new student has been tasked with preparing glyscolyated proteins and determining the impact of glycosylation on interactions with polysaccharide. Preliminary work utilizing a published glyscosylation approach for maize Prolamin revealed errors in the protocol. Work is currently underway on an improved technique.

15 Protein Fibrous Structures as Physical Simulacrums of High-MW Glutenin

P.I.: O.G. Jones

Co-P.I.: O.H. Campanella, Gordon Selling (USDA, Agriculture Research Station), B.H. Hamaker

Researcher: Enrico Federici, Ph.D. student

Objective: Determine the influence of physical and chemical attributes of fibrous protein assemblies on the mechanical behaviors of water/starch-based mixtures.

Progress: Aqueous suspensions of prolamins mixed with globulins or small molecule plasticizers were tested for their capacity to be spun into fibrous assemblies. Physical properties of spun fibers were analyzed by atomic force microscopy and force spectroscopy. Parallel experiments on the impact of spun fibers or extruded Prolamin powders on starch-rich doughs were performed under the supervision of Campanella. Current work is underway to determine the impact of additional components on the viscoelasticity and morphology of individual fibers, identifying their likely contribution to macroscale properties in starch-based doughs. Several manuscripts are in preparation.

16 Simultaneous Fluorescent Detection of Gliadins, LMW, and HMW Glutenins in Wheat Dough Samples Using Antibodies-Quantum Dots Complexes as Imaging Tools

P.I.: J. Kokini

Researcher: Jose Bonilla, Ph.D. student

Objective: To study the distribution of gliadins, LMW and HMW glutenins during different wheat processes.

Progress: We have successfully developed antibodies for HMW and LMW weight glutenins, which we conjugate to fluorescent quantum dots for detection of the glutenins subunits in dough. QDs are conjugated to carbohydrates groups found in the tails of the antibodies by a site-click chemistry reaction.

Dough samples are stained with the antibodies-QDs conjugates using a previously developed method. The samples are analyzed under an A1R-MP Nikon Confocal microscope. The collected fluorescent images display the in situ localization of the fractions among the starch matrix in dough for the first time in cereal science research. We have visualized and quantified the distribution of HMW glutenins, LMW glutenins, and gliadins throughout the mixing process in a Brabender Farinograph. We have seen how LMW glutenins and HMW glutenins interact differently with gliadins at different stages of mixing. Visualizing and understanding the distribution of the gluten fractions during mixing will advance our understanding of the mechanism of dough development and will improve the state of knowledge in cereal science, which will eventually lead to an improvement in the quality and an extent in the variety of wheat products.

17 Fabrication of Biodegradable Protein-Based Surface Enhanced Raman Spectroscopy Platforms for the Detection of Food Allergens and Toxins

P.I.: J. Kokini

Researchers: Hazal Turasan, Ph.D. student; Geraldine Tembo, M.S. student; Fei Jia, visiting scholar; Dr. Xiaoyuan Ma, visiting scholar

Objective: This project is aiming to fabricate protein based films and electrospun fibers for the detection of food toxins and allergens using surface enhanced Raman spectroscopy.

Progress: Due to their unique properties, such as being more hydrophobic than other plant-based proteins, film and fiber forming capabilities, zein, the most abundant corn protein, and kafirin, the protein of sorghum are excellent candidates for the production of biodegradable platforms for biosensors. The SERS platforms are fabricated both as nanostructured zein and kafirin films and as zein and kafirin electrospun fiber mats. For the optimization of mechanical, chemical and surface properties of protein films and fibers different plasticizer types and contents, solvents, and crosslinking are tested. The changes in the chemistry of the zein and kafirin films are closely monitored using Fourier transform Infrared spectroscopy and Fourier transform Raman spectroscopy. Mechanical and surface properties of the protein films are also tested to observe the effects of plasticization and crosslinking. After the optimization of all the properties, nanostructured protein films are fabricated using soft lithography and covered and decorated with gold layer and gold nanoparticles to enhance the SERS signal, respectively. Zein and kafirin fibers, on the other hand, are decorated with noble metal nanoparticles directly to enhance the SERS signal. Lastly, the protein based SERS platforms are validated with various food toxins and allergens.

18 Fabrication of Antimicrobial Kafirin Nanofibers Encapsulated with Essential Oil Phenols for Food Packaging Applications

P.I.: J. Kokini

Researchers: Yumi Higashiyama, undergraduate student; Hazal Turasan, Ph.D. student

Objective: The objective of this project is to fabricate antimicrobial nanofiber mats from a plant-based protein, kafirin, encapsulated with thyme and carvacrol for future food packaging applications.

Progress: Electrospun nanofibers provide a very high surface area, which would help the inactivation of bacterial growth and prolong shelf life of packaged food materials. Kafirin, the main storage protein of sorghum, is a nontoxic and edible plant protein with high hydrophobicity and good electrospinnability. So far the project is in its first stage, which is the extraction of kafirin from sorghum flour. After the extraction, kafirin solutions will be prepared and two phenolic compounds found in thyme oil and oregano oil, thymol and carvacrol, will be added to the kafirin solutions at different ratios to analyze the effect of antimicrobial agent concentrations on the antimicrobial property of the kafirin fibers. The kafirin solutions will then be fabricated using electrospinning and will be characterized using various techniques. The morphology of the nanofibers will be assessed with optical and scanning electron microscopy, and the chemistry of the fibers will be analyzed with FTIR and FT-Raman spectroscopies. Surface wettability of the antimicrobial electrospun fibers will also be analyzed. Lastly, to determine their antimicrobial properties, kafirin nanofibers will be tested against common food pathogens.

19 Effect of Contact Surface, Plasticized, and Crosslinked Zein Films are Cast On, on the Distribution of Dispersive and Polar Surface Energy Using the Van Oss Method of Deconvolution

P.I.: J. L. Kokini

Researchers: Morgan Malm (Meiser), Ph.D. student

Objective: To manipulate and characterize the surface free energy of zein films as a result of material cast on zein, a biodegradable prolamin protein of corn, is a byproduct of the ethanol industry that is widely available, inexpensive and underutilized. In this study, the surface properties of plasticized and crosslinked zein films were characterized as a result of the material the solutions were cast on. Due to its amphiphilic nature, zein has the ability to use the hydrophilic ends of its capsule structure to interact with hydrophilic materials or in contrast, it can use the hydrophobic sides of its structure to interact with hydrophobic materials or surfaces, thus offering tunable surface properties. However, the effect of zein's mobile structure on wetting and surface properties of zein films has not been studied. Understanding the surface properties of plasticized zein as a result of its interaction with different materials films are cast on, offers a path to further tune the surface properties of zein films.

We showed that the surface energy, and the distribution of the surface energy into the dispersive and polar components of the amphiphilic zein protein, was strongly affected when cast on polystyrene, polydimethylsiloxane (PDMS) and polytetrafluoroethylene (PTFE, Teflon). Plasticized zein films had higher fractions of dispersive Lifshitz-Van der Waals (γLW) components than the Lewis acid base (γAB) polar components overall when the surface energy was analyzed and deconvoluted using the Van Oss method. When cast on PDMS the polar component increased, water contact angles were the lowest and the total surface free energy increased as a result. Oleic acid and glutaraldehyde concentration were also varied during fabrication of the films in addition to contact surfaces. Film composition did not have an equally significant effect on the surface energy of films but as expected affected mechanical properties..

