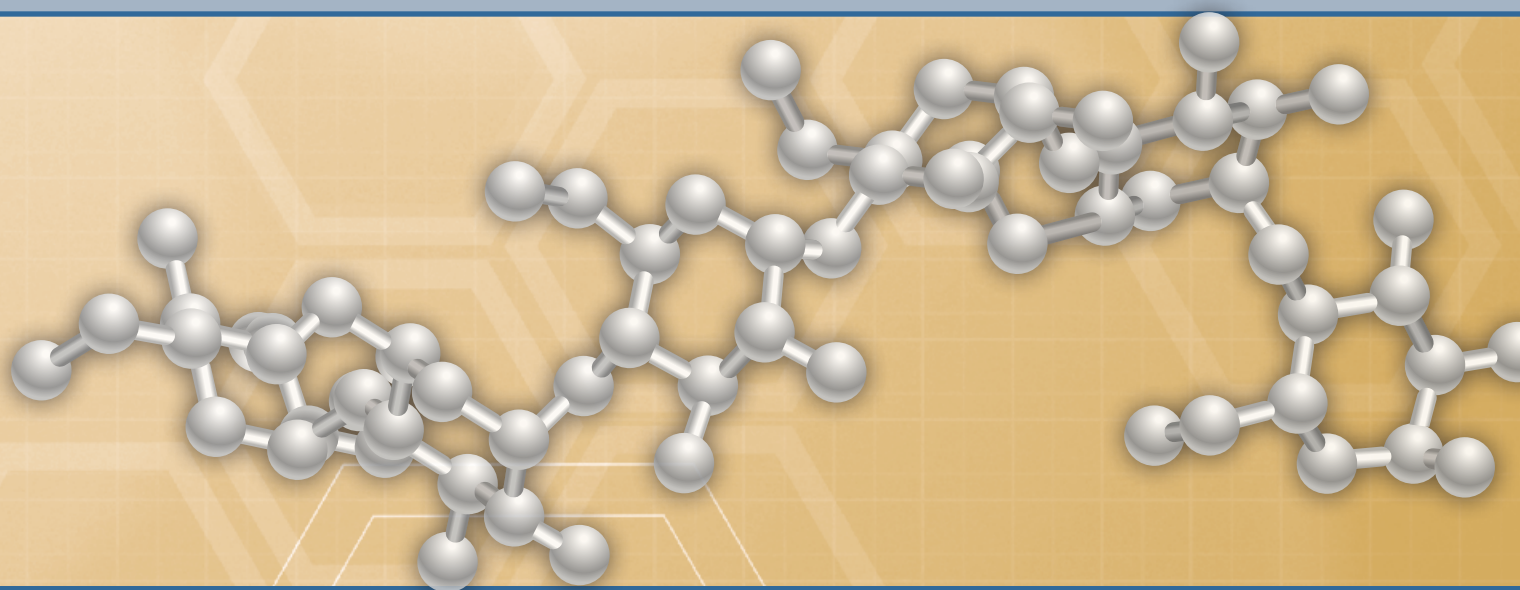


# WHISTLER CENTER for Carbohydrate Research



**2016**  
ANNUAL REPORT

**PURDUE**  
UNIVERSITY

# **Industrial Members**

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# Table of Contents

---

Director’s Statement ..... 5

Summary of Major Research Accomplishments ..... 7

Staff Directory ..... 11

Faculty..... 14

Adjunct Faculty..... 19

Visiting Professors ..... 20

Visiting Scientists ..... 22

Graduate Students..... 25

Ph.D. Post-Doctoral Research Associates ..... 36

Staff..... 38

Our People, Our Projects..... 39

Project Summaries ..... 41

Papers, Books, Book Chapters, and Patent Applications Published ..... 58

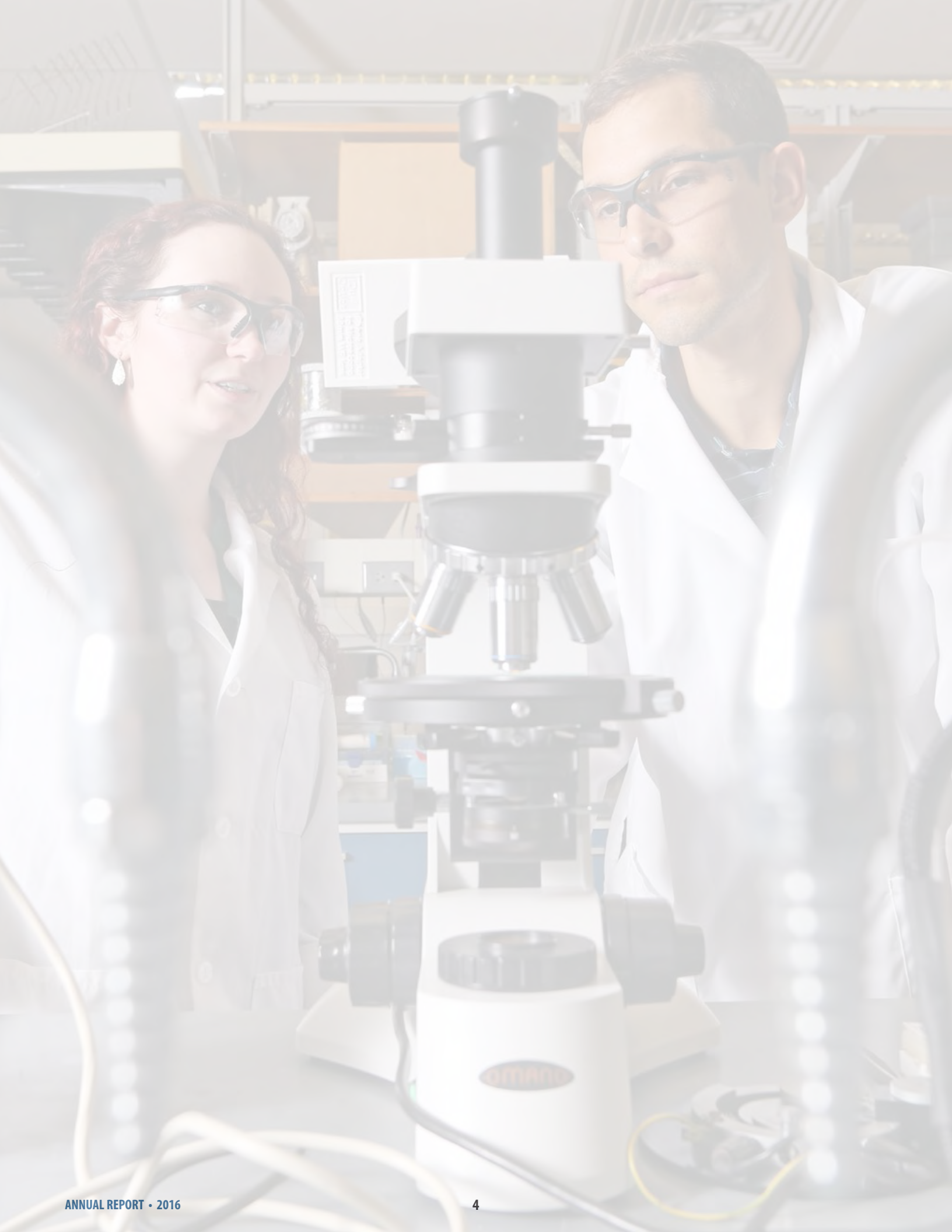
Papers Presented at Meetings, Conferences, and Invited Public Lectures ..... 62

Graduate Degrees Awarded..... 65

Recognitions, Awards, and Honors ..... 65

Special Events..... 66

Belfort Lecture..... 67



## Director's Statement

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Welcome to the Whistler Center for Carbohydrate Research annual report. In May 2016, at our annual meeting, we marked our 30th anniversary. Professor Philip Nelson, department head of Food Science, and Professor Roy Whistler started the Whistler Center for Carbohydrate Research in 1986. Professor James BeMiller became the founding director. Today, we are known for high-quality carbohydrate research, service to industry and the public, and our global reach.

Much has changed at the Whistler Center in three decades, and the same is true for the research and commercial environment related to food carbohydrates. One area that is taking off is gut microbiome and health. This frontier research field is beginning to show the mechanistic underpinnings to link the colon bacteria communities to development of chronic non-communicable diseases, such as obesity, metabolic syndrome diseases (diabetes), and even neurological diseases (Parkinson's disease.) Because dietary fibers are a main source

of nutrients for the bacteria, there is the potential, through their use, for making favorable shifts to the gut microbiome to improve health.

At the Whistler Center, we, along with medical centers and partners in microbiology, have been working on fibers as prebiotics for such functions. As part of an initiative by Purdue University, the Department of Food Science obtained a new faculty position in gut microbial ecology, and in August we welcomed Steven Lindemann to the department and Whistler Center. Professor Lindemann's research targets the ways that dietary influences shape the gut microbiome and the effects of those shifts on health (such as inflammation and gut colonization by pathogens) with the goal of identifying dietary solutions to health problems. We are thrilled to have Steve join the Whistler Center and become part of our vibrant research team in this important area.

Consumers react quickly these days to new food options, and shifts in buying habits also change. We recognize this and, though much of our research is fundamental in scope, we work and conduct research to solve immediate or near-term problems encountered by companies. The 12 faculty members of the Whistler Center cover a broad range of expertise in uses of food carbohydrates related to structures and functions for texturizing properties, coatings, delivery materials, and improved health and well-being. We also work on carbohydrates and water relations, plant genetics, and process optimization. Our analytical service provides analysis and interpretation of complex carbohydrate structures and their functionality.

In 2016, we welcomed Nestlé (Nestlé Research Center-Lausanne) as an industrial member and Wendy Madore as the Whistler Center Coordinator. Wendy comes with a wealth of experience at different levels of Purdue administration. We were sorry to see colleagues and friends leave us in 2016: Professor Mario Ferruzzi to North Carolina State University (still an adjunct professor to the Center and department), Dr. Srinivas Janaswamy to South Dakota State University as a tenure-track faculty, and our previous Coordinator, Mikaela Allen, to a local community position.

Please take some minutes to look through our 2016 Whistler Center annual report and see what we are up to. Feel free to contact Wendy or me with questions or for further information.

Sincerely,

A handwritten signature in black ink that reads "Bruce R. Hamaker". The signature is written in a cursive, slightly slanted style.

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





# Summary of Major Research Accomplishments

## Starches, non-starch polysaccharides, and cereals

**Dr. BeMiller** continued to publish on the impacts of the presence of hydrocolloids on the pasting, paste, and gel characteristics of starches; with the objective of establishing a rational basis for selecting native or modified food starches combined with a hydrocolloid for food use (Project 1).

**O. Campanella and B. Hamaker** have shown an interesting amylopectin aggregation phenomenon when a gelatinized waxy starch paste is exposed to shear, with shear-thickening result. This effect was amplified when a fairly low shear stress was applied at 4° C. This may have processing implications as well as in the stomach where a similar degree of shear is found (Project 2). The effect of viscosity of dietary fibers was also found to influence growth rate of isolated colon bacteria (*Bacteroides spp.*) in a model system, and a Matlab model was developed to explore the mobility of microbes, substrates and metabolites in viscous media (Project 6). Molecular dynamics simulation was used to study interactions between amylose and free fatty acids (Project 7).

**Dr. Campanella's** group furthered work on the development of models to describe food processes that promote the expansion of food products due to high temperatures and bubble growth. The models incorporate expansion and growth of vapor bubbles and deformable viscoelastic matrices (Project 4). Other work continued on development of models to be used to describe non-thermal processes that inactivate pathogenic bacteria in beverages (Project 5).

**B. Hamaker, O. Campanella, O. Jones and G. Schmidt** are developing starch-based nanoparticles for gastrointestinal cancer drug delivery (Project 13). The goal is to use benign and water-soluble nanoparticles from amylose, protein, and lipid carriers to deliver hydrophobic drugs. The nanoparticle carriers and degradation products are relatively inert with low or negligible toxicity within the digestive tract. Several collaborators from different departments are involved. Two proposals have been submitted with one proposal funded. Other preliminary studies, including scale up procedures, are underway.

**L. Mauer's** group takes materials science approaches to manipulate and investigate food ingredient structures and functions, including ongoing studies of the effects

of a variety of sweeteners and storage environments on starch thermal and functional properties (Project 24). Additional studies used a variety of small molecules and hydrocolloids to disrupt the crystallization tendencies of sugars, vitamins, and organic acids to build a framework of understanding around intermolecular non-covalent interactions, material properties (including glass transition temperatures, moisture contents, water activities, and viscosities), and storage environments (RH and temperature) on the physical state (amorphous and crystalline) and chemical reactivity of common food ingredients (Projects 25). Mauer's group also developed methods to generate RH-temperature phase diagrams of hydrate-forming deliquescent crystalline ingredients, including glucose and citric acid (Project 26). Investigations of blends of deliquescent crystalline ingredients (sucrose, fructose, sodium chloride) with amorphous maltodextrins generated valuable information about the relationships between deliquescence relative humidities (RH<sub>0</sub>s), critical water activities for glass transition events, temperature effects on both RH<sub>0</sub>s and amorphous ingredient water activities and the crossover points between these events, and the material properties of crystalline-amorphous blends in controlled temperature and RH environments (Project 26).

**Y. Yao's** work in 2016 was closely associated with the carbohydrate biomaterials in food and pharmaceutical areas, with emphases on the pathogen biofilm formation (Project 41), antimicrobial strategy (Project 42), dissolution of active ingredients (Project 39), and novel starch materials (Project 40). In addition, he collaborated with Purdue's College of Veterinary Medicine on the study of carbohydrate nanoparticle-based vaccine adjuvants.

## Carbohydrates, nutrition, and health

A significant area of research continues in the area of carbohydrates and health at the Whistler Center, and expanding in 2016 with the inclusion of a new faculty member, Steve Lindenman, in gut microbial ecology. This will result in an expanding of work in the area of dietary fiber and the gut microbiome related to health. We also continue to be active in research on glycemic response and related physiological effects of starch and other glycemic carbohydrate. **B. Hamaker's group** showed that dietary fibers respond differently in

distinctly different gut microbiota communities (*Prevotella* and *Bacterioides* enterotypes) and that short chain fatty acid outcomes are substantially different depending on the community structure (in collaboration with L. Zhao, Shanghai Jiao Tong University), and that insoluble fermentable fibers promote different groups of bacteria than soluble fibers that are associated with health-related endpoints (in collaboration with A. Keshavarzian, Rush Medical School) (Project 9). With E. Martens at University of Michigan Medical School, we have found high specificity of dietary fiber structures to competitive needs of bacteria, as studied in model systems (Project 10). In work focused on the upper gastrointestinal tract, we have found that starch  $\alpha$ -amylase digestion products are stimulatory to secretion of the gut hormone, glucagon-like peptide-1 (GLP-1), with higher response than to glucose or the short chain fatty acids of fiber fermentation, implying that slow starch digestion may have a satiating property (Project 12). Our work with **M. Ferruzzi** on phenolic inhibitors of the  $\alpha$ -glucosidases also continues (Project 11).

**M. Ferruzzi** has developed a research program focused on fundamental and applied aspects of both food science and nutrition disciplines. His long-term goal is to identify food science strategies that will contribute to the prevention of chronic disease in humans. Working toward this goal, **M. Ferruzzi** bridges the food and nutrition sciences by investigating the impact of the food matrix and processing on the physical and chemical stability, and bioavailability of phytochemicals. His primary research focus areas include: development of methods for determination of phytochemicals in complex matrices, assessment of phytochemical stability and reactivity in food systems, including interactions with carbohydrate and protein macromolecules, and determination of factors impacting phytochemical bioavailability from foods (Project 8).

Q. Xu, G. Schmidt, and **B. Hamaker** are investigating walnut phenolics with anti-cancer activity from the Indiana black walnut tree (Project 31). The goal of this research is to evaluate how phenolics extracted from black walnut shells and wood can be used to prevent and possibly cure diseases associated with oxidative stresses such as cancer. Screening these for antioxidant properties and anti-cancer activity is being done, and this approach is significant because it will add value to the Indiana black walnut tree by utilizing the shells and wood considered to be waste.

**G. Schmidt**, J. Wilker and Food Science faculty are working on a project to make adhesives from food components. Polysaccharides are being modified and formulated in the presence of small molecule components from food. The hypothesis is that glucose-based polymers can be used for designing non-toxic, strong and wet-setting glues. These new adhesives may find applications in food packaging, surgery and dentistry as well as biomedical applications. Preliminary results are showing that in-situ reactions can transform polysaccharides into high-strength adhesives (Project 32). Bond strengths can be up to 1/3 of commercial Super Glue. Ongoing studies are generating more results for publications and NIH proposal submissions.

## Polysaccharide structures

**S. Janaswamy's** research demonstrates the potential of utilizing polysaccharide fibers as cost-effective carriers of nutraceuticals and antimicrobial compounds. His group's research is to solubilize bioactive compounds in the organic solvents and to encapsulate in the water pockets of polysaccharide networks. Their systematic study on the encapsulation efficiency and release profiles of curcumin and resveratrol employing sodium iota-carrageenan (IC) revealed interesting results (Project 15). The work is toward developing value-added delivery systems of nutraceuticals, in particular, health promoting and disease preventing compounds, in general, based on the ordered polysaccharide networks. In addition, eugenol and carvacrol, essential oils, encapsulation in the sodium iota-carrageenan fibers demonstrates that the complexes have antimicrobial activity against *Listeria innocua* F4248, *Listeria monocytogenes* F4244, *Salmonella Enteritidis* ENT 1344, *Salmonella enterica* serovar Heidelberg 513, *Escherichia coli* O157: H7 ATCC 43295 and *Staphylococcus aureus* ATCC 25923 (Project 14). It appears that intrinsic functionality of essential oils can be preserved by encapsulating them in the ordered polysaccharide matrices for inhibition of growth of food spoilage microorganisms.

Interactions between polysaccharides and other components, particularly proteins, help to define the functionality and behavior of those components in food systems. Building upon previous experiments, work in **O. Jones'** group has demonstrated strong associative interactions between whey proteins and modified chitosan (Project 16), as well as between iota-carrageenan and zein aggregates (Project 17). In both



cases, the interacting polysaccharide increased stability of the protein components to aggregation in specific conditions of pH and concentration but reduced stability in other conditions. Efforts are also underway to confirm and further explore the notion that unmodified, solubilized starch chains can actually associate with proteins (Project 17), a concept not easily explored or clearly established in the literature.

