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* Carbohydrate Center at the Graduate Institute of Food Science and Technology at National Taiwan University (NTU/GIFST/Carbohydrate Center)

In Memoriam

Marilyn Yundt

Marilyn Yundt was hired (at a time when we still had secretaries) to be the secretary for Dr. BeMiller, Director of the Whistler Center, in the Spring of 1999, shortly after the Center had moved into the new Food Science building (now the Nelson Hall of Food Science). She was a little older and less experienced than the other candidates, but the one chosen by Dr. BeMiller. Having little experience, she had to start at the bottom of the ladder. However, Dr. BeMiller explained to her that, because the Center had grown considerably during its first 13 years and because of his travel schedule, what he was really looking for was an "administrative assistant", which under university HR rules, he did not qualify for. It was soon apparent that Marilyn was highly organized, very efficient, and quick to learn. As a result, she rather quickly moved up the ladder in responsibilities and positions. It wasn't long before all recognized that she was the heart and soul of much of the operation of the Center – pushing faculty members to get assignments in on time, recruiting students to help with tasks associated with annual meetings and short courses, desktop publishing of annual reports, preparing newsletters, scheduling, reserving rooms, etc., etc., etc. She rapidly grew into being the Center Coordinator and met her responsibilities with dedication, interest, understanding, and perfection. We miss her.

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DIRECTOR'S STATEMENT

I welcome you to read through our 2014 Whistler Center for Carbohydrate Research Annual Report. Food carbohydrates it seems continue to go through changes in the public's viewpoint in regards to role in the diet and more generally health. It's brought to our attention a need for straightforward and fairly simple education of what carbohydrates are, what they do once they enter the body, and how the concept of "carbohydrate quality" could differentiate dietary carbohydrates. What is not well seen outside of the science, are a number of exciting developments at the molecular level of carbohydrate science in delivery systems for better and more efficient obtaining of nutraceuticals and other bioactives and drugs, assemblages to build unique textures and matrices so that foods are more desirable and nutritious, and structural understanding of carbohydrates to deliver better nutrition and health and to positively affect the gut microbiome, in a natural and safe way. These are some of the topics we work on at the Whistler Center, and in multi-disciplinary teams both within Purdue University and among other universities and research centers in the US and abroad.

We had a year of accomplishments and also one of sadness. Our long-time Whistler Center Coordinator, friend and colleague, Marilyn Yundt became ill with cancer and passed away in January 2015. She held us together through her excellent organizational skills and gentle but strong persuasive ways. She was our ambassador and she made everybody who visited us feel special. We miss her deeply.

In 2014, we saw Dr. Amy Hui-Mei Lin leave Purdue and the Whistler Center for a tenure-track Associate Professor position at University of Idaho in the joint food science department between U of I and Washington State University. Amy helped steer us over the last 3 years to expand our partnerships globally, and in communication with our member companies; as well as her strong contributions in research on starch and digestive enzymes. We welcomed in a new faculty member to the Whistler Center, Dr. Mario Ferruzzi, who is widely recognized for his excellence in phytochemistry and nutrition. He brings expertise and on-going research in the area of phenolic compounds and their interaction with dietary carbohydrates, and their inhibition of the small intestine starch degrading enzymes and glucose transporters, as well as new research on the interplay between dietary phytochemicals, dietary fiber and the gut microbiome. His broad experience with the food industry is certainly another plus for the Center.

We were honored in May to have Prof. Inger Björck, from the Functional Food Science Centre, Lund University, Sweden, present our Belfort Endowed Lecture at the Technical Conference following our annual meeting. Her group's exciting human research on glycemic carbohydrates and the potential of using carbohydrates to promote health and cognitive performance has made them a world leader in this area. Prof. Sang-Ho Yoo from Sejong University, Seoul, South Korea also gave an excellent talk on carbohydrate synthesizing enzymes and new functional carbohydrates for food uses.