20 Zein- and Kafirin-Based Nanocomposites for Biodegradable Packaging

P.I.: J. Kokini

Researchers: Tahrima B. Rouf, Ph.D. student

Objective: The objective of this research is to functionalize and reinforce biodegradable zein and kafirin films by adding nanomaterials to improve its tensile strength, thermal stability and water vapor barrier properties.

Progress: A major storage prolamin protein of corn "zein" is an abundant byproduct of the ethanol industry. Zein has unique amphiphilic, antioxidant, antibacterial and adhesive film forming properties, and, therefore, is considered a highly suitable candidate for designing environmentally friendly polymers. Kafirin is the storage protein from sorghum which has been found extremely similar to zein. In this project, the fabrication of zein and kafirin-nanocomposites is optimized by using different engineered nano-fillers and different fabrication techniques to improve the mechanical, thermal and barrier properties of zein and kafirin nanocomposites. The morphology, chemical composition and property changes in the obtained nanocomposite films are characterized using an array of microscopic, spectroscopic and surface characterization techniques. Zein and Kafirin both have been tested with LAPONITE®, a silica-based nanoparticle, and the results indicate that significant improvement in tensile strength, thermal degradation temperature and water vapor permeability can be achieved by addition of the optimal concentration of nanofiller to zein and kafirin. Zein has also been tested with graphene oxide, a carbon-based nanomaterial which has shown even greater increase in mechanical properties at lower loadings than LAPONITE®. In addition, the surface properties of the films can be modified as desired, leading to possible application in biodegradable smart packaging as well as biosensors.

21 Effect of Aging Time and Temperature on the Non-Linear Rheological Properties and Secondary Structure of Different Flour Dough Samples

P.I.: J. Kokini

Researcher: Secil Turksoy, Ph.D. visiting scholar

Objective: To investigate the effect of aging time and temperature on the rheological and secondary structure of the wheat flour dough samples.

Progress: Wheat flour dough has long been the focus of attention of many cereal scientists due to its unique complex and composite biological structure. The main purpose of this study is to find the most realistic approach and also to answer the question of "How much molecular dough rheology can be explained in non-linear region due to the different aging times and temperatures?" To understand the change occurred in viscoelasticity of dough during aging period, large amplitude oscillatory shear (LAOS) tests are used in non-linear region. In addition, the change of average molecular weight from flour to dough during aging is determined by using gel electrophoresis. Fourier transform infrared spectroscopy (FTIR) have helped to clarify the secondary structure of gluten proteins during aging at different temperatures. A further characterization of molecular change in dough depending on the aging time and temperature with the help of different valuable techniques will provide valuable information for improved processing of wheat flour dough.

22 Establishment of Model Dietary Fiber-Consuming Gut Microbial Communities for Generalizable Fiber-Microbiota Research

P.I.: S. Lindemann

Researchers: Ming-Hsu Chen, Postdoc; Tianming Yao, Ph.D. student

Objectives: 1) To select for consortia that degrade specific dietary fibers of interest for use in fiber-microbiome studies, 2) Establishment of long-term cryopreservation methods for model communities, 3) Genome sequencing and reconstruction of model communities for use in systems biology analyses.

Progress: M.-H. Chen and T. Yao selected for communities of 1) inulin-degrading and 2) sorghum arabinoxylan (SAX)-degrading microbes using fecal microbiota as an initial species pool. Consortia stable in membership resulted after approximately 5–7 sequential transfers in batch culture. These consortia resulted in stable growth rates, pH, and gas production over sequential batch transfers. SAX-consuming consortia selected at two different time points from the same donor resulted in consortia very similar in composition, whereas selection of same-donor consortia on inulin at two different time points resulted in very different final communities. Amino acid and vitamin amendment of inulin-fermenting consortia resulted in significant alteration of community structure, but influenced SAX-fermenting consortia much less substantially. These data suggest that 1) generation of model fiber-fermenting communities is possible and 2) that SAX much more strongly structures fermenting microbial communities than does inulin. In the second case, fortification of media revealed that interactions based upon auxotrophies are more likely to structure inulin-consuming consortia. 16S rRNA amplicon sequencing revealed that fortification of inulin-containing media resulted in an entirely different final community composition, where fortification of SAX-containing media made only minor impacts upon microbiome structure. Interestingly, communities from fecal samples from the same individual one month later grew remarkably similar consortia on SAX media.

23 Particle Size Effects on Bran Fermentation by Gut Microbiota

P.I.: S. Lindemann

Collaborator: B. Hamaker

Researchers: Y. Tuncil, Postdoc; R. Thakkar, M.S. student

Objectives: 1) Determine the degree to which the fermentation of a bran particle depends upon its size, 2) Identify mechanisms by which particle size might influence the structure and function of gut microbiota.

Progress: Y. Tuncil and R. Thakkar discovered that the fermentation of hard red spring wheat bran particles, directly sieved from the miller sample into size ranges of 180–300, 300–500, 500–800, 850–1000, and > 1700m, result in very different successions of microbiota, with distinct metabolic function. Coarser particles favored members of family *Lachnospiraceae*, home to many butyrogenic taxa known to be associated with fermentation of wheat brans, and smaller particles favored most of the *Bacteroidaceae*. However, certain *Bacteriodes* species preferred larger particles, suggesting that the effect of selection by particle size can occur at the species or strain level. These differences in community structure produced distinct metabolic output — though small particles fermented more rapidly overall, coarser particles produced increased molar ratios of butyrate while finer particles produced increase molar ratios of propionate. Monosaccharide analysis revealed that smaller particles had increased glucose abundance, suggesting residual starches not removed by upper-GI in vitro digestion. However, milling of large particles suggested the difference was not starch content but availability, and that this may drive differences in microbial activity.

To separate the effect of chemical composition from particle size, Y. Tuncil and R. Thakkar milled down larger wheat bran particles and sieved them into a size range. No significant differences in monosaccharide composition were observed among sizes, but differences in microbial community composition and short-chain fatty acid production persisted. These data suggest that size, in its own right, governs metabolism of wheat brans. Further, we determined that there were significant differences between particle-associated and suspended microbial communities. Metagenome sequencing is underway to determine the functional differences associated with each community.

R. Thakkar extended this experiment into corn brans, by sieving out different size fractions and performing in vitro fecal fermentations. Our data suggest that corn bran particle size effects are more muted than for wheat, but particle size-dependent behavior was still observed. As for wheat brans, preference for particle size occurred at the level of individual species. Furthermore, to determine whether R. Thakkar addressed the question of whether particle size stably selected for microbiota over sequential batch cultivation, and discovered particle-size-dependent SCFA generation and microbial community structure. Interestingly, microbiota from three very different donors converged on very similar community structures when grown on particles of different size, suggesting a single consortium of organisms is most efficient in growing on wheat brans across individuals.

24 Bran Arabinoxylan and Inulin Chemical Structure Effects on Fermentation by Gut Microbiota

P.I.: S. Lindemann

Collaborators: B. Hamaker, B. Reuhs

Researchers: Ming-Hsu Chen, Postdoc; Y. Tuncil, former Postdoc; Tianming Yao, Ph.D. student

Objectives: 1) To identify the structural properties of soluble fiber carbohydrates that exert significant impact upon the rate of metabolism by gut microbiota and their final metabolic fate, 2) To determine which structural features of soluble fibers influence gut microbial community structure and function, and 3) To generate a mathematical model that describes linkages between soluble fiber structure and gut microbiome structure and function that can be generalized across soluble fibers.