Many polysaccharide-rich products have a physical structure resulting from an interplay between larger structures (e.g., colloidal assemblies, cells) and the polysaccharides. Colloidal assemblies of proteins are particularly of interest to **O. Jones**' research, and these protein colloidal assemblies can be spherical or fibrous in nature. Spherical protein assemblies generally result from rapid association of the protein in dilute-to-semi-dilute conditions, and **O. Jones**' group has prepared spherical assemblies from whey proteins or grain proteins in past years. For the past several years, **O. Jones** has studied the properties of fibrous structures from heat-treated whey proteins that can be stabilized in non-acidic pH conditions by interacting them with charged polysaccharides. In 2016, this work was furthered by identifying the capacity of the whey protein fibers to improve the properties of cellulose-based films and to facilitate the growth and differentiation of live cells (Project 18). Focus has also been given to spherical and fibrous assemblies of the corn protein, zein, which is poorly soluble in water. A recent project has shown that stabilizing spherical zein particles with interactive iota-carrageenan reduced aggregation and sedimentation, allowing these zein nanoparticles to disperse within composite films and improve their properties (Project 18). Fibrous protein assemblies of zein have also been formed using electrospinning techniques. These fibrous proteins have excellent capabilities to provide structural integrity to composite materials at low added weight fraction. One application of these zein fibers is to replace natural fibrous proteins, and a project of **O. Campanella** and **O. Jones** has investigated the use of zein fibers in gluten-free bread doughs (Project 18). Particulate assemblies, particularly those that are of a "soft" and deformable nature, have also been investigated in **O. Jones**' laboratory for the stabilization of emulsions or foams. To optimize specific emulsification properties in dynamic environments, it is desirable to selectively modify the deformability of these particulate assemblies. In the past year, a project was carried out to identify specific environmental conditions in which whey protein assemblies would expand or contract in

aqueous suspensions (Project 19). Future work will then determine the impact of this relative expansion and theoretical deformability on their ability to stabilize liquid-liquid interfaces. A new project is also planned that will apply these concepts to a polysaccharide-based assembly.

## Rheology

**O. Campanella**'s projects involve rheological and physicochemical characterization of biomaterials including food and non-food materials. The group is interested specifically in properties that are associated with the formation of structures, and the role of these physicochemical properties is also being analyzed in regard to material processability. Changes in proteins structures and their functions by changes in temperature, addition of other macromolecules such as co-proteins are being studied using rheological and spectroscopic techniques (e.g. circular dichroism, FTIR, isothermal calorimetry) and microscopy. Properties of these composite systems such as their rheology, and their structures, and how they affect the material's functional properties are being studied (Projects 2, 3, 4). Results of this research have an impact on the area of development of new materials and foods with good nutritional and textural qualities.

Development of new materials and understanding the physicochemical behavior of existing ones require a scientific foundation involving modeling and experimental validation. **O. Campanella**'s group also focuses on the functional efficacy of natural polymers used as part of food ingredients (Project 4). In these projects, rheological, thermophysical, spectroscopic and microscopic methods are being developed to study the effects and use of ingredients that can improve the functionality in food and non-food products. For instance, model systems are used to understand the mechanisms of viscoelasticity enhancement of non-gluten cereal-based systems like the protein zein. This functional change is believed to be the result of developing fibrous,  $\beta$ -sheet-rich protein networks; however, current understanding of the physicochemical properties of these polymers is limited. This research aims to present mechanistic frameworks for approaching these systems by highlighting structure/function relationships. With **B. Hamaker**, novel physicochemical and rheological methods are being developed to monitor the formation, stability, and scale-up of a nanocomplex formed by the interaction of starch (Project 13).

## Interfacial phenomena

**G. Narsimhan's** group continues to work on fundamental aspects of interfacial phenomena in food and biological systems. They are investigating pore formation in microbial cell membranes by antimicrobial peptides (Projects 27, 28) and characterization of connection between structure and pasting behavior of starch (Project 29).

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

## Genetics

**C. Weil's** lab has continued their work phenotyping genetically diverse collections of corn, sorghum and, more recently, pearl millet for novel and useful traits. Those relating to carbohydrates include overall content and type, digestibility and partitioning within the plant. Part of this work has been as part of a multidisciplinary team, including both engineering and plant science faculty, to develop remote sensing technologies for plant phenotyping in the field using color imaging, hyperspectral imaging and LIDAR mounted on tractor frames as well as flying on unmanned aerial platforms.

Characterizing the cell wall composition of over 1000 diverse sorghum lines has revealed associations of a region on sorghum Chr VI with a highly favorable lignin composition that helps release glucose from the biomass for processing into biofuels. In addition we have identified a small region of chromosome IX that is

associated with increased glucan and xylan content. Genes in these regions are currently under further investigation. Additional associations that control a set of 20 agronomic and morphological traits are also under further study.

Another project, in collaboration with **Y. Yao**, has been evaluation of phytyglycogen as a biodegradable nanomaterial. Phytyglycogen forms as a major component of maize endosperm in mutants defective for the starch debranching enzyme encoded by the *sugary1 (su1)* gene. The extensively branched polysaccharide forms spherical molecules, expansion of which is likely limited by the degree of branching; once there is no more room to add new branches the growing sphere cannot continue to get larger. We are testing this idea by comparing the phytyglycogen particle size distribution of various *su1* alleles, as well as combinations with alleles of other starch debranching enzymes

A third project examines how plants partition the carbon they fix during photosynthesis into different forms and different locations within the plant. In corn, this is typically as starch in the kernels of the ear, but in close relatives of corn (sugarcane and sorghum), the carbon can be stored as high levels of sugar in the stalk. Both from a biofuel and from a food ingredient standpoint, it would be useful to develop varieties that grow to large biomass and that accumulate sugar in the stalk, similar to what is observed for sugarcane or sweet sorghums. Several tropical varieties of maize already show significantly larger plants (up to 5 meters) and higher stalk sugar (as high as 20%) than is typical for corn; we are pursuing breeding strategies to better understand the genes responsible and their control of this process. We have developed a series of seven inbred lines derived from various tropical germplasm and are now evaluating hybrids of these lines.

The Weil lab has continued to characterize mutant lines of corn that show altered starch digestion. Recently this project has shifted to mapping genes for variation in starch digestibility of both cooked and uncooked flour in diverse maize inbreds. One inbred is notable for its more rapidly digested uncooked starch, which has tremendous potential as an improved poultry feed ingredient. Two QTL have been identified from these experiments, and the genes within them are being analyzed.

# Staff Directory

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## Faculty

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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



### **R. Chandrasekaran**

#### *General Research Areas*

- X-ray diffraction
- Molecular architecture of biopolymers

#### *Specific Research Areas*

- Starch crystallinity
- Conformation of carbohydrates and nucleic acids
- Structure-function relationships in polysaccharides and polysaccharide mixtures
- Implementation of modern techniques to fiber diffraction



## 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*

- Manipulation of starch digestion rate for low glycemic response/slow digestion
- Dietary fiber, modifications in functionality and gut fermentability, gut microbiota changes
- 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
- Electron and confocal microscopy of cereal components



## Srinivas Janaswamy

### *General Research Areas*

- X-ray crystallography
- Biopolymers structure and functionality

### *Specific Research Areas*

- Molecular structure, junction zone details of polysaccharides and polysaccharide blends and relationships to macroscopic behavior
- Developing novel and cost effective delivery systems using food hydrocolloids
- Structure-function relationships in biomaterials
- Tailoring polysaccharide structures for improved functionality
- Molecular dynamics simulations
- Starch crystallinity
- Biotexture of plant tissue derivatives



## 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
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## **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
- Plant cell wall compositions, structures, and functions
- Bacterial cell wall compositions, structures, and functions

### *Specific Research Areas*

- Extractions and purification of acidic polysaccharides from cell walls of plants and bacteria
- Pectin analysis
- Capsule, gum, and lipopolysaccharides analysis
- Application of HPLC, GC-MS, and NMR to structural studies of carbohydrates, including polysaccharides
- Role of polysaccharides in bacteria-legume symbiosis
- Detection of bacteria in plant roots



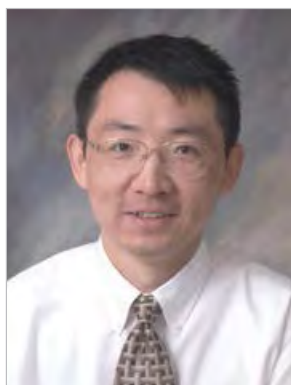
## Clifford F. Weil

### *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*

- Biomaterials for food and health
- Chemistry and genetics of carbohydrate polymers
- Nanotechnology for foods and drugs

### *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 structure and function analyses

## Adjunct Faculty



**Yonas Gizaw, Ph.D.**, is Principal Scientist at The Procter & Gamble Co. Currently he is a 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 he 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), VP R&D (1995-2000), VP R&D 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.**, retired from General Mills in March 2015 after more than 20 years and is now a strategic advisor. He 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

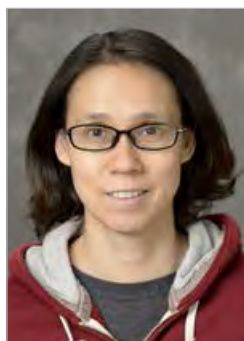
Buehler AG in Switzerland. In 1994, Bernhard joined General Mills, Inc. in Minneapolis and was Chief Scientific Officer and Vice President for Technology Strategy. He led the development of key enabling technologies resulting in major product innovations. Bernhard authored/co-authored over 100 patents, established a Game Changer program and created a novel “Cashless Venturing” initiative, enabling faster and more disruptive innovations.

## Visiting Professors



**Hanqing Chen** earned B.S. and M.S. degrees from the Department of Animal Science and Technology at Anhui Agricultural University in July 1991 and July 1998, respectively. He obtained his Ph.D. degree from the Department of Food Science and Technology at Jiangnan University in July 2005. Now

he is a professor in the College of Food Science and Engineering at Hefei University of Technology. He joined Dr. Campanella's group as a Visiting Professor in September 2016 with the research topic of structure and rheological properties of starch.



**Jingling Fan** is an Associate Professor of Food and Bioengineering, Henan University of Science and Technology, China. She received her Ph.D. of Food Science from Jiangnan University, China. Her research is in phytochemical chemistry with focus on food pigments and flavonoids. She

joined Dr. Yao's lab in July as a Visiting Scholar, with her research project focused on development of strategies for incorporation and stabilization of flavonoids with carbohydrate.

**He Liu** is a Visiting Professor in the College of Food Science and Engineering, Bohai University, Jinzhou, Liaoning, China. He worked with Dr. Reuhs and Dr. Campanella on tomato processing/viscosity during his stay at Purdue.



**Jae-Hoon Shim** is an Associate Professor in the Department of Food Science and Nutrition at Hallym University. His research focuses on food enzymology and food microbiology. He is a sabbatical Visiting Professor.



**Xiang Xiao** received her M.S. and Ph.D. degree in Food Science from Jiangnan University in 2006, and Jiangsu University in 2013. Her Ph.D. study was about microbial diversity and meat safety. She joined Dr. Hamaker's group as a Visiting Scholar in March 2016. Her research mainly focuses on the delivery and

absorption of nanoparticles.

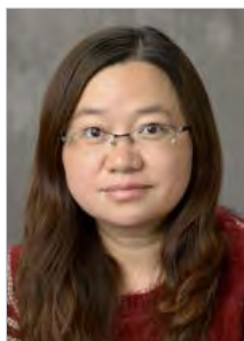


**Jianhua Xie** received B.S., M.S. and Ph.D. degrees in Food Science and Engineering from Nanchang University in 2005, 2008 and 2015, respectively. His M.S. study was about purification, structure and bioactivities of polysaccharides from food resources. His Ph.D. research focused on

modification of polysaccharides from *Cyclocarya paliurus* and their biological activities. He joined Dr. Hamaker's group as a Visiting Professor (postdoctoral fellow) in September 2016 with a governmental scholarship from China Scholarship Council. His research focuses on dietary fiber structure and gut microbiome.



**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 2016 with Dr. Hamaker.



**Danshi Zhu** is an associate professor in the College of Food Science and Engineering, Bohai University, Jinzhou, Liaoning, China. She worked with Dr. Reuhs and Dr. Campanella on a tomato viscosity project during her visit to Purdue.

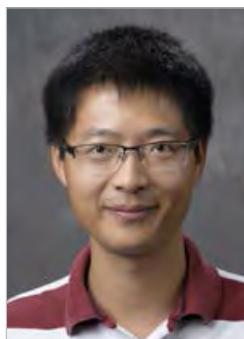
## Visiting Scientists



**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.

**Floriane Brunel** graduated with a Bachelor of Applied Nutrition in France. In 2016, she visited the Whistler Center, in Dr. Hamaker's lab, for a four-month internship as a Visiting Scholar. She worked with post-doc Dr. Martinez Martinez Mario on the effect of particle size and flour compactness of *in vitro* starch digestion.



**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 MS in 2012. He is now a visiting student at Purdue from 2015 and is co-advised by Drs. Campanella and Hamaker. His

research focuses on a three-component interaction and molecular dynamic simulation of the nanocomplex.



**Antonio Colantuono** earned his B.S. degree in Food Technology from the University of Naples Federico II, in 2011. He earned a M.S. degree with honors in Food Science and Technology from the same university in 2013. Currently, he is a Ph.D. student at the Department of

Agricultural Sciences, University of Naples Federico II (Tutor Prof. P. Vitaglione) with a national fellowship supplied by Italian Ministry of Education, University and Research. He was a Visiting Scholar in 2016, working with B. Hamaker and O. Campanella. His research focused on the inclusion of bioactive compounds from plants in starch-based matrices for the development of functional ingredients.

**Caroline Combette** graduated with a Bachelor of Chemistry in France. In 2016, she visited the Whistler Center, in Dr. Hamaker's lab, for a four-month internship as a Visiting Scholar. She worked with Visiting Scholar A. Colantuono on loading of phytonutrients in nano- and macroscale delivery materials.



**Elisabeth Diatta** is from Senegal. She had a Bachelor's degree in Plant and Animal Biology in 2012 and a Master's degree in Plant and Microbial Biotechnology in 2014, both from Cheikh Anta Diop University (UCAD) in Senegal. In January 2015, she enrolled for the Ph.D. program in Plant Breeding at the West Africa

Centre for Crop Improvement (WACCI), University of Ghana. She joined Dr. Weil's lab as a Visiting Scholar in October 2016. Her research focuses on protein digestibility of sorghum.

**Weili Fan** earned her Ph.D. of chemistry from Missouri University of Science and Technology in 2014, and Master of Public Health from Johns Hopkins Bloomberg School of Public Health in 2016. She joined Dr. Yao's lab in July 2016 with research interest on active food ingredients.

**Thaisa Jungles** earned her B.S. in Human Nutrition from the Pontifical Catholic University – PR in Brazil in 2008. She obtained her M.S. degree from the Department of Biochemistry and Molecular Biology of Parana Federal University in February 2013, and started her Ph.D. studies the same year. She joined Dr. Hamaker's group as a visiting student in March 2015, with support from the Ministry of Science, Technology and Innovation in Brazil. Her research is on the relationship between dietary fiber structural features and its effects on colon microbiota.

**Chunli Lei** received her B.S. in Chemistry from China Agricultural University (2014) in China. After that, she continued her M.S. studies at the same university. She joined Dr. Mauer's group from September 2015 to September 2016 as a visiting scholar, with support from the China Scholarship Council. Her project focused on the manipulation of the physical state of thiamine mononitrate solid dispersions and characterization of physical and chemical stability of the dispersions during storage. A variety of hydrocolloids were used in designing different architectures of solid dispersions, and relationships between intermolecular interactions, physical stability, and chemical degradation were explored.

**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 at China Agriculture University in June 2013. She started Ph.D. study in Food Science at Jiangnan University from September 2013. The research topic of her Ph.D. study is about 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.



**Monique Mi Song Chung** completed her B.S. in Food Engineering, M.S. in Material Science and Engineering and is currently a Ph.D. student in University of São Paulo, Brazil. Previously, she studied barrier properties of biodegradable films and effects of spray drying conditions on the physicochemical properties

and antioxidant activity of dried fruit pulp. She started working with Drs. Campanella and Jones in June 2016 and is conducting research about corn arabinoxylan gels loaded with curcumin and zein nanoparticles as an oral delivery system of curcumin in the colon.



**Kuenchan Na Nakorn** graduated with a B.S. in Food Science and Nutrition in 2005 and a Master of Science in Food Technology in 2009 from Prince of Songkla University. She is a Ph.D. student under Dr. Sunanta Tongta, School of Food Technology, Suranaree University of Technology, Thailand. She received a

scholarship from the Office of the Higher Education Commission to conduct research abroad, and was a visiting student at Purdue with Dr. Hamaker. Her research is about starch digestibility of imitated rice as affected by protein and fibers.



**Laura Roman Rivas** is currently a Ph.D. candidate in Food Science at the University of Valladolid, Spain, whose research focuses on the physicochemical characterization, enzymatic modification and new applications, in terms of nutritional and organoleptic improvement, of cereal

extruded flours. She received her B.S. in Agricultural Engineering and her M.S. in Food Innovation and Processing at the University of Valladolid, Spain. She was a visiting student in Dr. Hamaker's lab for three months; she conducted research on relationships between maize flour compactness and starch bioaccessibility and relationships between molecular size and retrogradation of extruded flours from different cereal sources.



**Han Tao** is a Ph.D. candidate in Food Science at Jiangnan University. Her Ph.D. research was on wheat starch and its non-starch constituents, and how they impact frozen bread quality and functionality. She joined Drs. Hamaker and Campanella's group as a Visiting Scholar from August 2015. Her research is on the

effect of viscosity on the growth of gut bacteria.



**Vinicius M. Valicente** is an undergraduate student at Federal University of Vicosa, in Brazil. In his previous internships he worked with antioxidants and bioactive compounds, milk and dairy products, and as a consultant to improve the physicochemical stability of a sauce with high fat content.

Vinicius joined Drs. Hamaker and Campanella's group in March 2015 and worked on methods to process functional dietary fibers.



## Graduate Students



**Matthew Allan** graduated from Washington State University in May 2012 with a B.S. in Food Science. He joined Dr. Lisa Mauer's lab in 2012 and received his M.S. degree in Food Science in August 2014. He is currently working toward his Ph.D. with Dr. Mauer. His main research focus is water-solid

interactions involving crystalline and amorphous solids, and starch retrogradation.



**Jennifer Allen** received her B.S. in Food Science and Human Nutrition from the University of Illinois at Urbana-Champaign in 2004. She began her career at Michael Foods Inc., where she spent five years working in research and development. In 2012, she obtained a M.S. in Food Science & Technology from Alabama

A&M University, where her research focused on the preventive effects of diets consisting of soy, flaxseed, and focused on the interactions of proteins with polyphenols and their subsequent effect on the protein's functionality as well as polyphenol bioavailability and bioaccessibility. She completed her Ph.D. in August.



**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 research assistant in 2009. Also, 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. Her research is on the nutritional and bioactive value of biofortified staple crops and native foods of Colombia.



**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, working on her M.S. in Food Science with Dr. Jozef Kokini. Emma's research focuses 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.



**Carlos Carter** received his B.S. degree in Food and Nutritional Sciences at North Carolina Agricultural and Technical State University in Greensboro, North Carolina. His undergraduate research focused on factors influencing Greek yogurt in acid whey production. He joined Dr. Janaswamy's lab in fall 2014 as

an Industry Fellow in the Department of Food Science. His master's research focused on developing polysaccharide-based essential oil carriers as antimicrobial inhibitors. He completed his M.S. in December.



**Jingfan Chen** graduated from the Food Science Department in 2015 and 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.



**Tingting Chen** received her B.S. and M.S. degree in Food Science and Technology from Nanchang University. Her M.S. study was about immunoassay development for small-molecular food contaminants. She joined Dr. Hamaker's group and started her Ph.D. in August 2011 with a governmental scholarship

from the China Scholarship Council. Her Ph.D. research was on dietary fiber structure, gut microbiota and colon health. She completed her Ph.D. in December.



**Christopher Cheng** received a B.S. in Food Science from Purdue University in 2012 and an M.S. from North Carolina State University in Food Science in 2014. He is currently pursuing his Ph.D. under Dr. Jones. His research focus has been 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. He discovered a passion for food science as a practical application of 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.