We continue to offer a successful yearly Short Course, primarily for our member companies for which it is free. Last year we had about 70 participants for our 3-day course and brought in three outside presenters, Stefano Renzetti from TNO/Netherlands, John Keller/consultant in hydrocolloids, and Madhuvanti Kale from USDA/ERRC. Presentation topics are listed on page 77. Internationally we have active formal partnerships between the Whistler Center and Sejong University, South Korea and Jiangnan University, China; and individual faculty visiting professorships at Monterrey Tech (O. Campanella) and Shanghai Jiao Tong University (B. Hamaker).

Please peruse our 2014 Whistler Center Annual Report and find out the exciting things we do and offer. For more information, feel free to contact either myself or Mikaela Allan, our new Center Coordinator.

Sincerely,

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

Starches, Non-Starch Polysaccharides, and Cereals:

A Visiting Scientist and a Visiting Scholar working with **Dr. BeMiller** continued studies of the impacts of the presence of hydrocolloids on the pasting, paste, and gel characteristics of starches by focusing on any effects of the presence of a hydrocolloid on retrogradation (Project 1).

Drs. Campanella and Hamaker have a second year project to better understand the structural properties of branched starches and their functional properties, and in particular shear thinning and thickening events relevant to processing as well as their digestion (Project 6).

A project of **B. Hamaker** on dietary fibers of amaranth, quinoa and three cereals showed compositional make-up, and revealed a way to make insoluble matrix fibers more fermentable (while retaining their comparably slower fermentation rate and presumed tolerability. Simple physical processing of quinoa fiber greatly increased its solubility, but interestingly creating a soluble fiber that in initial *in vitro* fermentation produced low gas but significant short chain fatty acids (Project 9).

B. Hamaker and O. Campanella's group continued to work on fundamental approaches to functionalize non-wheat cereal storage proteins, with a focus on corn zein. In 2014, Daniel Erickson completed his Ph.D. studies and he has published a study that is systematically examining changes in the structure and function of zein in the presence of a plasticizer and co-proteins. That project was in collaboration with TNO. The final part of his thesis research was a collaboration with Prof. Sinan Keten from Northwestern University. The work used molecular dynamics simulation to understand how zein peptide segments participate in viscoelastic fibril formation (Project 8). A manuscript has been finalized for publication and another manuscript dealing with the characterization of these fibrils will be submitted shortly. Daniel Erickson is now working for Nestle in St Louis, MO.

Dr. Yao's work in 2014 has mostly focused on functional carbohydrate biomaterials, with a particular emphasis on the delivery and formulation of antimicrobial compounds (Project 34), as well as the stabilization and dissolution of active ingredients including: antimicrobial compounds (Project 35), food nutrients and nutraceuticals (Projects 36, 37), and active pharmaceutical ingredients (Project 38). He has also initiated a project related to high-throughput starch screening (Project 39).

Carbohydrates, Nutrition and Health:

Research projects have expanded in the area of carbohydrates and health to include more research in the area of dietary fiber and the gut microbiota, phytochemicals and glycemic response, human studies on carbohydrates and sustained energy; and in the near future phytochemicals, carbohydrates, microbiota, and viscous polysaccharides and glycemic carbohydrate digestion. **B. Hamaker's** research is in two main areas: 1) control of glycemic carbohydrate digestion and physiological response (Projects 11, 12) and 2) dietary fiber structures, gut microbiota requirements, and functional endpoints (Projects 9, 10). The first addresses the question of how to moderate glycemic carbohydrate (mostly starch) digestion through examination of molecular fine structures, macro-assemblies and matrices, and at the level of enzyme-substrate relationships, as well as inhibitors. Much of this recent work has been done with Dr. Lee, post-doc, and in partnership with **Dr. Lin**, a Research Assistant Professor in the Center, who left in 2014 for a position at University of Idaho. The other objective of this work has been to understand cellular and physiological response related to slowly digestible carbohydrates, and has involved cell culture and *in vivo* studies which have shown change in feeding behavior and lowering of gene expression of hypothalamic appetite-stimulating neuropeptides in animals fed slowly digestible starch. They work with a multi-disciplinary collaborative group called "Starch Digestion Consortium" consisting of A. Lin at Purdue, B. Nichols at Baylor College of Medicine, R. Quezada-Calvillo in Mexico, D. Rose and M. Pinto in Canada, and H. Naim in Germany; and at Purdue on animal studies with T. Powley, R. Phillips, and K. Kinzig at the Department of Psychological Sciences. **Dr. Ferruzzi** has set up a cell monolayer system to quantify glucose uptake, with particular interest in studying phenolic compound interference with digestion and absorption of glycemic carbohydrates (Project 14).