Progress: With respect to arabinoxylans, preliminary evidence suggests that fine structural differences can exert large impacts on community structure and function. Y. Tuncil discovered that wheat bran arabinoxylans from hard red (HR) varieties (grown either in winter or summer) select for gut microbial communities dominated by *Prevotella*, where soft red (SR) varieties (grown in winter) select for communities anchored by *Bacteroides*. Linkage analysis revealed that HR arabinoxylans possess a greater amount of 4-Xyl linkages, whereas SR varietals possess more 2,3,4-Xyl linkages – these data suggested that SR arabinoxylans were more highly branched than HR. Furthermore, SR arabinoxylans fermented more slowly than did HR arabinoxylans and different stoichiometries of short-chain fatty acid products.

M.-H. Chen and T. Yao have begun a project to identify the impact of degree of polymerization (DP) on the fermentation rate and metabolic fate of differently-sized inulins. Inulin products across a size range were quantitated for DP and inoculated with inulin-consuming microbial consortia to determine the impact on growth rate and metabolic fate, finding preliminarily that increasing DP results in decreased growth rates and yields of inulin-consuming consortia selected on low-DP inulins. These data suggest that fermentation rates and metabolic fates may be strongly governed by DP. Sequential batch cultivation on different chain lengths (and one branched structure) of inulin revealed that longer chain inulins select for populations of organisms not present in shorter inulin fermentations, presumably because they are required for external hydrolysis and import of the molecules. Similarly, one organism was specific to branched agave inulin.

25 Differential Fermentation of Resistant Dextrins by Gut Microbiota

P.I.: S. Lindemann

Researchers: Arianna Romero, Ph.D. student

Objective: To determine whether different glucans select for different microbiota and result in different metabolic outcomes.

Progress: A. Romero performed an experiment with three donors in which each donor's microbiota was exposed to 12 different resistant glucan structures in *in vitro* batch fermentations, measuring pH, gas production, SCFAs, and microbial community structure via 16S rRNA amplicon sequencing. She observed that 1) metabolic outcome from the same resistant glucan varied across donors (e.g., with respect to relative propiogenesis vs. butyrogenesis) and microbial responses. However, across donors some taxa were repeatedly selected by certain dextrin structures, suggesting that there are specificities in interactions among resistant glucans and the organisms which best consume them. Additionally, antagonism/competition among organisms could be observed, in which some organisms are seen to increase in relative abundance at the expense of others.

26 Starch Properties in Different Environments

P.I.: L. Mauer

Researchers: Matt Allan, postdoctoral associate; Kathryn Johnson, M.S. student; Travis Woodbury, M.S. student; numerous undergraduate students

Objective: To investigate starch properties, including gelatinization and retrogradation, in the presence of a variety of sweeteners and oligosaccharides, and in environments containing different amounts of water.

Progress: We are investigating the thermal properties of starch in different environments and in the presence of a wide variety of sweeteners to establish relationships between sweetener and oligosaccharide type and structure, water activity, molecular weight, and intermolecular interactions with starch gelatinization, pasting, swelling, and retrogradation traits.

27 Amorphous Solid-State Dispersion (Amorphization) of Crystalline Ingredients

P.I.: L. Mauer

Researchers: Seda Arioglu-Tuncil, Ph.D. student; Collin Felten, M.S. student; Yahya Ismail, M.S. student; Adrienne Voelker, Ph.D. student

Objective: To manipulate the solid-state structure of inherently crystalline ingredients and document the resulting effects on physical and chemical stability.

Progress: We are investigating the differences in stability and delivery traits between crystalline and amorphous forms of both poorly water-soluble and highly water-soluble inherently crystalline ingredients. A variety of dispersion techniques and matrices are being explored to document crystallization inhibition properties of different polymers, as well as differences in solubility and stability traits between crystalline and amorphous forms of the same ingredient. In general, polymers that are capable of hydrogen bonding or ionic interactions with the target compound are better at maintaining amorphous structures during storage. Solubility enhancement was achieved when poorly water-soluble crystalline compounds were stabilized in amorphous dispersions, as well as between amorphous and crystalline forms of highly water-soluble ingredients. Physical and chemical stability differences between crystalline and amorphous states of a compound continue to be monitored. Interesting insights into molecular assembly and crystalline/ amorphous behaviors are being developed throughout the course of these studies.

28 Water-Solid Interactions and Phase Diagrams

P.I.: L. Mauer

Researchers: Matthew Allan, postdoctoral associate; Adrienne Voelker, Ph.D. student; numerous undergraduate students

Objective: To investigate the fundamentals and consequences of the five modes of water-solid interactions in terms of phase diagrams, kinetics, and their effects on the chemical and physical stability of single ingredients and multicomponent food systems.

Progress: We are investigating the fundamentals and consequences of deliquescence, absorption, and other water-solid interactions in food systems containing crystalline and/or amorphous components. In collaboration with a researcher in the Industrial and Physical Pharmacy Department, Dr. Lynne Taylor, we have demonstrated that deliquescence lowering occurs in mixtures of deliquescent crystalline ingredients (e.g., sugars, salts, organic acids, vitamins, etc.) and that reaction kinetics are influenced by this deliquescence lowering. We have also demonstrated that moisture sorption in blends of crystalline and amorphous solids deviates from a simple additive model, wherein the co-formulation of crystalline and amorphous ingredients has the potential to lower both the deliquescence RH and Tg of the blend, depending on the formulation, rendering the blend of ingredients more sensitive to environmental RH than the individual ingredients. Efforts are also focused on generating RH-temperature phase diagrams of different ingredient classes. This has importance for the formulation, sequencing, blending, storage, packaging and stability of dry ingredient mixtures and final food products.

29 Prediction of Swelling Behavior of Crosslinked Maize Starch Suspensions

P.I.: G. Narsimhan

Researchers: Prasuna Desam, Ph.D. student; Jinsha Lee, Ph.D. student

Objective: To characterize the pasting behavior of starch in terms of its structure.

Progress: Maize starch was crosslinked with sodium trimetaphosphate as evidenced by pNMR. The evolution of 8% suspension of crosslinked maize starch granule size distribution when subjected to heating to 70,75,80,85 and 90 °C at a heating rate of 15 °C/min were measured. Granule swelling was more pronounced at higher temperatures eventually approaching equilibrium with the swelling ratio decreasing with increase in extent of crosslink. A previously developed model for swelling of starch granules is improved to account for electrostatic interaction within a crosslinked granule. The number of crosslinks in the starch network was inferred from equilibrium swelling and related to peak viscosity and zeta potential of granule. Chemical potential profile as well as the temperature profile within the granule at different times were predicted which were then employed to evaluate the granule size at different times. The proposed model is able to describe the effect of crosslinking on swelling behavior.

30 Volume Fraction Dependence of the Elastic Behavior of Starch Suspensions

P.I.: G. Narsimhan

Researchers: Jinsha Lee, Ph.D. student, Prasuna Desam, Ph.D. student

Objective: To characterize the pasting behavior of starch in terms of its structure.