**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

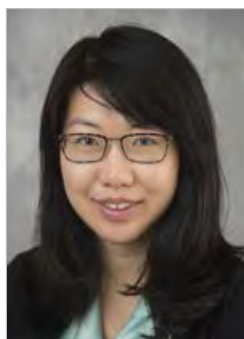
Product Developers in innovation, formulation, and commercialization of Pepsi products. Hawi joined Dr. Ferruzzi's lab in 2014 as a Ph.D. student, where she works on a project to evaluate the stability, bioaccessibility and bioavailability of bioactive compounds from native African plant materials.

**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 corn starch and modified waxy corn starch.



**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.

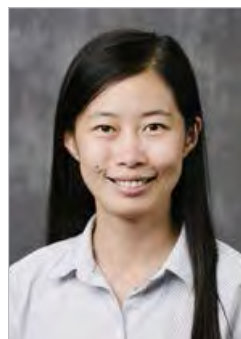


**Juan Du** received a B.S. in Food Science from Purdue University in 2009. She finished her M.S. in Food Science from University of Wisconsin-Madison in Dairy Chemistry. She came back to Purdue in 2013 to pursue her Ph.D. degree in Food Science with Dr. Owen Jones. Her research focuses on

interactions between polysaccharides and proteins. She completed her Ph.D. in December 2016.

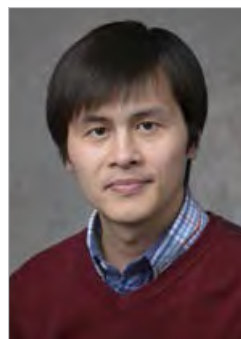


**Marwa El Hindaway** is from Cairo, Egypt, and is pursuing her Ph.D. degree with Dr. Hamaker. She earned bachelor and master's degrees in biochemistry in Egypt, and her research now focuses on dietary carbohydrate sensing by small intestine enterocytes, glucose release, and feedback responses.



**Fang Fang** earned her B.S. in Bioengineering from Central South University of Forestry and Technology in 2009 and her M.S. in Food Science from Jiangnan University in 2012. Fang began her Ph.D. studies at Purdue in fall 2013 with support from the China Scholarship Council. She is co-advised by Drs. Campanella

and Hamaker. Her research focuses on the relationship between rheology and digestion properties of starch with respect to molecular structure. She is working to complete her Ph.D. dissertation in 2017.



**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 began his Ph.D. at Purdue in spring 2014 in Agriculture and Biological Engineering. His research is on the mechanical properties of single molecules and

specifically on the characterization of particles composing tomato products processed under different conditions. Xing Fei is also working under the supervision of Dr. Reuhs on the structural characterization of pectins isolated from processed tomato. Professor Jones is also assisting Xing in aspects related to the characterization of particles using atomic force microscopy. Xing is expecting to complete his Ph.D. in spring 2017.



**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. His research deals with screening for different salt forms of thiamine and characterizing the physical and chemical stability of

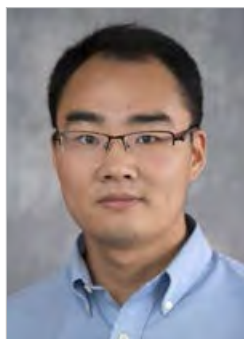
amorphous thiamine in foods.





**Maya Fitriyanti** completed her B.S. in Microbiology from Bandung Institute of Technology, Indonesia, in 2008 and an M.S degree in Chemical Engineering from there in 2012. She began her Ph.D. studies in the Department of Agricultural and Biological Engineering 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.



**Sarah Gafter** 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 after graduation, examining the effect of dietary fats on prostate malignancy; and then for Jenny Craig as a Personal

Consultant in 2014. Sarah then 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.



**Menglu Gao** received her B.S. in Food Science from Purdue University in May 2015. She joined Dr. Kokini's lab in June 2015 to pursue her Ph.D. degree. Her research focuses on numerical simulation and modeling of rheological behavior of dough during processing.



**Jay Gilbert** began attending Purdue University in August 2013. He received his B.S. degree in Food Science and Technology from the University of Massachusetts Amherst in May 2013. He bypassed his M.S. degree and is working toward his Ph.D. He is advised by Dr. Jones, and his research focuses on the

stability of protein fibrils for use in food, packaging, and pharmaceutical applications.



**Anna Hayes** received her B.S. in Food and Nutrition Science and her B.A. in Spanish from Saint Catherine University (St. Paul, Minnesota) in May 2014. Anna arrived at Purdue University in August 2014 and intends to bypass her M.S. and go directly 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.





**Yahya Ismail** received his B.S. degree in Food Science from Purdue in May 2016 and directly continued into the graduate program in Food Science under Dr. Mauer. His project extends the understanding of polymer-vitamin noncovalent interactions and their effects on the physical and chemical

stability of vitamin C forms in the amorphous state.



**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, but decided to come back into Food Science to work in Dr. Hamaker's group, where his research focuses on the role of fiber and the microbiota in colon health.



**Chinmay Joglekar** received his B.S. in Chemical Engineering from the Institute of Chemical Technology, Mumbai, India, in June 2011. After completing his M.S. in Chemical Engineering from Purdue University, he joined the Department of Agricultural and Biological Engineering in August 2014 and left in June

2016. He was co-advised by Drs. Campanella, Hamaker, and BeMiller.

**Kin Lau** earned his B.S. degree in Biology from Davidson College in May 2010. He conducted research in synthetic biology using *E. coli* as a model organism. He is currently pursuing a Ph.D. in Plant Breeding and Genetics in the lab of Dr. Weil. His main project is to identify modifiers of certain developmental mutations and to map and clone those modifier genes.



**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; it was 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 a project, "Prediction of swelling kinetics of waxy native maize starch," since then. Jinsha is the recipient of the Fredrick N. Andrews Fellowship.



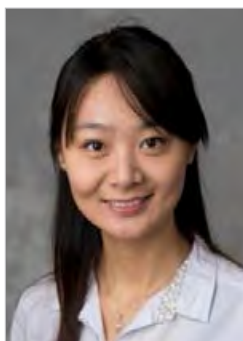
**Kathryn Johnson** received her B.S.A. in Food Science and B.S. in Chemistry from the University of Georgia in December 2013. She worked at Golden State Foods in Conyers, Georgia, as a Product Development Food Technologist before joining Dr. Mauer's lab as an Industry Fellow in fall 2015 to pursue a

M.S. in Food Science. Her current research investigates the effects of different sweeteners on starch thermal properties and behaviors.



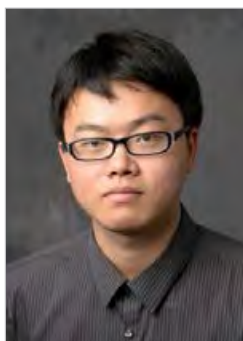
**Jongbin Lim** earned his M.S. degree in Food Science and Technology from Sejong University in South Korea. He joined Dr. Hamaker's lab group in August 2014 to begin his doctoral work. His research is on the moderation of starch digestion rate by inhibition of digestion enzymes and the development of glycemic

carbohydrates to digest in the ileal region of the small intestine for stimulation of physiological feedback systems.



**Yuan Lyu** (Yuan Lv) earned her B.S. degree in College of Life Science from Henan Normal University in July 2010, and M.S. degree in School of Life Science from East China Normal University in July 2013. Her M.S. research was on development of soybean products, including isolated soybean protein and

dietary soybean fiber. Yuan joined Dr. Ganesan Narsimhan's lab in August 2013 in pursuit of a Ph.D. degree. Her current research focuses on strategies to obtain antimicrobial peptide from soybean protein.



**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 three years as a technical advisor for food processing companies in Honduras. He joined Dr. Kokini's lab in fall 2013. His Ph.D. research focuses on the characterization and encapsulation of bioactive compounds with nanomaterials.



**Joel Meehl** earned a B.S. in Biochemistry and Molecular Biology from Marquette University in 2001. After work and further study as a laboratory technician and in some other fields, he joined the Food Science Department as a Ph.D. student in August 2015. Co-advised by Drs. Ferruzzi and Hamaker, his research

focuses on phytochemical interaction with carbohydrates and the gut microbiota.



**Morgan Meiser** 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, focusing 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. Morgan will continue her research on functionalizing proteins for the application of a platform for the detection of allergens and toxins.



**Sydney Moser** earned her B.S. in Food Science from Penn State University in 2011. She continued her M.S. studies on milk protein-flavan-3-ol interactions and their impact on polyphenol bioaccessibility in Dr. Ferruzzi's lab. Following completion of her M.S. in 2013, she continued her studies in Dr. Ferruzzi's lab. Her

research involved applying *in vitro* digestion and Caco-2 small intestinal epithelial cell models to determine the impact of fiber on polyphenol bioaccessibility and metabolism and impact of various polyphenol-rich fruits and vegetables. Additionally, her research examined the ability of polyphenols in fruits and grains to modulate glucose release during digestion and subsequent intestinal transport. She completed her Ph.D. in August.



**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 objective to use extrusion and nutrition-related technologies to better utilize and expand the market 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 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.



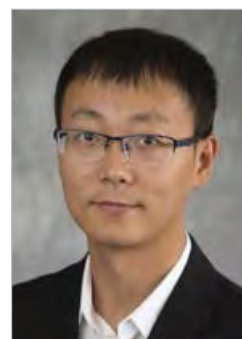
**Ryan Murphy** earned his B.S. in Food Science from the University of Manitoba in May 2013. He arrived at Purdue University in August 2013 with an Andrews Fellowship and is co-advised by Drs. Jones and Farkas. Ryan bypassed his M.S. degree and studies now toward his Ph.D. He interned with Kraft Foods and previously

started and ran a small agribusiness focused on the production, light processing, and sale of local agricultural products. His research focuses on emulsion stabilization using protein and polysaccharide-based nanoparticles.



**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, a M.S. in Food Science and Technology was obtained from

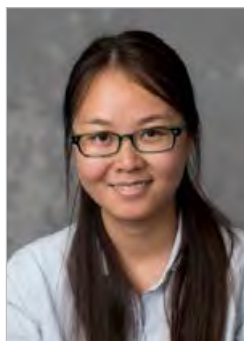
Jiangnan University, China. He has worked for the Institute of Food Technology (ITA) in Dakar since 2003 and is a member of the Cereals and Leguminous Vegetables Department. He joined Dr. Ferruzzi's lab after receiving a fellowship from the ERA USAID project to study biofortification of extruded cereal products using native African plant materials as biofortification agents. He is now part of the USAID Food Processing Innovation Lab and will finish his Ph.D. in 2017.



**Xin Nie** earned his B.S. and M.S. degrees in the Department of Chemistry from China Agricultural University, Beijing. He joined Dr. Hamaker's group as a Ph.D. student in August 2011 with support from the China Scholarship Council government scholarship. Xin's research focused on dietary

fiber's structure-function relationships related to colon and whole body health. He completed his Ph.D. in December.





**Xiang Ning** earned her B.E. degree from the Department of Food Engineering of Hunan Agricultural University in July 2011. She obtained her M.S. degree from the Department of Food Science of Wageningen University in the Netherlands in June 2013. The research topic of her M.S study was “The relation between

structure of globular proteins and their cross-linking activity with microbial transglutaminase.” She joined Dr. Narsimhan’s group as a visiting student in July 2013 to study the function of homogenization on soy  $\beta$ -conglycinin and pectin stabilized encapsulation system. She is continuing her Ph.D. under Dr. Narsimhan with the research topic of pore formation in lipid bilayers by antimicrobial peptides.



**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.



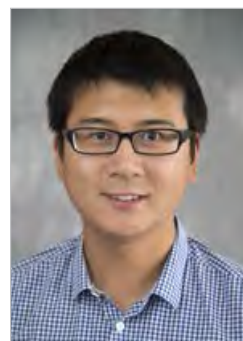
**Gabriella Mendes Candido de Oliveira** received a B.S. in Food Engineering (five years degree) from the University of São Paulo, Brazil, in 2013. She has been recipient of several scholarships from the Brazil Government and the Exchange Program between the University of São Paulo,

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 a placement in a Ph.D. program in the United States under the program “Science Without Borders.” She arrived at Purdue in fall 2014, and her research focuses on novel processing technologies from an experimental and modeling standpoint. She works with Dr. Campanella.



**Darwin Ortiz** is currently a Ph.D. candidate in Food Science at Purdue University. He holds a bachelor’s degree in Chemistry from Universidad del Valle in Colombia. He has worked in the International Center for Tropical Agriculture (CIAT), where he participated in the development of the nutritional

quality laboratory. He also worked for Harvest Plus and AgroSalud Projects from 2007 to 2012. During this period, his research focused in the evaluation of bioactive compounds, antioxidant activity, and the evaluation of in vitro bioavailability of iron, zinc, protein and carotenoids. He was awarded a Fulbright Scholarship, “Francisco Jose de Caldas,” for his Ph.D. degree in the USA by Fulbright Colombia, and the Colombian government (Colciencias). In 2012, he joined Dr. Ferruzzi’s lab, where his research focuses on the evaluation of micronutrient stability during post-harvest, storage, and food processing of biofortified plant-based crops.



**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 began his Ph.D. at Purdue in fall 2014 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

is working toward her Ph.D. degree, under Dr. Hamaker, on physiological effects of glycemic carbohydrates.



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



**Benjamin Redan** earned a B.S. in Biochemistry from the University of Scranton, Pennsylvania, in 2011. Afterward, he received training in Cell and Molecular Biology as a post-baccalaureate fellow at the National Institutes of Health's Division of Pre-Clinical Innovation. He then joined Dr. Ferruzzi's lab in

2012 and received a fellowship through the National Science Foundation to study gut adaptation to chronic exposure of polyphenol-rich foods and beverages. He completed his Ph.D. in August.



**Rándol Rodríguez** obtained his B.S. Degree from the Food Science Department of Zamorano University, Honduras. He works with Dr. Yao on the structure and function of carbohydrate particulates. He is pursuing his Ph.D. degree.



**Tahrira Binte Rouf** completed her B.S. in Chemical Engineering from Bangladesh University of Engineering and Technology (BUET) in 2012 in Bangladesh. After graduation, she was a lecturer in the department of Chemical Technology at Ahsanullah Institute in Bangladesh, before joining Dr.

Kokini's group in August 2014. She is now pursuing a Ph.D. degree in Food Science. Her research mainly is on the functionalization of biopolymers using different nano-materials.



**Juan Sanchez** completed his M.S. in Food Science with the support of the Industry Fellows program and a Ross Fellowship from the Purdue Graduate School. He graduated from Dartmouth College in 2013 with a double major in chemistry and history. Juan studied water-solid interactions and their

effects on the chemical degradation of ascorbic acid in the amorphous solid state. He completed his M.S. in December.



**Leigh Schmidt** earned her B.S. in Food Science from Purdue in 2003 and her M.S. in Food Science from the University of California, 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. The following fall he began his studies at Purdue in the Interdisciplinary Life Sciences Ph.D. program (PULSe). He joined the Weil Lab in May 2016, where he studies cell wall composition in sorghum.



**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 fall 2014 and is currently working toward his Ph.D. degree.



**Seda Arioglu Tuncil** received her B.S. in Food Engineering 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 mainly is on the crystallization inhibitor

properties of different polymers in bioactive amorphous solid dispersions. She completed her M.S. in December 2014 and is now working toward her Ph.D.



**Yunus Emre Tuncil** received his B.S. in Food Engineering at Ataturk University in Turkey in 2008. He was awarded a scholarship for his M.S. and Ph.D. in the USA by the Turkish government. He joined Texas A&M University's Food Science and Technology department as a M.S. student in 2010; he

studied the effects of wheat proteins on dough rheological properties. He arrived at Purdue University in August 2012 and completed his Ph.D. in December 2016 under the guidance of Dr. Hamaker. His Ph.D. research focused on dietary fiber utilization strategies of the members of colonic microbial community. It was a collaborative project with Dr. Eric Martens at University of Michigan Medical School.



**Hazal Turasan** completed her B.S. degree in Food Engineering at Middle East Technical University in 2011 in Turkey. She also completed her M.S. degree in the same department, focusing on encapsulation of rosemary essential oil. After receiving a Fulbright Scholarship in 2014, she joined Dr. Jozef 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. 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. Adrienne has also been a teaching assistant for food microbiology and food chemistry laboratory courses.



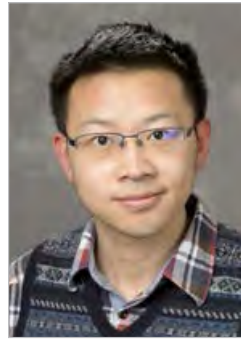
**Xi Wu** earned her B.S. degree in the Department of Applied Chemistry from China Agricultural University, Beijing, in July 2011. She joined Dr. Narsimhan's group in January 2012 to pursue a Ph.D. degree in the Department of Agricultural and Biological Engineering and is working on

investigation of pore formation in cell membrane by synthetic antimicrobial peptides.



**Ying Xie** received her M.S. degree in Processing and Storage of Agriculture Products from China Agricultural University, Beijing. She joined Dr. Yao's group and started her Ph.D. study in August 2012. Her research focuses on modified carbohydrate particulates and their functional properties,

with potential applications in food and pharmaceutical areas.



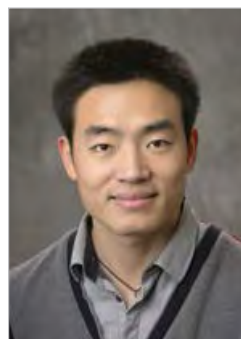
**Tianming Yao** obtained his B.S. in Food Science and Technology from Shanghai Jiao Tong University, China. His undergraduate research was on the OSA modification of small granule starches. He joined Dr. Janaswamy's group in August 2015 as a Master's student with support from the China Scholarship Council

(CSC). His research focused on the interaction between polyphenols and starches.



**Ximena Yopez** received a B.S. degree in Food Engineering from Escuela Politecnica 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, with the goal of defending her Ph.D. in December 2017.



**Xiaowei Zhang** received both his 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.

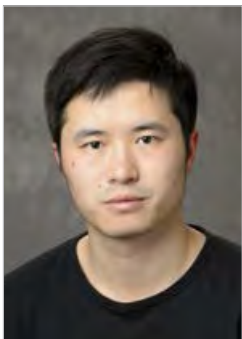


## Ph.D. Post-Doctoral Research Associates



**Mohammad Chegeni** completed his B.S. in Biology at Ferdowsi University in 2002 in Iran, and his M.S. degree in Public Health at Ball State University. He joined Dr. Hamaker's group on January 2010 and successfully defended his Ph.D. in December 2014. His Ph.D. research focused on

intestine enterocytes and sucrase-isomaltase maturation and trafficking. He has continued in B. Hamaker's lab as a post-doc.



**Cheng Li** joined Dr. Hamaker's group as Postdoctoral Research Fellow in December 2015. His research was on understanding starch source differences in fine and granular structures that lead to improved slowly digestible property in breads and cakes. Before moving to Purdue, he finished his B.S. in Biotechnology at Northwest

A&F University in 2011 in China. After that, he completed his Ph.D. in July 2015 in Agricultural Biotechnology at the University of Queensland under the advisement of Professor Robert Gilbert, and worked on developing transgenic rice plants with improved starch structure that is slower to digest. Cheng left the lab in October 2016.



**Min Li** received his B.S. in Ecology from Xiamen University in 2006. His M.S. was from Xiamen University, with dissertation work on characterization of plant polyphenols. In 2009, he continued his Ph.D. studies on plant polyphenols in Miami University (Oxford, Ohio).