In the second area of work on dietary fibers and the gut microbiota, **B. Hamaker** and **B. Reuh's** groups study fiber molecular structures and gut bacteria response, as well as requirements of bacteria and how they compete for fiber substrates (Projects 9, 10). Collaborators are A. Keshavarzian and group at Rush Medical School, Chicago; E. Martens, U. Michigan Medical School, Ann Arbor; and L. Zhao, Shanghai Jiao Tong University, China.

In 2014, **B. Hamaker's** group completed a Bill and Melinda Gates Foundation funded project in Bamako, Mali, done collaboratively with co-PIs B. Nichols (Baylor College of Medicine) and A. Rahmanifar (nutrition advisor), Ph.D. student F. Cisse, and physicians at Gabriel Toure Hospital in Bamako. They showed that stunted, marginally malnourished children have adequate α-glucosidases function to digest starches equal to or at a somewhat higher level than normal children, which appears to allow them to digest local thick sorghum porridges well (Project 13).

Dr. Lin's research focuses on starch chemistry and its nutritional aspects, with the emphasis on glycemic response management from the food science perspective. In 2014 (January-June), the third year of Lin's faculty appointment, she led a small research group with one Master's student, and one visiting Master's student. She continues collaboration with other members of the Starch Digestion Consortium as mentioned above. The long-term goal of her research is to improve human health and prevent diseases of the general population related to glycemic carbohydrates by providing solutions for problems related to starch digestion rate and location of delivery from the starch chemistry prospective. Lin and her students moved to the Bi-State School of Food Science at University of Idaho (Moscow, ID) and Washington State University (Pullman, WA) in July, 2014.

In 2014, they finished a study examining *in vivo* starch digestion in a sucrase deficient shrew model (Project 22), which was a paired study with a previous Mgam knock-out mouse model. In addition to understanding the digestion role of individual enzymes *in vivo*, the study tested a potential enzyme supplement for patients with Congenital Sucrase-Isomaltase Deficiency (CSID) and successfully enhanced dietary glucose generation *in vivo*. The group continues to study the relationship between starch fine structure and digestive enzymes, and moved on to identify the architecture of internal amylpectin molecules and the production of sustained dietary glucose (Project 21). **A. Lin's** group continues to work on the improvement of the measurement of starch digestibility *in vitro* with an emphasis on measuring slow or sustained dietary glucose (Project 23), which is associated with the physiological benefits that she and **B. Hamaker** continue to work on.

Dr. 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, Dr. Ferruzzi's research program 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.

Polysaccharide Structures:

Dr. Janaswamy's research demonstrates the utilization of carbohydrate fibers for the design and development of cost-effective carriers of nutraceuticals, drugs, and antimicrobial compounds. The research idea is about solubilizing functional molecules in an organic solvent and then encapsulating them in the water pockets of carbohydrate networks. His study on the encapsulation efficiency and release profiles of eugenol, an antimicrobial compound, employing sodium iota-carrageenan revealed sustained release of eugenol from the complex. A subsequent antimicrobial study demonstrated that the complexes are effective in controlling the proliferation of the foodborne pathogen *Listeria innocua F4248* (Project 15).

Dr. Jones's research follows the impact of polysaccharides on the development of biopolymer-based structures that have potential application in food systems. Polysaccharides contribute to the development of biopolymer-based structures by interactions, such as electrostatic, hydrogen-bond, and dispersion forces, which are readily controlled by laboratory methods. Thermodynamics and stoichiometry of interactions contributing towards structural development is frequently determined in our laboratory using spectroscopic techniques and calorimetry. Resulting structures are then characterized by a suite of nanoscale characterization techniques, including atomic force microscopy and light scattering. Major applications of such biopolymer-based structures pursued in our laboratory include emulsion/foam-interface stabilization, controlled release of active molecules in aqueous suspensions, and active films/gels for packaging or biomedical use.