Progress: Evolution of volume fraction φ and pasting of 8% w/w suspension of waxy and normal maize, waxy and normal rice starch when heated at 60, 65, 70,75,80,85 and 90 °C were characterized by particle size distribution and G', G" in the frequency range of 0.01 to 10 Hz respectively. The pastes exhibited elastic behavior with G' being much greater than G". G' increased with time for waxy maize and rice starch at all times. For normal maize and rice starch, however, G' reached a maximum and decreased at longer times for temperatures above 80 °C due to softening of granules as evidenced by peak force measurements. Experimental data of G' vs φ for all starches subjected to different heating times and temperatures fall into a master curve except for conditions under which the granule becomes deformable, i.e., longer time data of normal maize and rice at temperatures above 80 °C.

31 Synergistic Effect of Low Power Ultrasonication on Antimicrobial Peptide Action

P.I.: G. Narsimhan

Researchers: M. Fitrityanti, Ph.D. student

Objective: To characterize the synergistic effect of low-power ultrasound and antimicrobial peptides on deactivation of microorganisms.

Progress: Recent studies have shown that both low frequency (20-100 kHz) ultrasonication and antimicrobial peptides (AMPs) treatment processes have a significant advantage in inactivating bacterial cells than the conventional heat treatment due to higher food texture quality of the final product. However, the effect of the combined process has not been fully investigated in complex matrices such as food. In this study, deactivation of Escherichia coli in different concentrations of milk and orange juice were performed using three different treatments: low frequency ultrasonication (20 kHz) at different power levels, antimicrobial peptide Cecropin P1 at different concentrations, and combination of both. The results of all samples showed that the combined treatment is more efficient, reducing the cell density of E. coli up to four orders of magnitude, compared to individual treatments. However, the milk concentration results in lower synergistic effect. This is believed to be due to complexation of milk proteins with Cecropin P1 thus resulting in less availability of the latter for antimicrobial action. This dependence was not observed in orange juice samples. Ultrasonication resulted in insignificant decrease in viscosity, color and vitamin C for both milk and orange juice except at higher power level of 160W at longer exposure time.

32 Pore Formation in DOPC/DOPG Bilayers by Antimicrobial Peptide Alamethicin

P.I.: G. Narsimhan

Researchers: Meng-Ke Zhang, Ph.D. student, Yuan Lyu, Ph.D. student

Objective: To understand the mechanism of pore formation in DOPC/DOPG bilayers by antimicrobial peptide alamethicin

Progress: Alamethicin (ALM) inhibits the growth of bacteria by disrupting their cell membrane. ALM exhibits poor solubility in aqueous medium thus limiting its application. A method is proposed for encapsulation of ALM with γ-cyclodextrin (γ-CD) by forming a complex of higher solubility with thermal and pH stability as confirmed by FT-IR and DSC, thus greatly improving its application in food safety. Molecular dynamics simulation suggested a stable configuration of the complex when hydrophobic residues are inserted into the hydrophobic cavity of γ-CD. Aggregation of the complex was inhibited at higher γ-CD/ALM molar ratio. γ-CD/ALM complex exhibited significant antimicrobial activity against L. monocytogenes with the minimum inhibitory concentration being dependent on γ-CD/ALM molar ratio (>0.429 mg/mL for 1:1; > 1.094 mg/mL for 5:1; >2.078 mg/mL for 10:1). Optimum γ-CD/ALM molar ratio for maximum antimicrobial activity is the result of competing effects of higher solubility and shielding of hydrophobic ALM groups by γ-CD.

33 Nucleation and Growth of Pores in 1,2-Dimyristoyl-sn-glycero-3-phosphocholine (DMPC) / Cholesterol Bilayer by Antimicrobial Peptides Melittin, its Mutants and Cecropin P1

P.I.: G. Narsimhan

Researchers: Yuan Lyu, Ph.D. student, Maya Fitriyanti, Ph.D. student

Objective: To understand the mechanism of pore formation in DOPC/DOPG bilayers by antimicrobial peptide melittin

Progress: Antimicrobial peptides are one of the most promising alternatives to antibiotics for targeting pathogens without developing resistance. In this study, pore formation in 1,2-Dimyristoyl-snglycero-3-phosphocholine (DMPC) / cholesterol liposome induced by native melittin, its two mutant variants (G1I and I17K), and cecropin P1 was investigated by monitoring the dynamics of fluorescence dye leakage. A critical peptide concentration was required for dye leakage with the rate of leakage being dependent on peptide concentration above a critical value. A lag time was required for dye leakage for low peptide concentrations that are above the critical value, which decreased at higher peptide concentrations eventually approaching zero. Lag time was found to be in the order I17K mutant with lower hydrophobicity and higher net charge>G1I with higher hydrophobicity>melittin>cecropin P1. Cecropin P1 exhibited the highest rate of dye leakage followed by melittin, G1I and I17K. Size distribution and transmission electron microscopy (TEM) of liposomes exposed to peptides of different concentrations indicated pore formation with accompanied stretching of liposomes at low peptide concentrations for both melittin and cecropin P1. At much higher concentrations, however, size distribution indicated three peaks for both peptides. In both cases, TEM images show that the middle and small peaks are shown to be due to stretched liposome and broken stretched liposome respectively. For melittin, the large peak is due to peptide aggregates as well as aggregates of liposome. For cecropin P1, however, the large peak indicates cecropin P1 aggregates with solubilized lipids thus suggesting carpet mechanism.

34 Using Molecular Rotor to Detect the Supramolecular Structure of Amylopectin and Phytoglycogen

P.I.: Y. Yao

Researcher: Xingyun Peng, Ph.D. Student (graduated in 2018)

Objective: To use molecular rotor to characterize the branch structure of amylopectin and phytoglycogen

Progress: In this project, molecular rotor (MR) is used as a novel probe to characterize the branch structure of amylopectin (AP), phytoglycogen (PG) and their derivatives. Both AP and PG are plant-based, highly branched -D-glucans and normally their chain length distributions are used to describe their structures at the supramolecular level. In a biopolymer matrix, the fluorescent signal of MR is quantitatively correlated with molecular density, and thus the branching density of glucan molecules can be determined through using MR. Based on MR detection result, the concept of "nanopockets" is proposed to describe the spatial restriction of glucan branches to small molecules.

35 Visualization of Starch Retrogradation Using Molecular Rotor

PP.I.: Y. Yao

Researcher: Xingyun Peng, Ph.D. Student (graduated in 2018)

Objective: To use molecular rotor to visualize starch retrogradation

Progress: Starch retrogradation is one of the most important properties of starch for food and other applications. During starch retrogradation, glucan chains aggregate and form crystalline structures. A number of methods have been used to characterize retrogradation; however, method for visualizing individual starch granules at retrogradation has not been reported. In this project, we apply molecular rotor (MR) in the dispersions of gelatinized starch and use CLSM to image individual starch granules at various stages of retrogradation.

36 Phytoglycogen and its Derivatives to Improve the Solubility of Poorly Water-soluble Active Ingredients

P.I.: Y. Yao

Researchers: Randol Rodriguez, Ph.D. Student (graduated in 2018); Jingfan Chen, Ph.D. Student

Objective: To improve water solubility and efficacies of poorly water-soluble active ingredients

Progress: A large number of active ingredients (AIs) are hydrophobic and thus poorly water-soluble, which adversely affects their bioaccessibility and bioavailability. In this project, curcumin, resveratrol, and quercetin are used as poorly water-soluble AI models to evaluate the capabilities of phytoglycogen and its derivatives (e.g. octenylsuccinate hydroxypropyl phytoglycogen) in solubilizing AIs and enhancing their biological efficacies such as Caco-2 cell monolayer permeation, inhibition of cancer cells, and reduction of biofilm formation of *Helicobacter pylori*.