Under the guidance of Dr. Ann Hagerman, Min focused on characterizing interactions between plasma proteins and green tea polyphenols. He characterized the binding interaction between serum albumin and epigallocatechin gallate (EGCg), and discovered the restorative effect of EGCg on serum albumin that was severely modified by glucose-induced glycation. Min joined Dr. Ferruzzi's lab in September 2014. His project is to characterize interactions between grain bioactives, including phenolics and carotenoids, with a specific aim to explore impacts of whole grain bioactives on starch digestion, glucose uptake and the ability to modulate inflammatory stress in gut model systems.



**Mario Martinez** completed his B.S. in Agricultural Engineering, his M.S. in Food Innovation and Processing and his Ph.D. in Chemistry at the University of Valladolid, Spain. He joined Dr. Hamaker's group as a Postdoctoral Research Associate in February 2016. His main research focuses on investigating: 1) the starch

structure and the basic principles and mechanisms for starch digestion and; 2) the physical structure and digestibility of edible plant tissues considering holistically the interplay between macronutrients that can lead to thermodynamic and kinetic resistant forms. His ultimate aim is to delay prevalence of hyperglycemia-related diseases through the consumption of high-quality foods with a sustained glucose release.



**Rohollah Sadeghi** received his M.S. and Ph.D. degrees in Food Science and Engineering from University of Tehran, Tehran, Iran, in 2004 and 2014, respectively. His M.S. thesis focused on application and optimization of membrane technology for clarification and purification of glucose syrup. His Ph.D. research focused on

fabrication of biocompatible nanoparticles and nanotubes and their application as delivery systems. He joined Dr. Kokini's lab as a visiting scholar in 2012 at the University of Illinois, Urbana-Champaign during his Ph.D. study. He again joined Dr. Kokini's lab in September 2015 at Purdue University as a postdoctoral associate researcher. His research focuses on the fabrication and application of edible nanoparticles and nanotubes as well as using micro-rheology to understand rheological properties of dilute solutions.



**María Julia Spotti** obtained her B.S. in Biotechnology from National University of Litoral in 2008 in Argentina. In 2013, she completed her Ph.D. degree in Chemistry in the Food Technology Institute of the same university, and continued her work as a post-doc for two years, spending the second year with

Dr. Campanella. Her research was on functional properties of protein-polysaccharides conjugates. She worked with Dr. Jones' group from July 2015 to July 2016 on solubilization and interaction between polysaccharides in aqueous solutions.



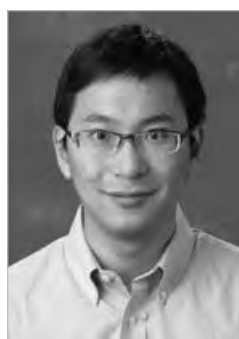
**Alpana Thorat** received a Bachelor of Pharmacy degree from Pune University in 2006, and a Masters of Technology in Pharmaceutical Technology-Biotechnology from the National Institute of Pharmaceutical Education and Research (NIPER, Mohali, India) in 2008. She worked in the pharmaceutical industry

for one year (senior research chemist, 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 is working on understanding the amorphization of sugars.



**Senem Yetgin** received her B.S degree in Chemical Engineering from Inonu University, Turkey. She completed M.S. and Ph.D. degrees in Chemical Engineering from the Izmir Institute of Technology, Turkey, in 2007 and 2013, respectively, while working as a Research Assistant. She is

presently an Assistant Professor in the Food Engineering Department, Kastamonu University, Turkey. She joined Dr. Campanella's group as a visiting scholar in July 2016. Her post-doctoral research was supported by the Turkish Scientific Research Council (TUBITAK) 2219 Scholarship scheme for one year. Her main research focuses on investigating: separation processes, adsorption, polymers, sol gel process, atomic force microscopy applications, artificial neuron network application on data analysis, and, more recently, rheological modeling of viscoelastic materials.



**Bin Zhang** joined Dr. Hamaker's group as Post-doctoral Research Fellow in February 2015. His research is on dietary fiber, colon microbiota and human health. Before moving to Purdue, he finished his Ph.D. in Food Science and Nutrition at the University of Queensland under the advisement of

Professor Mike Gidley, and worked on molecular organization, digestion and physical properties of low-order starch matrices, such as granule "ghosts" and starch extrudates. Bin left the lab in May.



## Whistler Center Staff



**Mikaela Allan** began working in the Whistler Center in fall 2014, assisting with the annual short course and research focus meeting. Mikaela graduated from Washington State University in May 2012 with a B.S. in Food Science and received her M.S. degree in Food Science in August 2014 from Purdue University. She

served as the Administrative Coordinator until June 2016.



**Wendy Madore** joined the Whistler Center in August 2016 as the new Administrative Coordinator. She previously worked in Purdue's College of Agriculture, Office of the Vice President for Research, Discovery Park, and the Krannert School of Management.



**Bhavesh Patel** received a B.S. degree in Dairy Technology from Gujarat Agricultural University, Anand, India, and a 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 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 of their functional properties; he 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.



**Gudrun Schmidt** received a Diploma and Ph.D. in Macromolecular Chemistry from the University of Freiburg, Germany. She was an Alexander von Humboldt/ Feodor Lynen Fellow at the National Institute of Standards and Technology in Maryland, an Assistant Professor of Chemistry at Louisiana State

University, and an Assistant Professor in Biomedical Engineering at Purdue. Gudrun has expertise in polymer science and biopolymer chemistry with a focus on developing structure-property relationships. This includes the design, synthesis and characterization of polymer materials from the nanometer (atomic structures) to the micrometer (aggregate) length scales. Her current emphasis is on polysaccharides.



**Anton Terekhov** is director of Analytical Services for the Whistler Center. He is proficient in analytical chemistry, molecular biology techniques and analytical instruments, such as NMR, GCMS, LCMS and FTIR. Anton has extensive experience in an interdisciplinary laboratory environment,

including the fields of analytical chemistry, microbiology, genetics, geology, chemical and civil engineering.

# Our People, Our Projects

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## BeMiller

1. Impacts of Hydrocolloids on the Properties of Normal and Waxy Corn Starch

## Campanella

2. Industrial Processing Properties of Tomato Products
3. Shear-Thickening Behavior and Rheology of Gelatinized Waxy Starch Dispersions
4. Influence of Bubble Growth in Non-Fickian Transfer Of Mass
5. Modeling Inactivation Parameters of Spore Cells Subjected to Cold Plasma and other Non-thermal Processes
6. Modeling of Gastrointestinal Bacterial Growth Influenced by Viscosity
7. Using Molecular Dynamic (MD) Simulation to Understand the Stability of Amylose-Free Fatty Acid Complex

## Ferruzzi

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

## Hamaker

9. Dietary Fibers and *In Vitro* Fermentation: SCFA Production and Microbiota Changes
10. Dietary Fibers and Specific Actions Using Pure Strain Colon Bacteria
11. Investigations on Slowly Digestible Glycemic Carbohydrates
12. Cellular and Physiological Response Studies of Starchy Materials with Slow Digestion Profiles
13. Starch-Based Nanoparticles for Gastrointestinal Cancer Drug Delivery

## Janaswamy

14. Carbohydrate-Based Antimicrobial Carriers
15. Polysaccharide-Based Nutraceutical Carriers

## Jones

16. Protein-Polysaccharide Block Ionomer Complexes as a Core-Shell Controlled Delivery Vehicle for Hydrophobic Bioactive Compounds
17. Physical Stability and Colloidal Properties of Small Protein Assemblies in the Presence of Polysaccharides
18. Protein Fibers within Polysaccharide Composite Films
19. Swelling and Emulsion-Stabilizing Properties of  $\beta$ -Lactoglobulin Assemblies (Microgels)

## Kokini

20. Nanoparticulation of Edible Proteins to Develop GRAS Nano-delivery Systems
21. Development of Biodegradable Zein Matrices with Controllable Surface Properties In Order to Develop a Biodegradable Sensor Platform for Food Analytes
22. Large Amplitude Oscillatory Rheological Properties of Soft and Hard Wheat Flour Doughs
23. Zein-based Nanocomposites for Biodegradable Packaging Applications

## Mauer

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

## **Narsimhan**

27. Identification of Antimicrobial Peptides from Soy Protein
28. Pore Formation in DOPC/DOPG Bilayers by Antimicrobial Peptide Melittin
29. Pasting Behavior of Cross Linked Starch
30. Synergistic Effect of Low Power Ultrasonication On Antimicrobial Peptide Action

## **Schmidt**

31. Phenolics with Anti-Cancer Activity from the Indiana Black Walnut Tree
32. Wet Adhesive Glue from Food Components

## **Weil**

33. Analysis of Sorghum Genes Involved in Carbohydrate Metabolism and Production
34. Genes Controlling Starch Channelization
35. Genetic Interactions that Impact Starch Quantity and Quality
36. Genetics of Carbohydrate Transport and Partitioning in Maize
37. Genetics of Sugar Accumulation and Distribution in Maize and Sorghum
38. High-Value Corn Starch

## **Yao**

39. Carbohydrate-Based Biomaterials to Improve the Solubility of Active Ingredients (AI)
40. High-throughput Screening of Starch and Phenolic Compounds of Cereal Grains
41. Pathogen Biofilm Formation on Food Surface and its Impact on the Efficacy of Antimicrobial Compounds
42. Synergistic Effects among Antimicrobial Methods to Reduce Pathogenic Bacterial Load

# Project Summaries

## 1 Impacts of Hydrocolloids on the Properties of Normal and Waxy Corn Starch

**PI.:** J. BeMiller

**Researchers:** Li Guo, Visiting Scientist; Zhen Fu, Visiting Scientist

**Objective:** 1) To determine how hydrocolloids change the pasting, paste, and gel properties of a starch, 2) To define the effects of different hydrocolloids on different starches (with and without amylose, native and modified), 3) To establish a rational basis for selecting combinations of a native or modified food starch and a hydrocolloid for food use.

**Progress:** The following starches were used in the study: normal maize/corn starch (I), normal corn starch cross-linked with  $\text{POCl}_3$  (2 levels) (II), normal corn starch cross-linked with epichlorohydrin (2 levels) (III), hydroxypropylated (2 levels) normal corn starch (IV), waxy maize starch (V), waxy maize starch cross-linked with  $\text{POCl}_3$  (2 levels) (VI), waxy maize starch cross-linked with epichlorohydrin (2 levels) (VII), hydroxypropylated (2 levels) waxy maize starch. Each of the 14 starches were cooked (either in an RVA or a water bath) with water and the following 14 solutions: xanthan, xanthan in 1% NaCl, guar gum, CMC, sodium alginate, methylcellulose, HPMC, kappa-type carrageenan, iota-type carrageenan, lambda-type carrageenan, poly(ethylene glycol), sodium nitrate, sodium sulfate, sodium citrate. The following values have been determined for the cooked starch-hydrocolloid combinations: peak, trough and final viscosities, breakdown and setback (RVA) of I, II, III, V, VI and VII;  $G'$ ,  $G''$ ,  $\tan \delta$  and  $\eta^*$  after storage of the pastes at 4 °C for 0, 2, 4 and 6 days for I, II, III, V, VI and VII; swelling power, dissolved amylose and total starch dissolved after heating starch suspensions at 65, 75 and 85 °C for I, II and III; rates of retrogradation after heating to 100°C of IV and VIII.

**Underway:** One paper has been submitted and is under revision. At least two more will be prepared.

**Status:** Active.

## 2 Industrial Processing Properties of Tomato Products

**PI.:** O. Campanella, B. Reuhs

**Researcher:** Xing Fei, Ph.D. Student

**Collaborators:** O. Jones, A. Handa (Department of Horticulture, Purdue University), C.H. Syozi, H. Liu, D. Zhu

**Objectives:** 1) To investigate physical and chemical factors that influence the rheological properties of suspension systems containing cell wall material (e.g., from tomato products and other fruit and vegetables), 2) To understand the effects of ultrasound and physical treatments (e.g, shear) on the physicochemical properties of cell wall material and the rheological properties of suspension systems.

**Progress:** Suspensions of tomato particles with relatively high viscosity were produced by ultrasound treatment. Conversely, a high shear treatment caused a decrease in viscosity. The viscoelastic properties of the suspensions showed a similar behavior. It was observed, using microscopy, that both the ultrasound and shear treatments reduce the particle size of tomato cell clusters. However, as visualized by cryo-SEM, the ultrasound-treated suspensions had more intact cells into which the solubilized pectin could be trapped, resulting in an increase of the strength of the particles. The strength of particles was determined by measuring the peak force from a compression test using parallel plate geometry. Results confirmed that strength of the particles was in good agreement with rheological results obtained under a shear test in which viscosity and viscoelastic properties were determined. In addition, it was noted that the water-soluble pectin (WSP) fraction in the suspensions increased after ultrasound and shear treatments. This result suggests that pectin is leached out from particles, which causes changes of the particle properties. Current work investigates the role of mechanical properties of the cell clusters on the viscosity of tomato suspensions.

**Status:** Active, two manuscripts to be submitted.

### 3 Shear-Thickening Behavior and Rheopecty of Gelatinized Waxy Starch Dispersions

**P.I.s:** O. Campanella, B. Hamaker

**Researcher:** Fang Fang, Ph.D. Candidate

**Collaborators:** J. BeMiller, B. Reuhs

**Objectives:** 1) To understand the effect of inter- and intra-molecular interactions of highly branched biomacromolecules (e.g. amylopectin) on the rheological properties of the solutions, and 2) To explore potential application of these interactions to health benefits in terms of slow gastric emptying.

**Progress:** Initially, in this project, we found that some gelatinized starches have a shear-thickening behavior when a light shear is applied ( $20 \text{ s}^{-1}$ ). This was most pronounced for waxy potato starch and less so for waxy corn starch. Waxy rice starch did not display this property. In this last year, we investigated the mechanism of this interesting phenomenon. Shear-induced intermolecular aggregates were found to be responsible for the shear-thickening behavior around  $20 \text{ s}^{-1}$ , since components of large size are formed after application of shear. In addition to using rheology, these size changes observed in shear-thickened starch dispersion were determined by dynamic laser light scattering. Neutral hydrocolloids enhanced the shear-thickening behavior, probably by competing for water with the amylopectin molecules; whereas charged hydrocolloids with high concentration may inhibit the formation of amylopectin aggregates through electrostatic repulsion and, in turn, reduce shear-thickening behavior. Further, the shear-thickening effect, along with aggregation of waxy potato amylopectin, was notably enhanced at  $20 \text{ s}^{-1}$  at  $4^\circ\text{C}$  for 12 hours, and was related to amylopectin retrogradation as determined by DSC. Such intermolecular aggregation of amylopectin and the consequent increase in viscosity may have some practical applications, such as increasing viscosity in the stomach which approximates the same shear condition.

**Status:** Active, two manuscripts under preparation.

### 4 Influence of Bubble Growth in Non-Fickian Transfer Of Mass

**P.I.:** O. Campanella,

**Researcher:** Dongdong Ma, M.S. Student

**Collaborator:** C. Corvalan

**Objectives:** Drying and expansion of cereals is a critical and important process in the food industry, drastically impacting the quality of the final products. Quality issues include density changes, crust formation, puffing, and flavor and color development. The main objective of this project is to describe the flow of complex viscoelastic food materials in terms of deformations existing during cereal processing, specifically at high temperatures. The model incorporates swelling effects due to moisture transport as well as the effect of vapor bubble growth in a viscoelastic matrix. This overcomes limitations of models previously developed that do not account for product expansion due to vapor bubble formation. The new model provided a better description of changes of volume during processes that promotes expansion, notably extrusion pellet expansion and drying. Furthermore, this new model can be successfully applied to predict anomalous diffusion involving moisture transfer through deformable viscoelastic matrices.

**Progress:** A non-Fickian model accounting for moisture diffusion incorporating the effect of bubbles growth and deformable viscoelastic matrices was developed to describe the expansion of cereal product in a number of processes including extrusion, drying and pellet expansion. The model was able to predict both moisture diffusion and internal vapor expansion promoting expansion of products in these processes. It also showed the effect of the process conditions in the final texture of cereal products produced by direct expansion. This is an important additional finding because previous developed models mostly focused on shrinking behavior due to moisture transport, whereas no studies had been developed including puffing mechanisms. This developed model takes new insights into the mechanisms of moisture transport, and describes better final volume changes of viscoelastic biomaterials in processes promoting expansion, for example extrusion, pellet expansion and drying with the presence of crust.

**Status:** Finished. A manuscript in preparation.



## 5 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:** A. Deering (Food Science), A. Garner (Nuclear Engineering)

**Objectives:** The long-term goal of the research is to study nonthermal sterilization technologies able to inactivate microorganisms while retaining or minimally modifying nutritional attributes of fruit juices. Previous work has focused on the use of using plasma technology to inactivate spores in model liquids. A model was developed taking into account the variable concentration of the sterilizing gas species, and the model was validated with experimental results on spore inactivation. Pulsed electric field (PEF) is another emerging non-thermal technology with good potential to substitute thermal sterilization, and it is being investigated in this phase of the project. The objective of this particular application is to investigate the effect of process parameters, such as electric field strength, treatment time, pulse frequency, pulse width and pulse polarity, on vitamin C retention, carotenoid, and anthocyanin contents of açai and acerola juices. In addition to that, to evaluate the effect of those different process parameter conditions on inactivation of microorganisms of public health concern such as *Escherichia coli* O157:H7 and *Salmonella Typhimurium*. Following treatment and data collection, a modeling approach will be proposed to correlate the electric field intensity applied with the survival of microorganisms.

**Progress:** Microbiological training has been completed, as well the training on how to use the 300 nanoseconds pulser. The training on how to operate the continuous PEF system will be done in collaboration with Washington State University and Dr. Barbosa-Canovas. Training on determination of anthocyanin contents will be done in collaboration with Dr. Ferruzzi at North Carolina State University.

**Status:** Active, two articles in preparation.

## 6 Modeling of Gastrointestinal Bacterial Growth Influenced by Viscosity

**P.I.s:** O. Campanella, B. Hamaker

**Researcher:** Han Tao, Visiting Student

**Collaborators:** J. Patterson (Animal Science, Purdue), Doraiswami Ramkrishna (Chemical Engineering, Purdue), E. Martens (University of Michigan Medical School), and Xia Dongming and Xin Xu (undergraduate students, Purdue)

**Objectives:** 1) To understand the effects of viscosity on gastrointestinal bacterial behavior, 2) To develop mathematical models to describe growth curves and predict inhibition and/or inactivation of microbial growth under a variety of substrates.

**Progress:** The effect of viscosity on the growth of *Bacteroides ovatus* and *B. cellulosilyticus* *in vitro* by using media containing polyethylene glycol (PEG) of different viscosities was determined. Substrates containing inulin (long chain) and FOS (short chain) were also used to investigate the effect of the substrate chain length in the growth of these strains. In high-viscosity systems the growth rate of *B. ovatus* and *B. cell* was significantly reduced and lag time showed a significant increase. It was also observed that the effect of viscosity was more pronounced in systems having inulin (long chain) than in those having FOS (short chain). Thus, the effect of viscosity depends on the chain length of dietary fibers. A Matlab model was developed to validate the experimentally observed effects and whether the effect of the fiber structure is associated to the mobility of microbial cells, substrates and metabolites in viscous media.