Protein fibrils assembled from β-lactoglobulin show excellent promise for improved mechanical properties and as scaffolds for controlled-release materials or enzymes. The greatest challenge in β-lactoglobulin fibril research is the production of stable fibrils in non-acidic conditions and the production/isolation of fibrils in an industrially relevant mechanism. Previous research in our laboratory has shown means to preserve the stability of fibrils at neutral pH conditions (Project 16). Building upon this achievement, Project 17 investigates local heterogeneity, both in terms of structure and mechanics, within composite films containing protein fibrils in order to establish their potential use as active film systems. Project 17 also fulfills a long-term research goal of **O. Jones** and **O. Campanella,** which involves the fundamental relationships between nanoscale mechanical properties of individual biopolymer structures, their mesoscale architecture, and macro-rheological behaviors. Funding is currently being sought to facilitate these investigations.

Protein microgels (particulate agglomerates with diameters between 50 and 600 nm) may be formed from whey protein using thermal treatment; alternatively, protein nanoparticles are crafted from poorly soluble proteins, such as zein, using solvent nanoprecipitation techniques. Concluded research has shown that the size and porosity of microgels could be controlled by the amount and type of specific ions added to mixed solutions prior to microgel formation (Project 18). Project 18 also showed that other factors, including temperature and reducing agents, can be used to effectively control microgel attributes. Using this capacity to finely control microgel size and internal structure, an ongoing investigation is determining the efficacy and unique properties of such protein-based microgels as emulsion-interface stabilizers (Project 19).

Block ionomer complexes are assemblies of several polymers mediated by electrostatic interactions, where at least one of the polymers possesses two "blocks": one charged block capable of interaction and one uncharged but well-solvated block. With appropriate design of charged "blocks" and the proper selection of interactive polymers, a block ionomer complex will form a stable capsule within a liquid suspension that can be utilized for controlled release of active molecules. In order to make a block ionomer complex for controlled delivery in food systems, **O. Jones'** laboratory has created two block copolymers based on the charged polysaccharides chitosan and carboxymethyl-dextran (Project 20).

Rheology:

Dr. 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, e.g. during gelling, interaction of polymeric molecules with colloidal particles (e.g. silica), self-assembling of biomolecules, and the structure of fibers and their relevance in the incorporation high content of fibers in foods. The role of these physicochemical properties is also being analyzed in regards 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. Results of this research have an impact on the area of development of new materials and improved foods with good nutritional and textural qualities. The role of the material properties on processability is also being studied (Projects 2-8).

Development of new materials and understanding the physicochemical behavior of existing ones require a scientific foundation involving modeling and experimental validation. Work in this area also focuses on the functional efficacy of natural polymers used as part of food ingredients. Given the complex nature of these materials composition and the various conditions to which they are exposed during processing and storage, stability, functionality and quality under different environmental and processing conditions are key attributes that are being investigated by **O. Campanella's** group. In these projects rheological, thermophysical, spectrocopic 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, β-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, protein and fatty acids that has carrying capacity for sparingly soluble small molecules (Project 3).

Rheological characterization of colloidal systems the effects of particles on formation and properties of these systems are being studies using experimental methods (rheology, dynamic laser scattering (DLS), atomic force microscopy (AFM)) and molecular simulations. For the specific silica-protein system results are showing a significant interaction between the particles forming the suspension (silica) and the polymeric systems (protein) which in general results in increases of their viscoelasticity and viscosity (Project 2). Different types of interaction between the colloidal particles and the protein are being studied using isothermal calorimetry (ITC).