37 Micro-analysis of Starch Materials

P.I.s: Y. Yao, C. Weil, B. Hamaker

Researcher: Miguel Alvarez, M.S. student

Objective: To establish an analytical platform for high-throughput screening of cereal starches

Progress: This project is a part of a high-throughput single-kernel starch screening program. This screening program requires various property analyses for starch or flour samples at milligram level. Currently, the molecular rotor (MR) technique is being evaluated for its suitability to characterize several physical properties of starches that are subjected to specific treatments. The data obtained from MR analysis are correlated with those obtained from conventional methods such as microscopic imaging and RVA.

38 Phytoglycogen-Based Biomaterials to Improve the Solubility of Active Ingredients (AI)

P.I.s: Y. Yao, A. Bhunia (Department of Food Science)

Researcher: Yezhi Fu, Ph.D. Student

Objective: To reduce or remove pathogen biofilm at the surface of fresh produce

Progress: Pathogen biofilm formation at food surface is a major food safety concern. In this project, antimicrobial compounds are specifically formulated and applied at the surface of fresh produce, including cantaloupes and alfalfa sprouts, and the efficacies to reduce the biofilm formation and bacterial growth of *Listeria monocytogenes* and *Salmonella* Typhimurium are evaluated. The goal is to design practical and effective treatments to realize 3-5 log reduction of bacterial load at the surface of fresh produce.

Publications and Other Scholarly Activities

A. Papers, Books, Chapters, and Patent Applications Published

BeMiller, J.N.

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3. Brito-Oliveira, T. C., Bispo, M., Moraes, I. C., **Campanella, O. H.,** & Pinho, S. C. (2018). Cold-set gelation of commercial soy protein isolate: effects of the incorporation of locust bean gum and solid lipid microparticles on the properties of gels. *Food Biophysics, 13*, 226-239. doi:10.1007/s11483-018-9529-4

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5. Cheng, L., Feng, T., Zhang, B., Zhu, X., **Hamaker, B., Zhang, H., & Campanella, O.** (2018). A molecular dynamics simulation study on the conformational stability of amylose-linoleic acid complex in water. *Carbohydrate Polymers, 196*, 56-65. doi:10.1016/j.carbpol.2018.04.102

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B. Papers Presented at Meetings, Conferences, and Invited Public Lectures

January

Hamaker, B. Biochemical bases of texture of starchy foods, RTB Foods Workshop, Bill and Melinda Gates Foundation, Buea, Cameroon.

February

Hamaker, B. Modification of dietary fiber structures for different functions related to the gut microbiome, Novozymes Co., Copenhagen, Denmark.

Kokini, J.L. Recent advances in nanotechnology for food applications, Department of Food Science and Human Nutrition, University of Illinois at Urbana-Champaign.

Mauer, L.J. Update on CFSE approaches for developing novel pathogen detection technologies, ARS-FSIS National Meeting, Shepherdstown, WV.

March

Kokini, J.L. Introduction to the Rheology of Foods for Industrial Food Scientists, Institute of Food Technologists Webinar.

Kokini, J.L. Phase transitions of starch and gluten polymers: Role of phase transitions in dough rheology and finished product texture, AACCI Rheology Division, Rheology and Texture of Cereal Foods, Purdue University, West Lafayette, IN.

Kokini, J.L. Restructuring and functionalization of cereal food materials for food and non-food applications using cereal processing and nanotechnology, LACC4 (4th ICC Latin American Cereal Conference), Mexico City, Mexico.

Kokini, J.L. Rheology: Concepts and Fundamentals, AACCI Rheology Division, Rheology and Texture of Cereal Foods, Purdue University, West Lafayette, IN.

Zhang, X., Hamaker, B. Enzymatic modification of corn bran arabinoxylan alters the in vitro fecal fermentation profiles by human gut microbiota, ACS National Meeting & Expo, New Orleans, LA.

April

Ayua, E., Campanella, O., Nkhata, S., Hamaker, B.R. Feed moisture optimization of instant pearl millet flour quality using single screw extruder, International Sorghum Conference, Cape Town, South Africa.

Hamaker, B. Hub-and-Spoke food innovation model empowers rural women to drive markets and improve nutrition in West Africa, International Sorghum Conference, Cape Town, South Africa.

Hamaker, B. Slow digestion property of African traditional millet and sorghum foods, Cape Town, South Africa.

Hamaker, B. Sorghum as a slowly digestible, low glycemic index food and its attendant market opportunities, University of Pretoria Pre-conference Sorghum Workshop, Pretoria, South Africa.

Hamaker, B. Strategies to design dietary carbohydrates to affect physiological systems for better health, Seoul National University, Seoul, Korea.

Hayes, A.M.R., Martínez, M.M., Swackhamer, C., Mennah-Govela, Y.A., Bornhorst, G.M., **Hamaker, B.R.** Insights to the delayed gastric emptying rate and slow digestibility of pearl millet couscous. International Sorghum Conference, Cape Town, South Africa.

Lindemann, S.R. More than keeping you regular: How fiber-microbiome interactions shape health, Indiana Academy of Dietetics Annual Meeting, Fishers, IN.

Lindemann, S.R. Of niches, interactions, and maintenance of microbial diversity: Lessons from environmental and host-associated communities, Miami University Department of Microbiology, Oxford, OH.

Lindemann, S.R. Panel discussion, Madison Microbiome Meeting, Madison, WI.

Lindemann, S.R. The case for niche modeling as a cornerstone of microbiome engineering, Madison Microbiome Engineering Workshop, Madison, WI.

Moussa, M., Hamaker, B. Innovative way of making millet or sorghum couscous using a single screw mini-extruder for the West African market, International Sorghum Conference, Cape Town, South Africa.

May

Campanella, O. Modeling tools to predict inactivation of harmful microorganisms and control of harmful substances generated in food processing, Forum on Food Safety and Health, Guangzhou, China.

Campanella, O. Research on Material Science and Process Engineering at the Whistler Carbohydrate Research Center, South China University of Technology, Guangzhou, China.

Campanella, O. Water-soluble branched dextran with specific molecular weight as a tool to control the viscosity of starch pastes: Effect of filling of interstitial spaces, 14th International Hydrocolloids Conference, Nanchang, China.

Fang, F., Luo, X., **Campanella, O., Hamaker, B.** Shear-induced structure of highly-branched macromolecules influenced by hydrocolloids, International Food Hydrocolloid Conference, Nanchang, China.

Ferruzzi M.G. Role of polyphenol-macronutrient interactions on modification of food functionality and polyphenol bioavailability, Royal Society of Chemistry, Food & Function International Symposium, Xian, China.

Hamaker, B. A case for the role of insoluble fermentable dietary fiber in gut health, International Hydrocolloid Conference, Nanchang, China.

Hamaker, B. How dietary fiber polysaccharides might be used as prebiotics (keynote), Chinese Academy of Engineering International Conference, Guangzhou, China.

Hamaker, B. Strategies to design dietary carbohydrates to affect physiological systems for better health, Workshop on Food Biopolymers and Function, Guangzhou, China.