**Status:** Active, two manuscripts in preparation.

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

**P.I.s:** O. Campanella, B. Hamaker

**Researcher:** Lilin Cheng, Visiting Student

**Collaborator:** X. Zhu (Purdue ITaP Research Computing)

**Objectives:** 1) To understand the interactions between amylose and free fatty acid at the atomic level, and 2) To

investigate conditions under which the amylose-free fatty acid complex can form stable complexes.

**Progress:** The Gromacs force field was applied in this study. The results showed that amylose and free fatty acid can form stable complexes and the free fatty acid is located in the central part of the amylose molecule, while amylose alone stretched out quickly during the simulation period. Chair  ${}^4C_1$  was the domain conformation of the amylose in the complex. The intermolecular hydrogen bond is the main force to maintain the helical structure. Different concentrations of free fatty acid interacting with amylose were investigated as well. Complexation under different amylose/fatty acid ratios are currently being evaluated.

**Status:** Active, one manuscript in preparation.

## 8 Impact of Phytochemicals on Starch Digestion and Intestinal Glucose Transport

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

**Researchers:** Sydney Moser, Ph.D. Student; Amber Furrer, M.S. Student; Min Li, Post-doc.

**Objectives:** To develop and validate *in vitro*/cell-based gut models suitable for screening interactions between phytochemicals and starch in foods.

**General:** Dr. Ferruzzi's group focuses on the interactions between phytochemical constituents in foods and macronutrients (proteins and carbohydrates) as they impact phytochemical bioavailability and macronutrient availability. In these efforts, they have begun to develop *in vitro* and cell-based approaches that can be leveraged to screen foods for endpoints including phytochemical availability and glucose release and intestinal transport.

**Progress:** Coupled *in vitro* digestion/Caco-2 intestinal cell culture models have been adapted using a combination of brush boarder enzymes and labeled glucose (d7-glucose) to model both glucogenesis and transport through digestion. To date this has been applied to screen both phenolic-rich extracts and model food systems. In the past year, we have advanced the application of this model to whole food systems and mixed meals to explore interactions between phenolic rich beverages (juices, teas and coffee) with starch-rich meals. We have also expanded the screening methods to include exploration of intestinal adaptation to chronic polyphenol exposure with the goal of

identifying factors that can modify long-term polyphenol metabolism and glucose transport/homestasis in humans. In the coming year, correlation to *in vivo* data from three ongoing clinical trials will be prioritized.

**Status:** Active.

## 9 Dietary Fibers and In Vitro Fermentation: SCFA Production and Microbiota Changes

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

**Researchers:** Bin Zhang, Post-doc; Tingting Chen, Ph.D. Student; Xiaowei Zhang, Ph.D. Student; Thaisa Jungles, Visiting Scholar; Enosh Kazam, M.S. Student; Yunus Tuncil, Ph.D. Student

**Collaborators:** A. Keshavarzian (Rush Medical School, Chicago); L. Zhao (Shanghai Jiao Tong University); C. Nagler (University of Chicago); S. Lindenman (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 through favoring of certain bacteria or bacterial groups. Our interest is in finding functional and, where possible, targeted fermentable fibers, whether soluble or insoluble, to improve gut health; and to understand their fermentative properties and effects.

**Progress:** We continue to work with collaborators (listed and additionally including E. Martens in the next summary) on ways to promote individual bacteria or bacterial groups through dietary fibers for improved health. This includes the short chain fatty acid (SCFA) fiber fermentation products, and could themselves be the target of studies; however, in most of our studies we focus on how fiber molecules, chemical and physical structures, are used and preferred by gut bacteria as they function in certain community structures or ecologies. Strategies for enhancing individual or total SCFAs, and potentially other metabolites, can then be done in a predicted way.

In the study of X. Zhang, the role of the physical form of fibers on targeting gut bacteria is being researched. There is previous indication that fermentable insoluble fibers promote *Clostridium* cluster bacteria that are beneficial to gut health, as they contain some of the

major butyrate-producing bacteria and reside near the mucosal surface. Corn arabinoxylan is being used as a model fiber and was solubilized with alkali, leaving different degrees of feruloylation, that were then re-crosslinked using laccase. With the pure arabinoxylan in its both soluble and polymerized states, human fecal fermentations were conducted showing some change in parameters including SCFAs. DNA has been extracted for 16S rRNA sequencing.

T. Chen completed her Ph.D. in the last part of 2016, and had 2 papers in review on 1) butyrate in different SCFA mixtures and their effect on barrier function as measured in a Caco-2 cell culture model, and 2) in collaboration with L. Zhao, differences in fiber response in different gut bacterial communities (*Prevotella* and *Bacterioides* enterotypes). Interestingly, in the latter, SCFA outcomes were substantively different for the same fibers treated *in vitro* in the two different communities, with, for example, FOS and two arabinoxylans being highly propiogenic in the *Prevotella*-dominant community, and FOS and one of the arabinoxylans being more butyrogenic in the *Bacterioides*-dominant community. In work combined with B. Zhang's study, in stool samples from 36 individuals, insoluble fermentable fibers were clearly found to promote different bacteria than soluble fibers and data analysis is still ongoing examining fiber responses in healthy and diseased groups, and patterns that arise from testing with a standard panel of fibers.

T. Jungles, a sandwich Ph.D. student from Brazil, left in spring 2016. In the completion of her studies at Purdue, she used RT-qPCR, which she set up for the lab, to track abundance changes of *Clostridium* clusters IV and XIVa and two butyrogenic bacteria, *Eubacterium rectales* and *Rosburia spp.* In her final study, she used a microwave treatment we had developed previously to increase fermentability of insoluble dietary fibers which retaining their insoluble matrix property. Using insoluble fibers from Brazil, increasing fermentability was shown to promote bacteria in these groups.

Y. Tuncil studied whether hierarchical preference of glycans exists in the competitive environment of the colon. To answer this, a series of *in vitro* fermentation studies using fecal microbiota obtained from three healthy individuals was conducted, and a comparison was made of the degradation profiles of single glycans with a mixture containing an equal amount of these substrates. These results showed that, from the polysaccharide perspective, hierarchical preferences

exist in the competitive environment of the colon, and degradation of some glycans by fecal microbiota is delayed when they are present as a mixture. Therefore, this might be a logical strategy for delivering particular dietary fibers into the distal part of the colon so that the fermentative activity can be stimulated throughout the colon, and beneficial bacteria as well as more SCFA production in the distal colon can be promoted.

Work of post-doc B. Zhang and student T. Chen was funded through Nutrabiotix, a startup company of B. Hamaker and A. Keshavarzian directed toward disorders and diseases that can be addressed with fibers.

**Status:** Active, a number of manuscripts in review and preparation.

## 10 Dietary Fibers and Specific Actions Using Pure Strain Colon Bacteria

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

**Researchers:** Yunus Tuncil, Ph.D. Student; Xin Nie, Ph.D. Student

**Collaborator:** E. Martens (University of Michigan Medical School)

**Objective:** To increase our understanding of how dietary fiber structures are utilized by colonic bacteria for the purpose of developing strategies to change the gut microbiota for improved health.

**Progress:** With E. Martens at University of Michigan Medical School, we have worked to better understand the requirements and abilities individual bacteria have to access carbohydrate substrates and, in competitive systems, how they utilize fibers. Our joint goal is figure out how dietary fibers (oligosaccharides and polysaccharides) can be used to favorably affect the colon microbiota for reasons of health.

X. Nie completed his Ph.D. in December 2016. His last study showed, using an artificial competitive gut bacteria community (3 *Bacterioides* strains), that it is theoretically possible to disfavor a strain using dietary fiber strategies. Different arabinoxylan-based structures were used to create different competitive environments. By cooperating with *B. xylanisolvens* XB1A, *B. ovatus* 3-1-23 was shown to survive by cross-feeding on complex fiber structures that it cannot digest by itself. However, when on relatively simple arabinoxylan-based



substrates, such cross-feeding cooperation between the two bacteria was essentially inactivated, indicating that cross-feeding cooperation is determined by fiber structure. High percentage of disubstituted xylose residues were determined as the key structural feature for suppressing *B. ovatus* utilization of corn arabinoxylan hydrolysates. *B. cell* showed capacity to digest simple and complex xylan structures alone. On complex structures, *B. cell* is a strong competitor, while on simple structures, other bacteria like *B. ovatus* have ability to compete with *B. cell*. This study indicates that manipulation of dietary fiber structures could be a promising approach to achieve desired gut microbiota compositions for personalized human health.

Y. Tuncil also completed his Ph.D. in December 2016. He studied how the members of our gut microbiota utilize glycans and activate their respective polysaccharide utilization loci (PULs). A series of time-course assays in which two model organisms, *B. thetaioamicron* (*Bt*) and *B. ovatus* (*Bo*), were individually grown in a medium containing carbohydrates utilized by both bacteria: amylopectin (AP), arabinan (ARAB), chondroitin sulphate (CS), pectic galactan (PG), polygalacturonic acid (PGA), and rhamnogalacturonan I (RGI). *Bt* and *Bo* utilized some glycans before others, but with different prioritizations showing that bacterial species show species-specific hierarchical preference to dietary fibers. Bacteria sensitivities to some glycans are tightly tuned to the residual concentration of polysaccharide in the medium, while others remain highly expressed even after most of the target substrates have been depleted. Next, the possibility of change in substrate hierarchy was explored when bacteria are in a competitive environment. Relative abundances of these species in the co-cultured environment remained constant throughout the exponential phase. This is, most probably, due to their different glycan priorities which allow them to maintain their coexistence. Next, a hypothesis was tested whether molecular structure of a glycan affects its place in the hierarchy. To test this, we repeated the hierarchical substrate preference test for *Bo* by substituting AP with a starch analog [maltotetraose (MH) (low molecular weight hexasaccharide derived from starch)]. AP was used after RGI by *Bo* when AP was included in the mixture, whereas MH was used before RGI, so the utilization of RGI by *Bo* was delayed in the presence of MH. These results provide information about the strategies of *Bt* and *Bo* use to utilize different glycans that are often

present as a mixture in the colon, and the effects of a particular carbohydrate chemical structure on preference of use.

**Status:** Active, one manuscript in review and three in preparation.

## 11 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

**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 ileal deposition of glucose in the small intestine for the purpose of testing and targeting physiologic response; and, related to ways to manipulate starch digestion rate, to better understand natural inhibitors and their effect on the four mammalian  $\alpha$ -glucosidase enzymes.

**Progress:** Our current interest in glycemic carbohydrate research is to understand how to achieve slowly digestible carbohydrates that have the potential to effect physiological changes through ileal or colonic triggers to influence appetitive response and sustained energy effect. We have continued to study ways to prolong the glycemic response and to reduce the glycemic spike, but with emphasis on longer digestion times that may combine slowly digestible carbohydrate with fermentable resistant starch or hydrolyzates.

J. Lim continued work on phenolic inhibitors of the starch digestive enzymes, the enzymes that digest starch to glucose at the mucosal surface of the small intestine. The inhibitory effects of eight phenolic compounds were investigated and their structures were compared to the inhibition of  $\alpha$ -amylase. Three phenolic structural factors were considered, 1) compounds of differing molecular weights within the same galloyl group, 2) compounds of the same molecular weight with different



C-ring structures, and 3) aglycon and glycoside forms. In rank order, the highest inhibition property was observed for quercetin, followed by cyanin, EGCG, cyanidin, (-)-catechin gallate, (+)-catechin, epigallocatechin, and gallic acid. Even though the inhibition properties of all compounds observed had a low linear relationship with their Mw ( $r^2 = 0.313$ ), the correlation became  $r^2 = 0.811$  in the galloyl group on phenolic compounds. Quercetin (Mw: 302.24) showed higher inhibitory effect compared to epigallocatechin (Mw: 306.27) and (+)-catechin (Mw: 290.27) despite having similar Mw, and perhaps was related to the C-ring structure. Cyanin, the glycoside of cyanidin, had a 20% higher inhibition property. Moreover, the overall tendency was that the number of hydroxyl groups appeared to increase the inhibition influence of the phenolic compounds. This study provides insight on structural factors of phenolic compounds that relate to their inhibition of  $\alpha$ -amylase activity.

**Status:** Active, a number of manuscripts in preparation.

## 12 Cellular and Physiological Response Studies of Starchy Materials with Slow Digestion Profiles

**P.I.:** B. Hamaker

**Researchers:** Mohammad Chegeni, Post-doc; Marwa El-Hindaway, Ph.D. Student; Beth Pletsch, Ph.D. Student

**Collaborators:** H. Naim (University of Veterinary Medicine Hannover, Germany); B. Nichols (Baylor College of Medicine, Houston)

**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:** Marwa El-Hindaway continued work on the enteroendocrine L-cells, which are found in abundance in the lower small intestine and in the colon. She found that GLP-1 secretion in cultured L-cells are sensitive to higher order maltooligosaccharides, which are found in the products of starch digestion by  $\alpha$ -amylase, than for either glucose or the short chain fatty acids (SCFAs). GLP-1 is a gut incretin hormone that regulates insulin

and also activates the appetite center in the brain for satiety response and influences stomach emptying rate. These new findings imply a particular sensitivity of the L-cells in the ileum of the small intestine to the maltooligosaccharide digestion of products of starch by  $\alpha$ -amylase in triggering GLP-1. This adds to our recent work showing that slowly digestible carbohydrates, particularly starch, can actually reduce food intake, and has led us to plan further studies to develop such carbohydrates or strategies to activate this feedback system in the body.

M. Chegeni, as a post-doc, showed in a human study that certain slowly digestible carbohydrates, which we hypothesized reach the ileum to activate the ileal brake, do so but only in a subset of the subjects. The measured endpoint was change in gastric emptying rate. Respondents were consistent among responses to treatments, with some showing large decrease in gastric emptying rate when consuming the slowly digestible carbohydrates in a semi-solid food material matched for nutrient compositions and viscosity. The manuscript for this study is in preparation for submission for publication in 2017.

**Status:** Active, a number of manuscripts in preparation.

## 13 Starch-Based Nanoparticles for Gastrointestinal Cancer Drug Delivery

**P.I.s:** B. Hamaker, O. Jones, O. Campanella and G. Schmidt

**Collaborators:** R. Pinal (Pharmacy) and T. Lyle (Veterinary School)

**Objective:** To use benign and water-soluble nanoparticles from amylose, protein, and lipid for carriers to protect and deliver hydrophobic drugs. To test the potential for cancer drug delivery to gastrointestinal cancers via the oral route and to evaluate the interactions of nanoparticles with intestinal cells.

**Progress:** Two proposals have been submitted, with one proposal funded. More preliminary studies, including nanoparticle scale-up procedures, are underway.

## 14 Carbohydrate-Based Antimicrobial Carriers

**P.I.:** S. Janaswamy

**Researchers:** Carlos Carter, M.S. Student; Atul K. Singh, Post-doctoral Research Associate (A. Bhunia's lab)

**Collaborator:** A. Bhunia (Food Science, Purdue University)

**Objective:** Food quality and shelf-life define the appearance and consumer acceptance of products. Owing to their perishable nature, protecting food products from spoilage bacteria and pathogens during preparation, storage and distribution is important. Microbial growth is a primary reason why food loses its quality and becomes unsafe for consumption. Packaging of food under a modified atmosphere coupled with storage at low temperature can extend shelf-life and prevent pathogen growth. However, these processes alone are not sufficient for reducing foodborne outbreaks and public health concerns. Essential oils possess antimicrobial properties. However, essential oils are water insoluble and prone to oxidative degradation, so that higher concentrations are needed to achieve the desirable activity. This study aims at developing suitable carriers based on carbohydrates to protect essential oils from volatilization and oxidation.

**Progress:** Eugenol and carvacrol have been encapsulated in the sodium iota-carrageenan fibers. The antimicrobial activity was tested against *Listeria innocua* F4248, *Listeria monocytogenes* F4244, *Salmonella* Enteritidis ENT 1344, *Salmonella enterica* serovar Heidelberg 513, *Escherichia coli* O157: H7 ATCC 43295 and *Staphylococcus aureus* ATCC 25923 using the disc diffusion and macro broth dilution assay. Complexing the essential oils has the inhibitory effect on the growth of the microorganisms. Overall, the intrinsic functionality of essential oils could be preserved by encapsulating them in the ordered polysaccharide matrices for inhibiting the growth of spoilage microorganisms in food systems.

**Status:** Completed

## 15 Polysaccharide-Based Nutraceutical Carriers

**P.I.:** S. Janaswamy

**Researcher:** Tianming Yao, M.S. Student

**Objective:** Foods enriched with nutraceuticals help to gain health as well as aid in the prevention of diseases such as diabetes and cancer. However, nutraceuticals are often susceptible to oxygen degradation, temperature, enzymatic activity, pH, and light. These negative factors play a major role in reducing the overall bioavailability of nutraceuticals. In this regard, encapsulation allows the protection and polysaccharides are suited well due to their versatility. In our ongoing efforts about the design and development of stable-architecture carriers based on human compatible biopolymers, we demonstrated the feasibility of iota-carrageenan fibers for the encapsulation and controlled release of nutraceuticals. Our results suggested that size and functional groups present on the nutraceutical could influence the overall load and release behavior of encapsulated molecules. This observation forms the basis for the present research, and herein we report the effect of encapsulation time of curcumin and resveratrol in the sodium iota-carrageenan fibers.

**Progress:** Curcumin and resveratrol were encapsulated in sodium iota-carrageenan (IC) fibers for 1, 2, 3, 4 and 5 weeks. The results suggest that complexing time has effect on the overall encapsulated amount, and the optimal encapsulation duration appears to be 3 weeks. The encapsulated molecules are heat protected and are released in a sustained manner from the carrageenan network.

**Status:** Completed

## 16 Protein-Polysaccharide Block Ionomer Complexes as a Core-Shell Controlled Delivery Vehicle for Hydrophobic Bioactive Compounds

**P.I.:** O.G. Jones

**Researcher:** Juan Du, Ph.D. Student

**Objective:** To establish the assembly of block ionomer complexes from charged polysaccharides and proteins to replace surfactant-micelles as controlled delivery vehicles for bioactive compounds.

**Progress:** Previous work demonstrated that spherical assemblies were formed by the interaction of alpha-lactalbumin, a small whey protein, and a carboxy-methyl-dextran chain to which a poly(ethylene glycol) segment had been covalently attached. These spherical assemblies are less than 100 nanometers in diameter and were proposed to be a type of complex-coacervate core micelle structure. A project on the interaction and potential complex-coacervate core micelle formation of poly(ethylene glycol)-modified-chitosan and alpha-lactalbumin was performed in the past year. Molecular weight of the polysaccharide was varied in order to understand the impact of the polysaccharide chain length on interactions and assembly properties. Sub-micrometer spherical assemblies were successfully prepared from these materials in low-acid conditions. In some conditions, the chain length of the chitosan component significantly impacted the structure of the final complex.

**Status:** Completed, one manuscript published (2015), other manuscripts in preparation.

## 17 Physical Stability and Colloidal Properties of Small Protein Assemblies in the Presence of Polysaccharides

**P.I.:** O.G. Jones

**Researchers:** Chris Cheng, Ph.D. student; Angarika Rayate, M.S. student

**Objective:** To determine the degree of interactivity and relative stabilizing capacity of charged and uncharged polysaccharides with small protein assemblies in order to improve their performance as colloidal materials.