Rheology of food ingredients are also investigated. Pectin is one major component of plant cell walls and is used extensively as a functional food ingredient in a large number of products. The molecular structure and sugar composition of pectins affect their functionality, thus limiting commercial pectin production to a few plant sources. Specifically degree of methoxylation, degree of acetylation, pattern of methyl esterification, and molecular size determine the functional properties of pectins. Rheological measurements are of primary concern due to the importance of texture in assessing quality attributes of food products containing pectin. Analyzing the rheological profile of juice, serum, and particulate of these different varieties is helping to elucidate the impact of pectin methoxylation on the viscoelastic properties of many foods (Project 4, 5). New analysis of the data is showing that tomato products exhibit significant slippage and measurements could be prone to artifacts. Using the amount of pectins present in the serum it has demonstrated that the content of pectin has very little influence on the properties of tomato juice or sauce. It is hypothesized that the viscosity of tomato products is influenced by the characteristics of the tomato particles which can be affected by processing, e.g. cold break versus hot break

Methods to characterize rheological properties that are relevant to the texture of materials are being developed (Project 7).

Interfacial Phenomena:

Dr. Narsimhan's group continues to work on fundamental aspects of formation and stability of emulsions and foams. To complement the previous experimental and theoretical studies on unfolding of model proteins on nanoparticle surfaces, they are investigating pore formation in microbial cell membranes by antimicrobial peptides (Projects 26, 27).

Chemical Structures and Functions of Polysaccharides:

Dr. Reuhs and A. Terekhov run an 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 function related to physical functionality (described under Rheology), as well colon fermentation also described above (Projects 9. 10). Analysis typically involves monosaccharide profiling using the alditol acetate GC method, and linkage analysis by partial methylation using GC-MS and using NMR. Chromatography methods are used to profile molecular size and as a preparative technique.

Genetics:

Dr. Weil's lab now has a mutant population (~12,000 lines) of the important staple crop Sorghum bicolor. ~600 of these lines have been fully resequenced to catalogue all the mutations present in each. This database and seed for each mutant line are available to breeders worldwide at www.purdue.edu/sorghumgenomics. Novel mutations are already emerging from these data, including one mutation that lowers the gelatinization temperature of sorghum starch to an extent that could be significant in the brewing of fermented sorghum beverages. Additional mutants in these lines include those that improve the protein digestibility of the cooked sorghum flour. New waxy alleles have been identified, as well as in starch synthases and debranching enzymes. All these are being characterized further (Project 30) in collaboration with **L. Mauer** and **Y. Yao**.

Another project in the lab examines how plants partition the carbon they fix during photosynthesis into different forms and different locations within the plant (Project 31). 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 higher stalk sugar (as high as 20%) than is typical for corn, and we are pursuing breeding strategies to better understand the genes responsible and their control of this process. Using association mapping in recombinant inbred lines, three QTL for increased sugar content have been identified, and identification of the genes underlying these QTL that impact sugar accumulation is now the focus of this research. In addition, a reverse genetic strategy to knock out specific invertase enzymes to increase stalk sugar is being pursued.

In addition, the regulation of how carbohydrates are partitioned into seed, sugar or biomass is under genetic control, but is poorly understood. Together with colleagues at the University of Missouri, the University of Florida, and St. Michael's College, a NSF-funded project is characterizing the contents, functions and genetic networks that characterize phloem function, carbon partitionin, and yield. The Weil lab has now mapped over 90 of these mutations to candidate intervals on all ten chromosomes in the maize genome, and identification of the genes involved is being pursued. (Project 32).

As a part of this project the Weil lab is collaborating with The Purdue Physiological Sensors group to develop in planta sensors of sucrose movement during growth of both maize and sorghum. Using a combination of Fluorescence Resonance Energy Transfer (FRET), sensor proteins specific for sucrose, fiber optic resins, and the natural ability of aphids to insert their hollow stylets into phloem, the laboratory is developing the capacity to measure movement of sugar through the phloem tissue of the plants in real time in the field. The results will be valuable for understanding carbohydrate movement and changes in that movement. Current efforts on this project are in identifying optimal viscosity for the fiber optic resin to allow FRET restructuring once it has bound sucrose.