Mauer, L.J. Food materials science: Fundamentals and opportunities in education, research, outreach, and industry connections, Second Annual Texture Convening Conference, Tate & Lyle, Hoffman Estates, IL.

June

Campanella, O. Material Science Research in the Department of Agricultural and Biological Engineering and the Whistler Center for Carbohydrate Research, Purdue University, Bohai University, China.

Desam, G.P., Li, J., Chen, G., **Campanella, O.,** & **Narsimhan, G.,** Swelling and pasting behavior of maize, rice and cross-linked maize starch, AFRI Annual Awardees Meeting, Boston, MA.

Ferruzzi M.G. Health benefits of phenolic rich beverages: Are we missing something without recommendations for tea and coffee? ASN Nutrition 2018, Boston, MA.

Hamaker, B., Nie, X., Martens, E. Specificity of dietary fiber structures to gut *Bacteroides* utilization (keynote), International Dietary Fibre Conference 2018, Rotterdam, Netherlands.

July

Allan, M., Chamberlain, M.C., Grush, E., Owens, B., **Mauer, L.J.** Deliquescence and anhydrate-hydrate RH-temperature phase diagrams of three hydrate-forming crystalline ingredients: Lactose, trehalose, and caffeine, IFT Annual Meeting, Chicago, IL.

Arioglu-Tuncil, S., Taylor, L.S., **Mauer, L.J.** Degradation of amorphous and crystalline forms of thiamine in controlled temperature and RH environments, IFT Annual Meeting, Chicago, IL.

Bonilla, J. and **Kokini, J.** Fluorescent Imaging of Gliadins, Low Molecular Weight Glutenins, and High Molecular Weight Glutenins in Wheat Flour Dough, Institute of Food Technologists, Chicago, IL.

Campanella, O. Relationships between Dough Rheology and Quality, IFT Annual Conference, Chicago, IL.

Cheng, C.J., Ferruzzi, M., Jones, O.G. Simulated digestion of zein nanoparticles encapsulating lutein, Institute of Food Technologists Annual Meeting, Chicago, IL.

Desam, G.P., Li, J., Campanella, O., Narsimhan, G. Prediction of swelling behavior of crosslinked maize starch suspensions, Institute of Food Technology Annual Meeting, Chicago, IL.

Felten, C., Thorat, A., Taylor, L.S., **Mauer, L.J.** Effects of glycosylated polyphenols on the crystallization of amorphous sucrose, IFT Annual Meeting, Chicago, IL.

Fitriyanti, M., Narsimhan, G., Synergistic effect of low power ultrasonication on antimicrobial activity of cecropin P1 against E. coli in food systems, Institute of Food Technology Annual Meeting, Chicago, IL.

Hamaker, B. Physical processing to increase accessibility of insoluble fibers to gut microbiota, Institute of Food Technologists Annual Meeting, Chicago, IL.

Hamaker, B. Processing of dietary fibers to target specific bacteria groups, Institute of Food Technologists Annual Meeting, Chicago, IL.

Hayes A.M.R., Swackhamer, C., Martínez, M.M., Mennah-Govela, Y.A., Bornhorst, G.M., **Hamaker, B.R.,** Breakdown rate of couscous made from pearl millet versus wheat in a simulated gastric environment linked to gastric emptying, Institute of Food Technologists Annual Meeting, Chicago, IL.

Johnson, K. and **Mauer, L.J.** Effects of controlled HR storage and co-formulation with gluten, sugars, and sodium chloride on moisture sorption and amylopectin retrogradation in gelatinized starch lyophiles, IFT Annual Meeting, Chicago, IL.

Kokini, J.L. Nanotechnology in Food Packaging, International Association for Food Protection, Salt Lake City, UT.

Maldonado, L., Chough, S., and **Kokini, J.L.** Fabrication of Biocompatible Nanotubes (BNTs) from Chitosan/α-lactalbumin and BSA/κ-carrageenan for Curcumin Encapsulation, Institute of Food Technologists, Chicago, IL.

Malm, M. and **Kokini, J.L.** Modulating the surface properties of zein films for improved food packing. Institute of Food Technologists, Chicago, IL.

Mauer, L.J. From crystalline to amorphous and back again: Fundamentals and consequences of solid-state architecture and water-solid interactions. IFT 2018 Marcel Loncin Symposium, IFT Annual Meeting, Chicago, IL.

Schmidt, L.C., Hamaker, B.R. Ability of sorghum phenolic compounds to dynamically polymerize ovalbumin, Institute of Food Technologists Annual Meeting, Chicago, IL.

Voelker, A.L., Taylor, L.S., **Mauer, L.J.** Altering the crystallization tendency of amorphous sucrose utilizing a wide variety of polymers, IFT Annual Meeting, Chicago, IL.

Voelker, A.L., Taylor, L.S., **Mauer, L.J.** Chemical stability and reaction kinetics of two thiamine salts (thiamine mononitrate and thiamine chloride hydrochloride) in solution, IFT Annual Meeting, Chicago, IL.

Voelker, A.L., Verbeek, G., Taylor, L.S., **Mauer,L.J.** Effects of emulsifiers on the moisture sorption and crystallization of amorphous sucrose lyophiles, IFT Annual Meeting, Chicago, IL.

Yildirim, M., Turasan, H., and **Kokini J.L**. LAOS (Large Amplitude Oscillatory Shear) rheological characteristics of shear thickening corn starch as a model for shear thickening rheology, Institute of Food Technologists, Chicago, IL.

Rouf, T.B. and **Kokini, J.L.** Graphene Oxide Reinforced Zein Nanocomposites with Improved Mechanical, Thermal, Barrier and Surface Properties, Institute of Food Technologists, Chicago, IL.

Yao, Y. Phytoglycogen, a next generation of starch family, enables active ingredients for food, Institute of Food Technologists Annual Meeting, Chicago, IL.

August

Ferruzzi, M.G. What is the role of host metabolism in generating bioactivity? Examples of food and host related factors affecting polyphenol metabolite profiles, NIH-ODS workshop on Natural Product Clinical Trials, Washington, DC.

Hamaker, B. Hub-and-Spoke Food Innovation System and key factors for success, Rockefeller Foundation Project Launch, Nairobi, Kenya.

Hamaker, B. Hub-and-spoke Food Innovation Model empowers rural women to drive markets and improve nutrition in West and East Africa, WISHH Conference, Purdue University, West Lafayette, IN.

Hamaker, B. Institutional meals program sustainability: Nutrition studies in Africa - fortified flours that people want to eat, WISHH Conference, Purdue University, West Lafayette, IN.

Maldonado, L., Chough, S., Yilmaz, T., **Kokini, J.L.** Mechanistic understanding of the formation of edible spherical and tubular nanoparticles: Insights of the thermodynamics of interaction, 256th meeting of the American Chemical Society, National Meeting and Exposition, Boston, MA.

September

Ferruzzi, M.G. Effects of food processing on the bioaccessibility and bioactivity of polyphenols, 12th International Congress on Polyphenol Applications, Bonn, Germany.

Hamaker, B., Moussa, M., Bugusu, B. Hub-and-Spoke Food Innovation System and key factors for success, Scale-up Conference, Purdue University, West Lafayette, IN.

Hamaker, B. Things you didn't know about carbs and health, and how they benefit the body, INP Seminar, Department of Nutrition Science, Purdue University, West Lafayette, IN.