**Progress:** Zein nanoparticles were chosen as the first model system representing a poorly-soluble protein capable of forming spherical particles of ~100 nanometer in diameter. Because of their poor dispersibility in water, they were stabilized by addition of iota-carrageenan in acidic and neutral pH conditions. Addition of sufficient iota-carrageenan stabilized them against aggregation and sedimentation but did not influence their morphology or mechanical properties. These findings allow future exploration of their functionality and degradation in specific applications. A recent study has shown that incorporation of small quantities of dispersed zein nanoparticles into cellulose-based films increased the elasticity and decreased the water permeability. A

second study has also been initiated in 2016 that focuses upon the interactions between natural protein assemblies and uncharged polysaccharides, such as starch. A literature review and experimental observations of colloidal dimensions, interaction energies, and rheological changes are currently underway.

**Status:** Active. One manuscript submitted for publication; two manuscripts in preparation.

## 18 Protein Fibers within Polysaccharide Composite Films

**P.I.:** O. Jones

**Co-P.I.:** O. Campanella

**Researchers:** Jay Gilbert, Ph.D. Student; Enrico Fedirici, Visiting Scholar

**Collaborators:** N. Reynolds (Swinburne Institute of Technology, Melbourne, Australia)

**Objective:** Identify structural and mechanical attributes of fibrous aggregates of proteins; determine the impact of these protein fibers on the mechanical properties of composite polysaccharide films or gels.

**Progress:** Experiments have demonstrated the capability of forming pure and methylcellulose-composite films with protein fibrils, as well as composite films with other protein-based aggregate structures. The mechanical behavior of protein fibrils within pure and composite films were characterized by multifrequency atomic force microscopy methods. Films comprised of protein fibers were investigated for the support and growth of living cells in collaboration with a university in Australia. Fibers comprised of relatively hydrophobic grain proteins have been formed and used to successfully prepare doughs and breads without gluten proteins.

**Status:** Active. One manuscript published (2014), multiple manuscripts in preparation.

## 19 Swelling and Emulsion-Stabilizing Properties of $\beta$ -Lactoglobulin Assemblies (Microgels)

**P.I.:** O. Jones

**Researcher:** Ryan Murphy, Ph.D. Student

**Objective:** Determine the interfacial activity and physical stability of oil-in-water aqueous emulsions using particulate assemblies of  $\beta$ -lactoglobulin; determine influence of particle size, particle swelling ratio, and environmental conditions on interfacial properties.

**Progress:** Previous research in this area showed the capability of forming emulsions using protein assemblies with their physical stability significantly influenced by the properties of the protein-based structures. A recent study controlled the swelling and mechanical behaviors of the particulate assemblies by altering the conditions of the aqueous suspension.

**Status:** Active, two manuscripts published (2014, 2015). Manuscript in preparation.

## 20 Nanoparticulation of Edible Proteins to Develop GRAS Nano-delivery Systems

**P.I.:** J. Kokini

**Researchers:** Rohollah Sadeghi, Post-doc; Luis Maldonado, Ph.D. Student; Menglu Gao, Ph.D. Student

**Objective:** Manufacturing of GRAS based nano-delivery systems to encapsulate and improve bioavailability of bioactive compounds.

**Progress:** Nanoparticles of  $\alpha$ -lactalbumin and ovalbumin and BSA and poly-D-lysine (PDL) were manufactured using desolvation and the coacervation methods, respectively. The effect of preparation conditions—such as non-solvent/solvent ratio, temperatures and types of non-solvents, ionic strength, addition of glutaraldehyde as crosslinking agent, temperature and pH value on the size, morphology, loading capacity and structural changes of  $\alpha$ -lactalbumin, ovalbumin and the coacervates—have been fully studied. The encapsulation capacity of BSA and PDL coacervate nanoparticles was evaluated using curcumin as a model bioactive compound. Biocompatible nanotubes were assembled with the alternate layer-by-layer technique using BSA as the

positively charged biopolymer and sodium alginate as the negatively charged biopolymer. The combination of these two biopolymers led to the formation defined and stable nanotubular structures. Electrostatic interaction between BSA and sodium alginate was established by measuring their zeta potential at different pHs using dynamic light scattering. pH values around 3-4 were found to be suitable for the formation of the biocompatible nanotubes since the difference between the opposite charges was higher. Similar results have been obtained using chitosan (CHI),  $\alpha$ -lactalbumin (LAC), and sodium alginate (ALG). The optimum pH for CHI-LAC was around 7, whereas for CHI-ALG was found to be pH 4.0. Both CHI-LAC and CHI-ALG nanotubes were formed successfully.

**Status:** Active.

## 21 Development of Biodegradable Zein Matrices with Controllable Surface Properties in Order to Develop a Biodegradable Sensor Platform for Food Analytes

**P.I.:** J. Kokini

**Researchers:** Emma Barber, M.S. Student; Hazal Turasan, M.S. Student

**Objective:** The objective of this research is control the surface properties of zein in order to use zein films in various film and sensor applications.

**Progress:** Zein's unique film forming properties have made it the focal point of a number of different applications which require the use of biodegradable substances. In this project, zein is optimized to create a platform for food allergen and toxin sensing. Many different formulations are currently being tested to optimize mechanical, chemical, and surface properties of the films. Differences within the film include solvent type, plasticizer content, and crosslinking content. The platforms are being analyzed with various spectroscopic and surface techniques. The results indicate that desired mechanical properties can be achieved by changing the chemistry of the zein platforms. Also, the surface properties of the platforms can be modified accordingly.

**Status:** Active.



## 22 Large Amplitude Oscillatory Rheological Properties of Soft and Hard Wheat Flour Doughs

**P.I.:** J. Kokini

**Researchers:** Ozlem Duvarci, Visiting Scientist; Gamze Yazar, Visiting Scholar; Jose Bonilla, Ph.D. Student; Menglu Gao, Ph.D. Student

**Objective:** To study the non-linear properties which are highly relevant to high shear processing of doughs.

**Progress:** In processing of food materials, they are usually subjected to large and sudden deformations. The latest approaches on nonlinear oscillatory deformation enable us a deeper understanding on the rheological behavior of food materials. Non-linear oscillatory shear flow (LAOS) on hard and soft wheat was investigated to reveal the structural changes experienced by these materials and the differences in rheological behavior. Hard and soft dough showed strain hardening and shear thinning behavior in a nonlinear region with different extension which cannot be detected by steady shear and small oscillatory shear flows. It is possible to differentiate the rheological behaviors of similar but different structures like hard dough and soft dough. Our results showed that the elastic component of the hard wheat flour dough was more affected by mixing than the viscous component at all applied frequencies. In addition, the nonlinear rheological behavior of hard wheat flour dough was simulated, and the model was able to fit the data we obtained.

**Status:** Active.

## 23 Zein-based Nanocomposites for Biodegradable Packaging Applications

**P.I.:** J. Kokini

**Researchers:** Tahrira Rouf, Ph.D. Student

**Objective:** To improve the properties of biodegradable films by adding nanostructures to improve tensile strength and permeability.

**Progress:** The objective of this study was to apply different engineered nano-fillers, using different fabrication techniques to produce zein-nanocomposites, and characterize the morphology, chemical composition and property changes in the

obtained nanocomposite films leading to possible application biodegradable smart packaging as well as biosensors. In pursuing this objective, zein nanocomposite films were produced using a solution casting technique, and some preliminary characterization experiments have been conducted with generally favorable outcomes, but more experiments need to be performed to obtain statistically significant results.

**Status:** Active.

## 24 Starch Properties in Different Environments

**P.I.:** L. Mauer

**Researchers:** Kathryn Johnson, M.S. Student; Matt Allan, Ph.D. Student

**Objective:** To investigate starch properties, including gelatinization and retrogradation, in concentrated solutions of a variety of sweeteners 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 type and structure, water activity, molecular weight, and intermolecular interactions with starch gelatinization, pasting, and retrogradation traits.

**Status:** Active.

## 25 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; Juan Sanchez, M.S. Student; Adrienne Voelker, M.S. Student; Alpana Thorat, Post-doctoral Associate; Chunli Lei, Visiting Scholar

**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.

**Status:** Active.

## 26 Water-Solid Interactions and Phase Diagrams

**P.I.:** L. Mauer

**Researchers:** Matthew Allan, Ph.D. Student; Alpna Thorat, postdoctoral associate

**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.

**Status:** Active.

## 27 Identification of Antimicrobial Peptides from Soy Protein

**P.I.:** G. Narsimhan

**Researchers:** Yuan Lyv, Ph.D. Student; Xiaoyu Wu, Ph.D. Research Associate

**Objectives:** 1) Development of methodology for identification of desirable peptide sequences from soy  $\beta$ -conglycinin, and 2) Characterization of antimicrobial activity of selected peptide segments against *L. monocytogenes* and *E. coli*.

**Progress:** Antimicrobial peptides (AMPs) inactivate microbial cells through pore formation in cell membrane. Because of their different mode of action compared to antibiotics, AMPs can be used to replace antibiotics in human health and animal feed and immobilized on food packaging films. We developed a methodology based on mechanistic evaluation of peptide-lipid bilayer interaction to identify AMPs from soy protein. Initial screening of peptide segments from soy glycinin and  $\beta$ -conglycinin subunits was based on their hydrophobicity, hydrophobic moment and net charge. Out of several candidates chosen from the initial screening, two peptides satisfied the criteria for antimicrobial activity, viz. (i) lipid-peptide binding in surface state and (ii) pore formation in transmembrane state of the aggregate, as evaluated by all-atom molecular dynamics (MD) simulation. Their antimicrobial activities against *Listeria monocytogenes* F4244 and *E. coli* O157:H7 EDL933 were confirmed by bioassay. This methodology is also applicable for identification of AMPs from any protein.

**Status:** Active.

## 28 Pore Formation in DOPC/DOPG Bilayers by Antimicrobial Peptide Melittin

**P.I.:** G. Narsimhan

**Researchers:** Yuan Lyv, Ph.D. student; Ning Xiang, Ph.D. student

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

**Progress:** Antimicrobial peptides (AMP) kill microbial cells through insertion and damage/permeabilization of the cytoplasmic membranes. Since their mechanism of action differs from that of antibiotics, they could be very useful for combating drug-resistant microbes and for treatment of microbial infections. Pore formation in DOPC/DOPG bilayers by the antimicrobial peptide melittin was investigated by explicit solvent molecular dynamics (MD) simulation to mimic their permeation action on the cell membrane of microorganism. The effects of number and orientation of melittin molecules inside the lipid bilayer on the formation of a water channel (pore) was characterized. The minimum number of peptides required for pore formation is compared with the critical pore size predicted by a mathematical model based on the free energy of pore formation. The salient features of the simulation results are then compared with experimental data for pore formation as inferred from (i) leakage of fluorescent dyes (calcein, FD4 and FD20) of different molecular weights encapsulated within liposomes exposed to melittin and (ii) the antimicrobial activity of melittin against the Gram-positive bacterium *Listeria monocytogenes* as characterized by absorbance and plate count.

**Status:** Active.

## 29 Pasting Behavior of Cross-Linked Starch

**P.I.:** G. Narsimhan

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

**Objective:** To characterize the pasting behavior of cross-linked starch in terms of its structure.

**Progress:** Pasting behavior of starch greatly influences the texture of a variety of food products. The annual

consumption of starch in the U.S. is 3 million metric tons. Starch consumption is believed to be linked to the occurrence of diabetes and obesity. Resistant starch with lower digestibility, which may represent a solution to diabetes and obesity, is produced by modifying the starch using different extent of crosslinking. Cross-linking of starch is achieved by chemical treatment and has a large influence in its pasting behavior. It is, thus, important to characterize the connection between the structure, composition and architecture of the starch granules and its pasting behavior in order to arrive at a rational methodology to design modified starch of desirable rate of digestion and texture. The overall goal of this investigation is to develop a predictive model for pasting behavior of starch in terms of its structure and composition. Polymer solution theories were applied to quantify the swelling of starch at different heating rates in terms of its molecular weight, second virial coefficient and granule elasticity. The extent of cross linking and the degree of ionization of waxy maize starches were varied through reaction with phosphoryl chloride of different concentrations at different pH. The molecular weight distribution and second virial coefficient were quantified using multiangle laser light scattering, and intrinsic viscosity was measured to elucidate the conformation of starch molecule. The evolution of starch granule size distribution during pasting was measured using static light scattering. Kinetics of swelling of starch granules subjected to different rates of heating were predicted using Flory-Rehner theory, and the experimental granule size distributions were compared with model predictions.

**Status:** Active

## 30 Synergistic Effect of Low Power Ultrasonication On Antimicrobial Peptide Action

**P.I.:** G. Narsimhan

**Researchers:** Xi Wu, Ph.D. student; M. Fritiyanti, Ph.D. student

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

**Progress:** Since antimicrobial peptides kill bacteria by pore formation in cell membranes, transient pores formed by low power ultrasonication should result in enhancement of antimicrobial activity. Because of its

relatively gentle action (low intensity), low frequency ultrasound is expected to have no adverse effect on food texture. Experiments were conducted for deactivation of *L. monocytogenes* using a naturally occurring antimicrobial peptide (AMP) melittin in the absence as well as in the presence of ultrasonication. In the absence of AMP melittin, ultrasonication has very small effect on cell density up to a power level of 40 W. However, at a higher power level of 60 W, a dramatic decrease in cell density was observed, which implied cell lysis. At low AMP concentration, low power ultrasonication did not improve the antimicrobial activity. At high AMP concentrations, however, AMP was found to completely inactivate *L. monocytogenes*. The synergistic effect of AMP with ultrasonication was found to be the maximum at AMP concentration of 0.78 µg/ml of melittin. A dramatic decrease in 2 orders of magnitude in cell density was observed for ultrasonication in the presence of 0.78 µg/ml of melittin compared to either ultrasonication alone or AMP action alone.

**Status:** Active

## 31 Phenolics with Anti-Cancer Activity from the Indiana Black Walnut Tree

**P.I.s:** Q. Xu, G. Schmidt, and B. Hamaker

**Objective:** To evaluate how phenolics extracted from black walnut shells and wood can be used to prevent and possibly cure diseases associated with oxidative stresses, such as cancer. To extract and identify phenolic components and screen these for antioxidant properties and anti-cancer activity.

**Progress:** A proposal has been submitted to the Purdue AgSEED program, and preliminary studies extracting phenolic components are ongoing.

## 32 Wet Adhesive Glue from Food Components

**P.I.s:** G. Schmidt, Jonathan Wilker

**Collaborators:** Food Science faculty collaborators will be added once optimal adhesive formulations have been identified.

**Objectives:** To make non-toxic, strong and wet-setting adhesives from polysaccharides and small molecule food components. To optimize synthesis and

formulation and to evaluate the use of these adhesives for food packaging, surgery and dentistry as well as biomedical applications.

**Progress:** Preliminary results are showing that *in-situ* reactions can transform polysaccharides into high-strength adhesives. Bond strengths can be up to 1/3 of commercial Super Glue.

**Status:** Active.

## 33 Analysis of Sorghum Genes Involved in Carbohydrate Metabolism and Production

**P.I.:** C. Weil

**Researchers:** Jacquee Anderson, Moriah Massafaro, Mitch Tuinstra, Brian Dilkes, Charles Addo-Quaye, Eric Danquah, Hamadou Traore.

**Objective:** Characterization of a large mutagenized population of *Sorghum bicolor* and identification/characterization of genes and gene functions.

**Progress:** We have now developed and begun to characterize one of the largest mutagenized populations of *Sorghum bicolor* in the world. Based on our preliminary DNA sequencing of genomes from these lines, this population of 12,000 mutants (made in the genome-sequenced inbred BTx623) contains approximately 3.6 million single-base DNA changes that are predicted to alter protein coding sequences. An estimated 120,000 of these are predicted to have dramatic effect on the protein produced by the affected gene. We are screening the population for improved digestibility of the cooked starch and protein, and have identified a series of candidate mutants and demonstrated that the changes are heritable. These lines have had their genomes resequenced, and the mutations are now available as a public, searchable database, including all those in starch biosynthetic genes. We have also identified several mutant lines that have altered carbon partitioning, altered protein digestibility and improved forage quality. Initially this project was also a collaboration with researchers in Ghana and Burkina Faso. We have now obtained additional resources to expand those efforts into Niger and Senegal. We are looking for partners to help us develop these materials into food products for these African and other markets.

**Status:** Active.



## 34 Genes Controlling Starch Channelization

**P.I.:** C. Weil

**Collaborator:** J. BeMiller

**Objective:** In the past, in conjunction with Dr. BeMiller, we have analyzed genetic changes associated with differences in the number of channels formed in starch granules. Using the data on how much actin can be extracted from channels in these recombinant inbred lines (the Relative Degree of Channelization, or RDC), we have used association mapping techniques to identify regions likely to have genes that control channel formation. Several of these regions contain actin and tubulin genes, and genes that impact endosperm morphology. Our goal now is to test their specific roles in forming channels in maize starch granules.

**Progress:** The RDC between B73 and another inbred, Oh43, as well as 200 RILs derived from these inbreds have now been phenotyped in the BeMiller lab. We have performed association analyses on these RILs to identify additional genes that impact channelization.

As a tool for these studies, we made a *brittle1 brittle2* double mutant and, together with Dr. BeMiller, analyzed the amyloplasts by SEM. These mutant amyloplasts appear unfilled and may lack starch entirely, facilitating the study of the cytoskeleton that surrounds them before they fill.

**Status:** Active.

## 35 Genetic Interactions That Impact Starch Quantity and Quality

**P.I.:** C. Weil

**Researcher:** Sean Tague, undergraduate

**Progress:** This project is awaiting a new researcher. Many mutations show differences in the phenotypes they cause when they are moved into various genetic backgrounds. The starch mutants *ae1*, *su1* and *wx* are being crossed to 27 highly diverse inbreds to identify interacting genes that affect starch quantity and quality, particularly phytoglycogen. We will analyze F2 of these crosses for differences in starch content and quality.

Once the effects have been determined, we will use association mapping to quickly identify and isolate novel genes that alter starch characteristics.

**Status:** Active.

## 36 Genetics of Carbohydrate Transport and Partitioning in Maize

**P.I.:** C. Weil

**Researchers:** David Huizinga, Ph.D. Research Associate; Meghan Ahearn, Lauren Miranda, visiting undergraduate students (St. Michael's College)

**Progress:** In summer 2015 we mapped 10 new mutations impacting carbohydrate transport and distribution in maize, have identified over 350 more, and have developed F2 mapping populations for 320 of these. In summer 2017, we will map 40 more mutations for detailed analysis. In addition, we are collaborating with Dr. Jenna Rickus of Purdue's Physiological Sensors group to develop fluorescent sensor measurements of sucrose levels at varying positions in field-grown plants.

**Status:** Active.

## 37 Genetics of Sugar Accumulation and Distribution in Maize and Sorghum

**P.I.:** C. Weil

**Collaborators:** N. Carpita, D. Szymanski (Purdue University), Jiri Adamec (University of Nebraska)

**Progress:** Sugar-accumulating grasses store sucrose in the vacuoles of stem (stalk) cells in preparation for remobilizing that sugar to developing seeds. In grasses such as sugarcane and sweet sorghum, that remobilization is reduced, and the stalks are harvested to collect the sugar. In maize, remobilization to the developing ear has been selected for as a part of the domestication process, and is under genetic control. Some tropical maize varieties flower late in temperate climates and do not make ears (although they still set seed normally under shorter day lengths in the tropics). Some of these continue to accumulate sugar as though they were going to make ears, while others do not; we are trying to understand and make use of this variation. In the past year, we have mapped two QTL that impact sugar accumulation in maize stalks. The next steps will

be to determine the genes underlying these QTL. The focus is on increasing the processes loading sugar into the vacuoles of stalk cells and decreasing its remobilization out of those vacuoles. In addition, we are now in the fourth generation of breeding tropical maize varieties to increase a combination of biomass and sugar content.

**Status:** Active.

## 38 High-Value Corn Starch

**P.I.:** C. Weil

**Researcher:** Sean Tague, undergraduate student

**Collaborators:** L. Mauer, Y. Yao

**Objectives:** Genetics and mutagenesis are used to identify and develop maize lines that produce specialized corn starches. The working hypothesis is that corn mutants can produce starch in the kernel that has some of the same properties currently obtained by chemical modification. These mutants would, therefore, reduce processing time, cost, and variability. A second objective is to screen mutants for more digestion-resistant cooked starch, and a third is to screen for more rapidly digesting starch for use as a biofuel feedstock and improved poultry feed. Large populations of mutagenized seeds have been developed in the inbred maize lines W22 and B73. The natural diversity of maize has also been examined.

**Progress:** We have screened ~500 families of these seed and identified mutants that slow digestion of cooked flour to a steady release that eventually reaches normal levels of overall glucose release. We have also identified lines where there is more digestion in 20 minutes than normal starch achieves in 2 hours. We have improved our digestion assay, which now couples NIR spectroscopy with a two-enzyme digestion and automated liquid handling, allowing us to control more precisely for input starch, timing and consistent mixing, with increased throughput. We now want to understand what has been altered in these lines, have identified homozygous mutants for 30 of them, and are looking at branch length distribution and differences in endosperm transcript profiles. In addition, we have identified three diverse inbred lines that have slower digestion of cooked starch and at least one inbred with more rapidly digested uncooked starch.

**Status:** Active.

## 39 Carbohydrate-Based Biomaterials to Improve the Solubility of Active Ingredients (AI)

**P.I.:** Y. Yao

**Researchers:** Ying Xie, Ph.D. Student

**Objective:** To improve the water solubility and efficacies of AIs.

**Progress:** A large number of active food ingredients are hydrophobic. Roughly 40% of new drug molecules present drug delivery challenges due to their low solubility. The Biopharmaceutics Classification System (BCS) was developed to classify Active Pharmaceutical Ingredients (APIs) based on their solubility and permeability. Based on the BCS, drug solubilization is necessary for the delivery of APIs of Class II (low solubility, high permeability) and Class IV (low solubility, low permeability). In particular, for compounds in Class II, solubilization technologies can solve the delivery problem. In this project, carbohydrate-based biomaterials are prepared and tested using a number of model AIs. The results showed that both the solubilities and in vitro efficacies of AIs can be enhanced through complexation with carbohydrate biomaterials. Based on these results, we will conduct animal tests to evaluate the bioavailability and efficacy of selected active ingredients.

**Status:** Active.

## 40 High-throughput Screening of Starch and Phenolic Compounds of Cereal Grains

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

**Researcher:** Dr. Lingxiao Gong, Visiting Scholar

**Objective:** To establish an analytical platform for high-throughput screening of starch and phenolic compounds for individual corn kernels (and possibly other cereal grains)

**Progress:** “Clean label” for starch, a major food ingredient, not only demands technology innovations, but also the advancement of science at the interface of food chemistry, genetics and genomics, and high-throughput analysis. The overall hypothesis of this study is that the large populations of cereal seeds subjected to mutagenesis are feasible pools for screening high-value traits related to starch and

nutrients. Specifically, this project targets the establishment of a high-throughput screening platform for corn seeds. There are two primary targets for screening: 1) starch with enhanced processing and storage stabilities, and 2) individual kernels with enhanced amounts of phenolic compounds. The single-kernel screening (SKS) technique is employed to sample and analyze each kernel without affecting its vitality as seed upon later planting is needed to identify its genotype for both fundamental studies and breeding programs. Currently, a microplate-based microanalysis has been generated to compare starch gelatinization and resistance to shear—properties that are closely associated with the stability of starch in food processing. A number of commercial cross-linked or stabilized starches are used as benchmarks. Concurrently, the content of phenolic compounds of individual kernels are quantified, also using a newly established, microplate-based technique.

**Status:** Active.

## 41 Pathogen biofilm formation on food surface and its impact on the efficacy of antimicrobial compounds

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

**Researcher:** Yezhi Fu, Ph.D. Student

**Objective:** To study the formation and reduction of pathogenic bacteria biofilm at food surface.

**Progress:** Biofilm formation by various pathogenic bacteria on food surface is a major food safety issue. In this study, the ability of selected pathogens to form biofilm on fresh produce, such as cantaloupe, was documented. *Listeria monocytogenes*, *Salmonella* Typhimurium, and *E. coli* O157:H7 are used as model pathogens for characterizing the formation of biofilms. The biofilms are observed using cryo-scanning electron microscopy (Cryo-SEM) over 2-48 h of incubation. Results obtained indicated that these pathogens were capable of forming biofilms on cantaloupe rind surface. Furthermore, the inoculated cantaloupe rind surfaces were treated with lauroyl arginate ethyl (LAE) or sodium hypochlorite (SHC). The results showed that *Listeria* and *Salmonella* biofilms on the cantaloupe surface had different impact on the efficacy of LAE, and

*E. coli* O157:H7 biofilm had strong resistance to both LAE and SHC. Based on the outcome of these studies, we are exploring methods to enhance the antimicrobial efficacy against pathogenic biofilms.

**Status:** Active.

## 42 Synergistic Effects among Antimicrobial Methods to Reduce Pathogenic Bacterial Load

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

**Researcher:** Yezhi Fu, Ph.D. Student

**Objectives:** To evaluate the synergistic effects among different antimicrobial methods against food pathogens.

**Progress:** Synergistic effects among different antimicrobial methods not only reduce the cost of treatment for achieving targeted reduction of microbial load, but also achieve antimicrobial results that are not feasible with individual methods. In this project, we are testing several types of antimicrobial methods used in combinations regarding their capabilities to inhibit or reduce the development of pathogenic bacterial biofilms. The model pathogens include *Listeria monocytogenes*, *Salmonella*, and *E. coli* O157. Once the basic understanding is established, the concept will be tested with specific food systems, such as fresh and fresh-cut produce, to test their protective effects against food pathogens.

**Status:** Active.

# Publications and Other Scholarly Activities

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

### BeMiller

1. **BeMiller, J.N.**, Gums/hydrocolloids: analytical aspects. Chapter 6 in A.-C. Eliasson (ed.) *Carbohydrates in Food*, 3<sup>rd</sup> Edn., Taylor and Francis.
2. Hong, J.S., **Bemiller, J.N.**, & Huber, K.C. (2016). Impact of reagent infiltration time on reaction patterns and pasting properties of modified maize and wheat starches. *Carbohydrate Polymers*, 151, 851-861.

### Campanella

3. Ayala-Soto, F.E., **Campanella, O.H.**, Serna-Saldívar, S.O., & Welti-Chanes, J. (2016). Changes in the structure and gelling properties of maize fiber arabinoxylans after their pilot scale extraction and spray-drying. *Journal of Cereal Science*, 70, 275-281.
4. **Campanella, O.H.** (2016). Editorial overview: Food physics and material science. *Current Opinion in Food Science*, 9, vii-ix.
5. Chen, J., Miao, M., **Campanella, O.H.**, Jian, B., & Jin, Z. (2016). Biological macromolecule delivery system for improving functional performance of hydrophobic nutraceuticals. *Current Opinion in Food Science*, 9, 56-61.
6. **Demirkesen, I.**, Puchulu-Campanella, E., Kelkar, S., **Campanella, O.H.**, Sumnu, G., & Sahin, S. (2016). Production and characterisation of gluten-free chestnut sourdough breads. *Quality Assurance and Safety of Crops & Foods*, 8, 349-358.
7. **Eren, N.M.**, **Narsimhan, G.**, & **Campanella, O.H.** (2016). Protein adsorption induced bridging flocculation: the dominant entropic pathway for nano-bio complexation. *Nanoscale*, DOI: 10.1039/C5NR06179B.
8. **Feng, T.**, Zhu, X., & **Campanella, O.** (2016). Molecular modeling tools to characterize the structure and complexation behavior of carbohydrates. *Current Opinion in Food Science*, 9, 62-69.

9. Kahn, J.L., **Eren, N.M.**, **Campanella, O.**, Voytik-Harbin, S. L., & Rickus, J. L. (2016). Collagen-fibril matrix properties modulate the kinetics of silica polycondensation to template and direct biomineralization. *Journal of Materials Research*, 31, 311-320.
10. Khalef, N., **Campanella, O.** and Bakri, A. (2016). Isothermal calorimetry: methods and applications in food and pharmaceutical fields. *Current Opinion in Food Science*, 9, 70-76.
11. Tarhan, O., **Spotti, M.J.**, Schaffter, S., Corvalan, C.M., & **Campanella, O. H.** (2016). Rheological and structural characterization of whey protein gelation induced by enzymatic hydrolysis. *Food Hydrocolloids*, 61, 211-220.

See paper in **Hamaker** (Taylor et al.)

### Ferruzzi

12. Koga, C.C., Andrade, J.E., **Ferruzzi, M.G.**, & Lee, Y. (2016). Stability of trans-resveratrol encapsulated in a protein matrix produced using spray drying to uv light stress and simulated gastro-intestinal digestion. *Journal of Food Science*. 81(2):C292-300.
13. Furrer, A. N., **Chegeni, M.**, & **Ferruzzi, M. G.** (2016). Impact of potato processing on nutrients, phytochemicals and human health. *Critical Reviews in Food Science and Nutrition*.
14. Jacobi, J.L., Yang, B., Li, X., Menze, A.K., Laurentz, S.M., Janle, E.M., **Ferruzzi, M.G.**, McCabe, G.P., Chapple, C., & Kirchmaier, A.L. (2016). Impacts on sirtuin function and bioavailability of the dietary bioactive compound dihydrocoumarin. *PLoS One*, 11(2).
15. He, Z., Chen, J., Moser, S.E., **Jones, O.G.**, & **Ferruzzi, M.G.** (2016). Interaction of  $\beta$ -casein with (-)-epigallocatechin-3-gallate in a milk-based tea beverage model system assayed by fluorescence quenching: effect of thermal processing temperature. *International Journal of Food Science and Technology*. 51 (2), 342-348.



16. **Ortiz, D.**, Rocheford, T., & **Ferruzzi, M.G.** (2016). Influence of temperature and humidity on the stability of carotenoids in biofortified maize cultivars. *Journal of Agricultural and Food Chemistry*. 64(13), 2727-2736.
17. Shahnazari, M., Turner, R.T., Iwaniec, U.T., Wronski, T.J., Li, M., **Ferruzzi, M.G.**, . . . & Halloran, B.P. (2016). Dietary dried plum increases bone mass, suppresses proinflammatory cytokines and promotes attainment of peak bone mass in male mice. *The Journal of Nutritional Biochemistry*, 34, 73-82.
18. **Moser, S.**, Lim, J., **Chegeni, M.**, Wightman, J.D., **Hamaker, B.R.**, & Ferruzzi, M.G. (2016). Concord and Niagara grape juice and their phenolics modify intestinal glucose transport in a coupled in vitro digestion/caco-2 human intestinal model. *Nutrients* 8: 414, doi:10.3390/nu8070414.
19. Kachenpukdee, N., Santerre, C.R., **Ferruzzi, M.G.**, & Oonsivilai, R. (2016). Modified dietary fiber from cassava pulp and assessment of mercury bioaccessibility and intestinal uptake using an in vitro digestion/Caco-2 model system. *Journal of Food Science*, 81(7).
20. Dzakovich, M.P., **Ferruzzi, M.G.**, & Mitchell, C.A. (2016). Manipulating sensory and phytochemical profiles of greenhouse tomatoes using environmentally relevant doses of ultraviolet radiation. *Journal of Agricultural and Food Chemistry*, 64(36), 6801-6808.
21. Li, M., Koecher, K., Hansen, L., & **Ferruzzi, M.G.** (2016). Phenolic recovery and bioaccessibility from milled and finished whole grain oat products. *Food & Function*, 7, 3370-3381.
- Hamaker**
22. Hutkins, R.W., Krumbeck, J.A., Bindels, L.B., Cani, P.D., Fahey, G., Goh, Y.J., **Hamaker, B.**, Martens, E.C., Mills, D.A., Rastal, R.A., Vaughan, E., & Sanders, M.E. (2016). Prebiotics: why definitions matter. *Current Opinion in Biotechnology* 37, 1-7.
23. Taylor, J.R., Taylor, J., **Campanella, O.H.**, & **Hamaker, B.R.** (2016). Functionality of the storage proteins in gluten-free cereals and pseudocereals in dough systems. *Journal of Cereal Science*, 67, 22-34.
24. Delcour, J.A., Aman, P., Courtin, C.M., **Hamaker, B.R.**, & Verbeke, K. (2016). On prebiotics, fermentable dietary fiber and health claims. *Advances in Nutrition* 7, 1-4.
25. Zhang, G., & **Hamaker, B.R.** (2016). The nutritional property of endosperm starch and its contribution to health benefits of whole grain foods. *Critical Reviews in Food Science and Nutrition* DOI:10.1080/10408398.2015.1130685.
26. Bertoft, E., Annor, G.A., **Shen, X.**, **Rumpagaporn, P.**, Seetharaman, K., & **Hamaker, B.R.** (2016). Small differences in amylopectin fine structure may explain large functional differences of starch. *Carbohydrate Polymers* 140, 113-121.
27. Nichols, B.L., Diaz-Sotomayor, M., Avery, S.E., Chacko, S.K., Hadsell, D.L., Baker, S.S., **Hamaker, B.R.**, **Yan, L.**, Lin, H.M., & Quezada-Calvillo, R. (2016). Milk glucosidase activity enables suckled pup starch digestion. *Molecular and Cellular Pediatrics* DOI: 10.1186/s40348-016-0032-z.
28. Sorndech, W., Sagnelli, D., Meier, S., Jansson, A.M., **Lee, B.H.**, **Hamaker, B.R.**, Rolland-Sabaté, A., Hebelstrup, K.H., Tongta, S., & Blennow, A. (2016). Structure of branching enzyme- and amylomaltase modified starch produced from well-defined amylose to amylopectin substrates. *Carbohydrate Polymers* 152, 51-61.
29. **Lee, B.H.**, Rose, D.R., Lin, A.H.M., Quezada-Calvillo, R., Nichols, B.L., & **Hamaker, B.R.** (2016). Contribution of the individual small intestinal  $\alpha$ -glucosidases to digestion of unusual  $\alpha$ -linked glycemic disaccharides. *Journal of Agricultural and Food Chemistry* 64, 6487-6494.
30. Miao, M., Jia, X., **Hamaker, B.R.**, Cui, S.W., Jiang, B., & Huang, C. (2016). Structure-prebiotic properties relationship for  $\alpha$ -D-glucan from *Leuconostoc citreum* SK24.002. *Food Hydrocolloids* 57, 246-252.
31. **Rumpagaporn, P.**, **Reuh, B.L.**, **Cantu-Jungles, T.M.**, **Kaur, A.**, Patterson, J.A., Keshavarzian, A., & **Hamaker, B.R.** (2016). Elevated propionate and butyrate in fecal ferments of hydrolysates generated by oxalic acid treatment of corn bran arabinoxylan. *Food & Function* 7, 4935-4943.
- See paper in **Ferruzzi** (Moser et al.)

## Janaswamy

32. Xu, Q., Chen, C., Rosswurm, K., Yao, T., & **Janaswamy, S.** (2016). A facile route to prepare cellulose-based films. *Carbohydrate Polymers*, 149, 274-281.

## Jones

33. **Jones, O.G.** (2016). Developments in dynamic atomic force microscopy techniques to characterize viscoelastic behaviors of food materials at the nanometer-scale. *Current Opinion in Food Science*, 9: 77-83.
34. Kim, H.W., Steyabrata, D., Lee, Y.J., **Jones, O.G.**, & Kim, Y.H.B. (2016). Pre-treated mealworm and silkworm as a novel non-meat ingredient in emulsion sausages. *Innovative Food Science and Emerging Technologies*, 38: 116-123
35. **Murphy, R.**, Farkas, B., **Jones, O.G.** (2016). Dynamic and viscoelastic behavior of  $\beta$ -lactoglobulin microgels of varying sizes at fluid interfaces. *Journal of Colloid & Interface Science*, 466: 12-19.
36. **Jones, O.G.** (2016). Recent advances in the functionality of non-animal-sourced proteins contributing to their use in meat analogues. *Current Opinion in Food Science*, 7: 7-13.
37. **Du, J.**, **Reuhs, B.L.**, & **Jones, O.G.** (2016). Influence of PEGylation on the ability of carboxymethyl-dextran to form complexes with  $\alpha$ -lactalbumin. *Food Chemistry*, 196, 853-859.

See paper in **Ferruzzi** (He et al.)

## Kokini

38. **Bonilla, J.C.**, Bozkurt, F., Ansari, S., Sozer, N., & **Kokini, J.L.** (2016). Applications of quantum dots in Food Science and biology. *Trends in Food Science & Technology*, 53, 75-89.
39. Etoriki, A.M., Gao, M., Sadeghi, R., Maldonado-Mejia, L.F., & **Kokini, J.L.** (2016). Effects of desolvating agent types, ratios, and temperature on size and nanostructure of nanoparticles from  $\alpha$ -lactalbumin and ovalbumin. *Journal of Food Science*, 81(10).

40. Gezer, P.G., Liu, G.L., & **Kokini, J.L.** (2016). Detection of acrylamide using a biodegradable zein-based sensor with surface enhanced Raman spectroscopy. *Food Control*, 68, 7-13.
41. Karimi, M., Habibi-Rezaei, M., Rezaei, K., Moosavi-Movahedi, A.A., & **Kokini, J.** (2016). Immobilization of inulinase from *Aspergillus niger* on octadecyl substituted nanoporous silica: Inulin hydrolysis in a continuous mode operation. *Biocatalysis and Agricultural Biotechnology*, 7, 174-180.
42. Rouf, T.B., & **Kokini, J.L.** (2016). Biodegradable biopolymer-graphene nanocomposites. *Journal of Materials Science*, 51(22), 9915-9945.
43. Yazar, G., Duvarci, O.C., Tavman, S., & **Kokini, J.L.** (2016). Effect of mixing on LAOS properties of hard wheat flour dough. *Journal of Food Engineering*, 190, 195-204.
44. Rathod, M.L., & **Kokini, J.L.** (2016). Extension rate distribution and impact on bubble size distribution in Newtonian and non-Newtonian fluid in a twin screw co-rotating mixer. *Journal of Food Engineering*, 169, 214-227.
45. Gezer, P.G., Hsiao, A., **Kokini, J.L.**, & Liu, G. L. (2016). Simultaneous transfer of noble metals and three-dimensional micro- and nanopatterns onto zein for fabrication of nanophotonic platforms. *Journal of Materials Science*, 51(8), 3806-3816.
46. Gezer, P.G., Liu, G.L., & **Kokini, J.L.** (2016). Development of a biodegradable sensor platform from gold-coated zein nanophotonic films to detect peanut allergen, Ara h1, using surface enhanced raman spectroscopy. *Talanta*, 150, 224-232.
47. Luecha, J., & **Kokini, J.L.** (2016). Molecular organization and topography of prolamin protein films. *Food Engineering Series Imaging Technologies and Data Processing for Food Engineers*, 243-267.