Kokini, J.L. Phase Transitions, thermodynamics and kinetics of polyelectrolyte complexation leading to a window of success in the fabrication of Layer by Layer nanotubes, Conference of Food Engineering, Minneapolis, MN.

Lindemann, S.R. Fiber structure and maintenance of microbial diversity, Nestlé Research Center, Lausanne, Switzerland.

Mauer, L.J. Phase transformations of vitamins C and B1 in food production and storage, Conference on Food Engineering, Minneapolis, MN.

Mauer, L.J., Sommer, A. Moisture mediated interactions in complex ingredient blends: Case studies of seasoning blends, EuroFoodWater2018, Prague, Czech Republic.

Mauer, L.J., Allan, M., Grush, E., Rajwa, R., Butzke, C. The water activity of wines and spirits, EuroFoodWater2018, Prague, Czech Republic.

Turasan, H., Cakmak, M., and **Kokini, J.L.** Creating biodegradable corn protein-based electrospun nanofiber platforms for SERS detections, Donald Danforth Plant Science Center Fall Symposium, St. Louis, MO.

Voelker, A.L., Felten, C., Thorat, A., Forny, L., Meunier, V., Taylor, L.S., **Mauer, L.J.** Altering the crystallization tendency of amorphous sucrose utilizing polymers, polyphenols, emulsifiers, sugars, salts, and other co-formulated additives, EuroFoodWater2018, Prague, Czech Republic.

Voelker, A.L., Arioglu-Tuncil, S., Ismail, Y., Sanchez, J., Christina, B., Taylor, L.S., **Mauer, L.J.** Amorphous solid dispersions of vitamins C and B1: Vitamin degradation in the glassy state, EuroFoodWater2018, Prague, Czech Republic.

October

Ayua, E., Campanella, O., Nkhata, S., Hamaker, B.R. Feed moisture influences the pasting and viscoelastic properties of instant flours, AACC International Annual Meeting, London, U.K.

Bonilla, J.C., Schaber, J.A., Bhunia, A.K., **Kokini, J.L.** Simultaneous fluorescent detection of gliadins, LMW, and HMW glutenins in wheat dough using specifically developed antibodies-quantum dots complexes, Wheat Gluten Technical Session, AACCI Annual Meeting, London, U.K.

Chegeni, M., **Hayes, A.M.R.,** Gonzalez, T.D., Manderfeld, M.M., Menon, R., Holschuh, N., **Lim, J., Hamaker B.R.** Slowly digestible carbohydrates reduce gastric emptying in humans suggesting activation of the ileal brake, Cereals & Grains 18, AACC International Annual Meeting, London, U.K.

Hamaker, B. Digestibility of glycemic carbohydrates, Hayashibara, Okayama, Japan.

Hamaker, B. Potential of prebiotics to make changes in the gut microbiota for improved health (plenary), Korean Nutrition Conference, Busan, Korea.

Hamaker, B. Slowly digestible carbs: Focus on digestion and nutrition aspects, Roquette Co., Letrem, France.

Kokini, J.L. The LAOS behavior of food materials and its importance in quality and processing history, 1st Conference on the Rheology and Texture of Foods, Istanbul, Turkey.

Lindemann, S.R. Fiber carbohydrate structure governs microbial diversity and metabolism, CP Kelco, San Diego, CA.

Lindemann, S.R. The influence of fiber structure on the structure and function of gut microbiota, 3rd Probiotics Congress, San Diego, CA.

Malm, M., and **Kokini, J.L.** Fabrication of biodegradable corn zein films with varying hydrophobic/hydrophilic balance using different techniques, American Institute of Chemical Engineers International Conference 2018, Pittsburgh, PA.

Mauer, L.J. Challenges encountered in the amorphization and crystallization of small molecules in solid dispersions… and lessons learned about sucrose, Ingredion, Bridgewater, NJ.

Mauer, L.J. Update on CFSE approaches for developing novel pathogen detection technologies, CFSE-USDA Annual meeting, Philadelphia, PA.

Rouf, T.B., and **Kokini, J.L.** Eco-friendly fabrication and characterization of mechanically strong, thermally stable, largely impermeable and biodegradable zein-graphene oxide nanocomposites, American Institute of Chemical Engineers International Conference 2018, Pittsburgh, PA.

Schmidt, L., Hamaker, B.R. Developing phenolic-mediated stable protein matrices in cereal grains for potential control of starch digestion, AACC International Annual Meeting, London.

Torres-Aguilar, P., Yepez, X., Hayes, A.M.R., Martínez, M.M., **Hamaker, B.R.** Effect of pearl millet extrusion on the formation of amylose-lipid complexes and their slow digestion property, Cereals & Grains 18, AACC International Meeting, London.

Turasan, H., Cakmak, M., and **Kokini, J.L.** Fabrication and decoration of zein-based electrospun nanofiber platforms for SERS detection, American Institute of Chemical Engineers International Conference 2018, Pittsburgh, PA.

Yildirim, M., Turasan, H., and **Kokini, J.L.** The effect of instrumental inertia on large amplitude oscillatory shear (LAOS) testing of starch suspensions, Society of Rheology Conference, Huston, TX.

November

Bonilla, J.C., Schaber, J.A., Bhunia, A.K., **Kokini, J.L.** 'In situ' fluorescent detection of gliadins, LMW glutenins, and HMW glutenins in wheat dough using antibodies-quantum dots complexes, Global Food Science Student Competition at Jiangnan University, Wuxi, China.

Hamaker, B.R. Role of dietary carbohydrates in activation of the gut-brain axis and effect on food intake, 7th International Genetic Disorders Conference, Dubai, U.A.E.

Kokini, J.L., Liu, G.L., Gezer, G., **Barber, E., Turasan, H., Jia, F., Ma, X.** Biodegradable Biosensor platforms from gold coated zein nanophotonic films and fibers to detect food allergens and toxins, International Forum of Marine Foods and Molecular Nutrition (III): Advanced Technologies in Food Processing, China Ocean University Qingdao, China.

Li, J., Desam, G. P., Campanella, O., Narsimhan, V., **Narsimhan, G.** Volume fraction dependence of the elastic behavior of starch suspensions, American Institute of Chemical Engineers Annual Meeting, Pittsburgh, PA.

Narsimhan, G. Antimicrobial peptides in food safety, 2018 International Forum of Marine Foods and Molecular Nutrition, China Institute of Food Science and Technology Annual Meeting, Qingdao, China.

Narsimhan, G. Pore formation by antimicrobial peptides in cell membranes, American Institute of Chemical Engineers Annual Meeting, Pittsburgh, PA.

Rouf, T.B., and **Kokini, J.L.** Mechanistic understanding of the fabrication and characterization of graphene oxide reinforced zein nanocomposites with improved mechanical, barrier and thermal properties, SMART Films Consortium Workshop, Birck Nanotechnology Center, West Lafayette, IN.

Turasan, H., Cakmak, M., **Kokini, J.L.** Fabrication and decoration of zein-based electrospun nanofiber platforms for SERS detection, SMART Films Consortium Workshop, Birck Nanotechnology Center, West Lafayette, IN.

December

Hamaker, B.R. Towards designing of healthier carbohydrate-based processed foods, International Conference on Advanced Technology in Food Science and Biotechnology (keynote), My Tho City, Vietnam.