## Mauer

48. Li, N., Taylor, L.S., & **Mauer, L.J.** (2016). Heat transport model for the deliquescence kinetics of crystalline ingredients and mixtures. *Journal of Food Engineering*, 169, 298-308.
49. **Allan, M.**, Taylor, L.S., & **Mauer, L.J.** (2016). Common-ion effects on the deliquescence lowering of crystalline ingredient blends. *Food Chemistry*, 195, 2-10.
50. **Allan, M.**, & **Mauer, L.J.** (2016). Comparison of methods for determining the deliquescence points of single crystalline ingredients and blends. *Food Chemistry*, 195, 29-38.
51. San Martin-Gonzalez, F. and **Mauer, L.J.** (2016). Ch. 2. The principles of food science. In *Culinology®: The Intersection of Culinary Art and Food Science*, Ed. J. Jeffrey Cousminer, Research Chefs Association, John Wiley & Sons.

## Narsimhan

52. **Narsimhan, G.** (2016). Characterization of Interfacial Rheology of Protein-Stabilized Air-Liquid Interfaces. *Food Engineering Reviews*, 8(3), pp.367-392.
53. Xiang, N., Lyu, Y., & **Narsimhan, G.** (2016). Characterization of fish oil in water emulsion produced by layer by layer deposition of soy  $\beta$ -conglycinin and high methoxyl pectin. *Food Hydrocolloids*, 52, pp.678-689.
54. Wu, X., Singh, A.K., Wu, X., Lyu, Y., Bhunia, A.K. & **Narsimhan, G.** (2016). Characterization of antimicrobial activity against *Listeria* and cytotoxicity of native melittin and its mutant variants. *Colloids and Surfaces B: Biointerfaces*, 143, pp.194-205.

55. **Narsimhan, G.** (2016). Drainage of particle stabilized foam film. *Colloids and Surfaces A: Physicochemical and Engineering Aspects*, 495, pp.20-29.
  56. Xiang, N., Lyu, Y., Zhu, X., Bhunia, A.K. & **Narsimhan, G.** (2016). Methodology for identification of pore forming antimicrobial peptides from soy protein subunits  $\beta$ -conglycinin and glycinin. *Peptides*, 85, pp.27-40.
- See **Campanella** (Eren et al.)

## Reuhs

57. Whitney, K., **Reuhs, B.L.**, Martinez, M.O., & Simsek, S. (2016). Analysis of octenylsuccinate rice and tapioca starches: Distribution of octenylsuccinic anhydride groups in starch granules. *Food Chemistry*, 211, 608-615.
- See **Hamaker** (Rumpagaporn et al.), **Jones** (Du et al.)

## Yao

58. Fu, Y., Sarkar, P., Bhunia, A.K., & **Yao, Y.** (2016). Delivery systems of antimicrobial compounds to food. *Trends in Food Science & Technology*, 57, 165-177.
59. Sarkar, P., Bhunia, A.K., & **Yao, Y.** (2016). Emulsion stabilized with starch octenyl succinate prolongs nisin activity against *Listeria monocytogenes* in a cantaloupe juice model. *Journal of Food Science*, 81(12).
60. Sarkar, P., Bhunia, A., & **Yao, Y.** (2016). Nisin adsorption in colloidal systems formed with phytyglycogen octenyl succinate. *Food Biophysics*, 11(4), 311-318.

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

### April

1. **Ferruzzi, M. G.** The food matrix as a partner in delivery of bioactive phytochemicals. Experimental Biology annual meeting, San Diego, California.
2. **Hamaker, B. H.** Gut hormone secretion by dietary maltooligosaccharide chemosensation in small intestine enteroendocrine cells. Experimental Biology annual meeting, San Diego, California.
3. **Li, J., Desam, G.P.R., Campanella, O., Narsimhan, G.** Swelling kinetics of waxy native maize starch, NIFA Progress Report, San Diego, California.

### May

4. **Hamaker, B., Nie, X., Tuncil, Y., Jungles, T., Reuhs, B.** Towards design of dietary fibers for gut health. 13<sup>th</sup> International Hydrocolloids Conference, Guelph, Canada.
5. **Ferruzzi, M.G.** Connecting food science and nutrition strategies to deliver bioactive plant phytochemicals. Instituto Politecnico Nacional, Mexico.
6. **Mauer, L.J.** Manipulating the solid state structure of thiamine. Food Engineering for Life Honorary Symposium for Professor Emeritus Marcus Karel. MIT, Cambridge, Massachusetts.
7. **Allan, M. and L.J. Mauer.** Relative humidity-temperature phase diagrams of hydrate forming deliquescent crystalline ingredients. The 9<sup>th</sup> International Conference on Water in Food. Leuven, Belgium.
8. **Janaswamy, S.** Ordered hydrocolloids networks as delivery vehicles of polyphenols. 13<sup>th</sup> International Hydrocolloids Conference, Guelph, Canada.
9. **Janaswamy, S.** Cellulose-based novel biodegradable films. 13<sup>th</sup> International Hydrocolloids Conference, Guelph, Canada.
10. **Janaswamy, S.** Novel biomaterials based on starch-polyphenol interactions. 13<sup>th</sup> International Hydrocolloids Conference, the University of Guelph, Guelph, Canada.

### June

11. **Campanella, O.** Extrusion for food and non-food materials. University of Sao Paulo, Brazil.
12. **Hamaker, B.** Natural fibers from food and their influence on the gut microbiota and human health. International Scientific Association for Probiotics and Prebiotics (ISAPP) Conference, Turku, Finland.
13. **Jones, O.G.** Polysaccharide-protein behavior and structures for food application. University of Sao Paulo, Department of Food Engineering, Pirassununga, Brazil.
14. **Jones, O.G.** Recent advances in guiding protein-polysaccharide behavior and structural assembly. University of Sao Paulo, Department of Food Science, Piracicaba, Brazil.
15. **Mauer, L.J.** The amorphization of vitamins C and B<sub>1</sub>, and resulting effects on physical and chemical stability. 13<sup>th</sup> International Symposium on the Properties of Water (ISOPOW). Lausanne, Switzerland.

### July

16. **Bonilla, J. Ryan, V., Bhunia, A., & Kokini J.L.** Specific anti-HMW glutenin and anti-LMW glutenin antibodies development by comparative genomics for in-situ imaging. Institute of Food Technologists annual meeting, Chicago, Illinois.
17. **Campanella, O.** Using soft matter concepts and modeling: An approach to understand the behavior of foods. University of Campinas, Brazil.
18. **Campanella, O.** Biomaterial Characterization. Harbin University, China.
19. **Campanella, O.** Extrusion of food and non-food materials and characterization of biomaterials. Jiangnan University, China.
20. **Cheng, C., & Jones, O.G.** Stabilizing zein nanoparticle dispersions with carrageenan. Institute of Food Technologists annual meeting, Chicago, Illinois.



21. **Hamaker, B.** Carbohydrate quality and how the concept may relate to healthier foods. International Carbohydrate Symposium, New Orleans, Louisiana.
22. **Hamaker, B.** Effect of amylose content on branching enzyme and amyloamylase chain transfer, Institute of Food Technologists annual meeting, Chicago, Illinois.
23. **Kokini, J.L., Yao, Y. & Zhou, P.** Designing Biomaterials for Sustainable Food and Health: Assembling Proteins and Carbohydrates to Construct Sensors and Carriers of Active Compounds. Institute of Food Technologists annual meeting, Chicago, Illinois.
24. **Mauer, L.J.** The amorphization of vitamins. Marcel Loncin Keynote. Institute of Food Technologists annual meeting, Chicago, Illinois.
25. **Yao, Y.** Dendrimer-like biopolymers to enhance active ingredients for food and health, Institute of Food Technologists annual meeting, Chicago, Illinois.
26. **Desam, G., Li, J., Campanella, O. & Narsimhan, G.** Swelling kinetics of waxy native maize starch, Institute of Food Technologists annual meeting, Chicago, Illinois.

## August

27. **Du J, Jones O.J.** Interaction and structure formation between  $\alpha$ -lactalbumin and chitosan grafted with poly(ethylene glycol) chains. American Chemical Society, fall meeting, Philadelphia, Pennsylvania.
28. **Hamaker, B.** High specificity of carbohydrate structures for gut bacteria provides clues for targeted prebiotics, KTH Royal Institute of Technology, Stockholm, Sweden.
29. **Hamaker, B.** Dietary fiber polysaccharides as potential prebiotics. Bertebos Conference, Falkenberg, Sweden.

## September

30. **Campanella, O.** Conference of Food Engineering (COFE) Section Chair and presentation, Ohio State University, Columbus, Ohio.
31. **Hamaker, B.** Carbohydrate quality and how the concept may relate to healthier foods. Symposium on the Alpha-Amylase Family (ALAMY\_6), Slovakia.
32. **Narsimhan, G.** Antimicrobial peptides in food safety, Conference of Food Engineering, Columbus, Ohio.
33. **Desam, G., Li, J., Campanella, O. & Narsimhan, G.** Model for prediction of swelling kinetics of waxy maize starch, Conference of Food Engineering, Columbus, Ohio.

## October

34. **Daniella, Z., Uzun, S., Sadeghi, R., and Kokini, J.** The effect of starch composition on starch nanoparticles characteristics, American Association of Cereal Chemists International annual meeting, Savannah, Georgia.
35. **Ferruzzi, M.G.** Emerging science of fruit juice bioactives and health. Academy of Nutrition and Dietetics, Food And Nutrition Conference and Expo, Juice Products Association sponsored session, Boston, Massachusetts.
36. **Hamaker, B.** Enhancing the prospect of success in the peer-review system. American Association of Cereal Chemists International annual meeting, Savannah, Georgia.
37. **Hamaker, B.** Novel applications of dietary fibers. American Association of Cereal Chemists International annual meeting, Savannah, Georgia.
38. **Kokini, J.** Designing starch based textures using extrusion, American Association of Cereal Chemists International annual meeting, Savannah, Georgia.
39. **Fang, F., Campanella, O., Hamaker, B.** Effects of hydrocolloids on shear-thickening behavior of starch dispersions and its impacts on gastric emptying rate. American Association of Cereal Chemists International annual meeting, Savannah, Georgia.

40. **Tuncil, Y.E.**, Xiao, Y., Porter, N., **Reuhs, B.**, Martens, E., **Hamaker, B.** Human colon bacteria show substrate dependent hierarchical preference to dietary fibers, with structure determining rank. American Association of Cereal Chemists International annual meeting, Savannah, Georgia.
41. **Hamaker, B.** International Conference and Exhibition on Nutraceuticals and Functional Foods (ISNFF) Conference, Orlando, Florida.
42. Peng, X., **Yao, Y.** Microscale structure and thermal and pasting properties of sweet corn and cow cockle starches, American Association of Cereal Chemists International annual meeting, Savannah, Georgia.
43. **Yao, Y.** Advances in the use of starch for imparting fat-like texture to foods, American Association of Cereal Chemists International annual meeting, Savannah, Georgia.

## November

44. **Barber, E.A.**, **Turasan, H.**, Devina, D. & **Kokini, J.L.** Optimized and tested zein film for utilization as an effective SERS sensor. American Institute of Chemical Engineers annual meeting, San Francisco, California.
45. **Barber, E.A.**, **Turasan, H.**, Rouf, T.B. & **Kokini, J.L.** Characterization of engineered biodegradable zein films for sensor-based platform production. European Federation of Food Science and Technology annual meeting, Vienna, Austria.
46. Duvarci, O.C., Yazar, G. & **Kokini J.L.** The non-linear rheological behavior and LAOS properties of corn starch dispersions. European Federation of Food Science and Technology annual meeting, Vienna, Austria.
47. **Ferruzzi, M.G.** Plant phenolics as a tool to modify glycemic response. XXII Encotro Lus-Galego de Quimica, Braganca, Portugal.
48. **Ferruzzi, M.G.** Leveraging native nutrient dense plant materials in development of market-led instant cereal grain foods. Catholic Relief Services Integrated Nutrition Conference, Nairobi, Kenya.
49. Lyu, Y., Xiang, N., Zhu, X. & **G. Narsimhan.** Pore formation by aggregates of melittin in 1,2-Dioleoyl-sn-glycero-3-phosphocholine (DOPC) and 1,2-di-(9Z-octadecenoyl)-sn-glycero-3-phospho-(1'-rac-glycerol) (DOPG) mixed lipid bilayer, American Institute of Chemical Engineers annual meeting, San Francisco, California.
50. **Turasan, H.**, **Barber, E.A.**, Meiser, M. & **Kokini, J.** Analyzing the chemical and the physical characteristics of crosslinked zein gel films cast from acetic acid solutions. American Institute of Chemical Engineers annual meeting, San Francisco, California.
51. Yazar, G. Duvarci, O.C., & **Kokini J.L.** Impact of gluten in the non-linear rheological behavior of dough and LAOS properties of different gluten-free dough. European Federation of Food Science and Technology annual meeting, Vienna, Austria.
52. Wu, X. & **Narsimhan, G.** Synergistic effect of low power ultrasonication and antimicrobial action in deactivation of *Listeria monocytogenes*, American Institute of Chemical Engineers annual meeting, San Francisco, California.

## December

53. **Campanella, O.** Modeling non-thermal food processes, Jiangnan University, China.
54. **Campanella, O.** 12-hour research course, University of Naples, Italy.

## C. Graduate Degrees Awarded

1. **Xi Wu, Ph.D.**, *Antimicrobial activity of natural and mutant variants of free and immobilized antimicrobial peptides against Listeria and E. coli*, May.
2. **Jennifer Allen, Ph.D.**, *Macronutrient-flavonoid interactions, effects in model food matrices*, August.
3. **Sydney Moser, Ph.D.**, *Influence of dietary polyphenols on carbohydrate intestinal digestion and absorption*, August.
4. **Benjamin Redan, Ph.D.**, *Intestinal adaptation to repeated exposure of flavonoid-rich foods: in vitro and clinical data*, August.
5. **Carlos Carter, M.S.**, *Antibacterial activity of essential oil encapsulated sodium iota-carrageenan fibers*, December.
6. **Tingting Chen, Ph.D.**, *Modulation of gut microbiota in vitro in stools from healthy and diseased individuals using soluble plant cell wall-based dietary fibers*, December.
7. **Juan Du, Ph.D.**, *Complex formation by alpha-lactalbumin and polysaccharide copolymers*, December.
8. **Xin Nie, Ph.D.**, *Relationship between dietary fiber structural features and human gut bacterial growth and their utilization strategies*, December.
9. **Juan Sanchez, M.S.**, *Amorphous ascorbic acid degradation in PVP solid dispersions and the effects of water and pre-lyophilization solution pH on its chemical stability*, December.
10. **Yunus Tuncil, Ph.D.**, *Complex glycan utilization preferences of human gut bacteria*, December.

## D. Recognitions, Awards, and Honors

1. **Matt Allan** received the first James and Pari BeMiller Graduate Scholarship.
2. **Fang Fang** received the Isydore Hlynka Best Student Paper Award from the AACCI Rheology Division.
3. **M. Ferruzzi** received a Named Fellow of the Royal Society of Chemistry (UK).
4. **Luis Maldonado** received the Purdue College of Ag Graduate Student Pathmaker Award.
5. **L. Mauer** was named a BIG Academic Alliance Academic Leadership Fellow (2016-2017).
6. **L. Mauer** received the Purdue University TEAM Award.
7. **Ryan Murphy** was selected as a Forbes Under 30 Scholar and was a member of the 2<sup>nd</sup> place IFTSA College Bowl team.
8. **Xin Nie** won 2nd place in the graduate student research paper competition of the Nutrition Division at the Institute of Food Technologists 2016 annual meeting.
9. **Leigh R. Schmidt** placed 2nd in the Protein Division poster competition at the Institute of Food Technologists Annual Meeting.
10. **Yunus Tuncil** received first place winner of the 2016 AACC International Carbohydrate Division/ Megazyme Award at the annual meeting in Savannah, Georgia. He was also a finalist in the best student paper competition at the AACCI.

## E. Special Events

### Whistler Center Short Course, October 4-6, 2016

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 structures and properties of polysaccharides, J. BeMiller
- Polysaccharide architecture, S. Janaswamy
- Starch Granule Structures 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

- Advances in chemical and physical modifications of starch part I, J. BeMiller
- Hydrocolloids and functionality part I, J. Keller
- Dietary factor affecting glucose homeostasis part I - slow digestion, B. Hamaker
- Dietary factor affecting glucose homeostasis part II - plant phytochemicals, M. Ferruzzi
- Complex carbohydrate structure analysis (non-starch) part I, part II, B. Reuhs

- Rheological properties of food biopolymers and their role in bioprocessing and product development, O. Campanella
- Prebiotics and the gut microbiome, B. Hamaker/S. Lindemann
- Polysaccharide architecture and functionality including starch, S. Janaswamy
- Extrusion technology for the production of food and non-food materials, O. Campanella
- Carbohydrate related enzymes and their applications, J. Shim
- Physical property testing of carbohydrates – Solids part I, L. Mauer
- Phase stability of polysaccharide mixtures, part I, O. Jones
- Phase stability of polysaccharide mixtures, part II, O. Jones
- An introduction to advanced methods of food material characterization part II, J. Kokini/G. Schmidt
- Predictive modeling of multicomponent systems part I and part II, G. Narsimham
- Biomedical applications, G. Schmidt
- Starch and genetic variability: Work the plant can do for you, C. Weil



## 2016 Belfort Lecture

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### **“Nutritional engineering of gut microbiome for optimized human metabolic health”**

2016 Belfort Lecturer

#### **Dr. Liping Zhao**

Distinguished Professor for Microbiology, Director of the Microbial Ecology and Ecogenomics Laboratory in School of Life Sciences and Biotechnology, Shanghai Jiao Tong University

*Dr. Liping Zhao* received his Ph.D. in 1989 from Nanjing Agricultural University and worked at Cornell University as visiting scholar from 1993 to 1995. He is currently Distinguished Professor for Microbiology and director of the Laboratory of Microbial Ecology and Ecogenomics in School of Life Sciences and Biotechnology, Shanghai Jiao Tong University. He is the director of the Laboratory of Nutritional Systems Biology in Shanghai Center for Systems Biomedicine. He is also the director the SJTU-Perfect (China) Joint Research Center on Microbiota and Health. He served as a board member of the International Society for Microbial Ecology from 2006 to 2012. He is a current editorial board member of FEMS Microbiology Ecology, Journal of Molecular Medicine, and a senior editor of the ISME (International Society for Microbial Ecology) Journal. He was elected a fellow of the American Academy of Microbiology in 2014.

His team has been applying molecular and genomic tools for systems understanding and predictive manipulation of the complex microbial communities in human and animal guts. They have published more than 30 research papers in PNAS, Nature Communications, ISME Journal, AEM, FEMS Microbiology Ecology, etc. He also published reviews in Nature Reviews Microbiology, Journal of Proteome Research, Molecular Aspects of Medicine, etc. He has been invited to give keynote and plenary talks in ASM general conference, ISME conference, etc. His current focus is the interactions between nutrition and gut microbiota in onset and progression of chronic diseases, such as obesity and diabetes, and how diet, traditional Chinese medicine and medicinal foods may modulate this relationship for achieving preventive healthcare. In June 2012, Science magazine featured a story on how he combines traditional Chinese medicine and gut microbiota study to understand and fight obesity (Science 336: 1248).



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