C. Graduate Degrees Awarded

Spring 2018

1. **Matthew Allan**, Ph.D., *Food materials science: RH-temperature phase diagrams of deliquescent and/or hydrate forming crystals, effects of sweeteners on starch gelatinization, and the water activity of wines*

2. **Xing Fei**, Ph.D., *Plant cell wall modification during tomato processing and its effects on the physical and rheological properties of end products*

3. **Ingrid Aragon Gallegos**, Ph.D., *Impact of processing of biofortified cassava and peach palm fruits on provitamin A carotenoid recovery and bioaccessibility*

4. **Aminata Diatta**, M.S., *Using corn zein to improve the quality of gluten-free bread*

5. **Cheikh Ndiaye**, Ph.D., *Quality and nutritional impacts of extrusion on pearl millet and nutrient dense native blends*

6. **Elizabeth Pletsch**, Ph.D., *Controlling the gastric emptying rate of whole grain foods using physical properties and methods to slow starch digestion*

Summer 2018

7. **Emma Barber**, M.S., *Optimization of zein based surface enhanced raman spectroscopy biosensor for the detection of Gliadin as a marker for Celiac Disease*

8. **Luis Maldonado Mejia**, Ph.D., *Mechanistic understanding of the design and characterization of biocompatible nanodelivery systems for the encapsulation and delivery of Curcumin*

9. **Angarika Rayate**, M.S., *Interactions between sodium caseinate and polyglucose in aqueous solutions*

10. **Randol Rodriguez Rosales**, Ph.D., *Phytoglycogen and its derivatives to incorporate Curcumin for enhanced solubility and efficacy*

Fall 2018

11. **Chris Cheng**, Ph.D., *Novel applications for zein nanoparticles*

12. **Marwa El Hindawy**, Ph.D., *Maltooligosaccharide chemosensation by intestinal enteroendocrine l-cells regulates the endogenous release of gut hormones and may affect weight gain*

13. **Collin Felten**, M.S., *Food materials science: Effects of polyphenols on sucrose crystallization and characterization and creation of alternative salts of thiamine*

14. **Andrew Hirsch**, M.S., *Functional properties of protein and chitin from commercial cricket flour*

15. **Xingyun Peng**, Ph.D., *Advanced characterization of glucan particulates: Small-granule starch, retention of small molecules, and local architecture defined by molecular rotor*

16. **Patrick Sweet**, M.S., *Analysis of biomass composition in a sorghum diversity panel*

17. **Seda Tuncil**, Ph.D., *Investigating stability in amorphous solid dispersions: A study of the physical and chemical stability of two salt forms of thiamine and the physical stability of citric acid*

18. **Ximena Yepez**, Ph.D., *Characterization and analysis of high voltage atmospheric cold plasma treatment of soybean oil*

D. Recognitions, Awards, and Honors

1. **Pablo Torres Aguilar**
   B.J. Liska Outstanding Teaching Assistant Award

2. **Jose Bonilla**
   Second Place, Agriculture and Biological Engineering Industrial and Research Annual Symposium, Purdue University

   Walter Bushuk Graduate Research Award in Cereal Protein Chemistry, AACCI

   First Place, Global Food Science Student Competition, Jiangnan University, Wuxi, China

   First Place, Protein Division Oral Competition, IFT

3. **Sarah Corwin**
   Third Place, Product Development Competition, ASB

4. **Fang Fang**
   Best Presentation, Texture Technologies Quality Research Award, AACCI

5. **Collin Felten**
   Third Place, Product Development Competition, ASB

6. **Anna Hayes**
   Poster Competition Finalist, Nutrition Division, IFT
   Feeding Tomorrow Scholarship Recipient, 2018-2019, IFT

   Best Student Research Award, Nutrition Division, AACCI

7. **Jinsha Li**
   Outstanding Service Award, College of Engineering, Purdue University

8. **Luis Maldonado**
   B.J. Liska Outstanding Teaching Assistant Award, Department of Food Science, Purdue University

   Teaching Academy Graduate Teaching Award, Center for Instructional Excellence, Purdue University

9. **Morgan Malm**
   Second Place, Food Packaging Division, Phi Tau Sigma & IFT

10. **Gabriella Medes Candido de Oliveira**
    Bilsland Fellowship, Purdue University

11. **Xingyun Peng**
    Bilsland Dissertation Fellowship, Purdue University

12. **Arianna Marcia Romero**
    Third Place, Global Food Science Student Competition, Jiangnan University, Wuxi, China

13. **Hazal Tursan**
    Travel Award, Purdue Graduate Student Government, Purdue University

    Travel Award, Donald Danforth Plant Science Center

E. Special Events

Whistler Center Short Course, October 2–4, 2018

As is our tradition, the course was designed to provide one day on carbohydrate fundamentals followed by two days of advanced special topic sessions. Day 1 consisted of a general session. Advanced topical areas were presented on days 2 and 3, so that each participant could attend three advanced topic sessions of their choice.

- Introduction to carbohydrates: Basic concepts – monosaccharides, oligosaccharides, and polysaccharides, Y. Yao
- Starch granule structure and properties, J. BeMiller
- Basic principles in rheology and viscoelasticity, J. Kokini
- Polyols, high-intensity sweeteners, and non-chemical modifications of starch, Y. Yao
- Chemical modification of polysaccharides, J. BeMiller
- Carbohydrate nutrition and labeling, B. Hamaker

Wednesday and Thursday Breakout Sessions

Phase stability of polysaccharide mixtures, O. Jones

Hydrocolloids and functionality (Part I & II), J. Keller

Glycemic carbs and the concept of carbohydrate quality, B. Hamaker

Extrusions technology for the productions of food and non-food materials, O. Campanella

Dietary fibers, gut microbiome and health, B. Hamaker

Complex carbohydrate structure analysis (non-starch) (Part I & II), B. Reuhs

Advances in chemical and physical modifications of starch (Part I & II), J. BeMiller

Fiber carbohydrate-microbiome interactions, S. Lindemann

Phenolic-starch interactions as modifiers of functionality and starch digestibility, M. Ferruzzi

Sugars and dietary fiber functionality: From fundamentals to product development (Part I & II), S. Renzetti

Predictive modeling of multiphase systems (Part I & II), G. Narsimham

Polysaccharide architecture and functionality, S. Janaswamy

Physical property testing of carbohydrates – solids, L. Mauer

An introduction to advanced methods of food material characterization, J. Kokini

Rheological properties of food biopolymers and their role in bioprocessing and product development

2018 Belfort Lecture

2018 Belfort Lecturer

Dr. Lubbert Dijkhuizen

Professor of Microbiology
University of Groningen

The Belfort Lectures were established and endowed by Dr. Anne D. Belfort in memory of her late husband, Dr. Alan M. Belfort, who was awarded a Ph.D. degree from Purdue University in carbohydrate chemistry in 1960. Support for the Belfort Lectures is generously continued by Alan and Anne's daughter Anne E. Belfort. Persons honored by being chosen to give a Belfort Lecture are scientists who have made outstanding contributions to glycoscience.

Dr. Lubbert Dijkhuizen, professor of Microbiology, initiated many research projects into life processes in micro-organisms and relevant industrial and other applications of this fundamental knowledge. The main focus in this research is on the ability to use micro-organisms and enzymes in biotechnological processes, in particular in the conversion of carbohydrates. Dijkhuizen's research also focuses on tuberculosis.