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, carried out by an undergraduate student, Sean Tague. 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.

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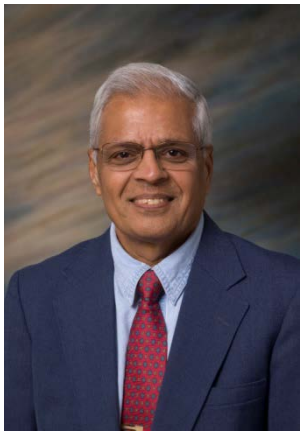
GENERAL RESEARCH AREAS
- Starch
- Carbohydrate chemistry

SPECIFIC RESEARCH AREAS
- Starch granule structure, reactivity, and behaviors
- Chemical and biological modifications of starch
- Structure-functional property relationships of polysaccharides
- Starch-hydrocolloid interactions
- Uses of carbohydrates in food and other commercial applications

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
- On-line 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

Bruce R. Hamaker

GENERAL RESEARCH AREAS

- Carbohydrates and health
- Starch
- Cereal chemistry and functionality

SPECIFIC RESEARCH AREAS

- Starch digestion control, low glycemic response/slow digestion and physiologic response
- Dietary fiber, modifications in functionality and colon fermentability, microbiota changes
- Cereal starch and protein functionality
- Functional properties influenced by starch fine structure
- Interactions between starch and other food components
- Appropriate methods of improving cereal utilization in developing countries

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

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

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

SPECIFIC RESEARCH AREAS

- Specific ion effects on milk protein-polysaccharide interactions
- Encapsulation methods for flavor oils using protein-polysaccharide structures
- Protein-fibril/polysaccharide electrostatic interactions for development of fibrous systems

Amy Hui-Mei Lin

GENERAL RESEARCH AREAS

- Starch chemistry
- Carbohydrates and human health

SPECIFIC RESEARCH AREAS

- Starch structure and its nutritional functionality
- Starch structure and its technical functionality
- Starch digestive enzymes
- Starch digestibility and its influence on physiological responses

Lisa J. Mauer

GENERAL RESEARCH AREAS

- Food chemistry
- Water-solid interactions

SPECIFIC RESEARCH AREAS

- Structure-function relationships of food ingredients
- Deliquescence
- Glass transitions
- Moisture sorption
- FT-IR spectroscopy

Ganesan Narsimhan

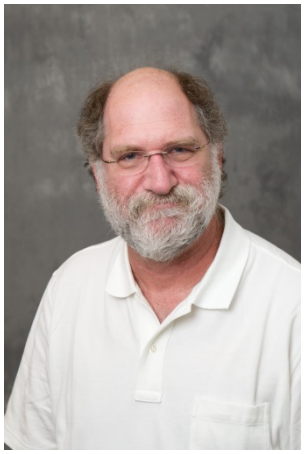
GENERAL RESEARCH AREAS
- Emulsions and foams
- Biopolymer interactions

SPECIFIC RESEARCH AREAS
- Pore formation by antimicrobial peptides in cell membranes and lipid bilayers
- 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

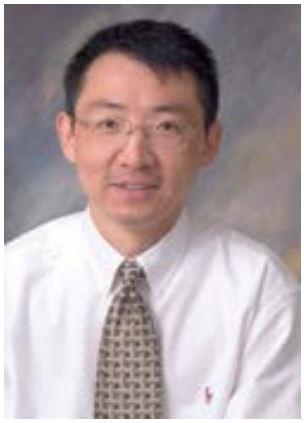
SPECIFIC RESEARCH AREAS
- Extractions and purification of acidic polysaccharides from cell walls of plants
- and bacteria
- Fiber analysis
- Pectin analysis
- Capsule, gum, and lipopolysaccharides analysis
- Application of HPLC, GC-MS, and NMR to structural studies of carbohydrates, including polysaccharides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



Clifford F. Weil

GENERAL RESEARCH AREAS
- Plant classical and molecular genetics
- Genomics of starch digestion, composition and architecture
- Genetics of carbohydrate redistribution in plants
- Gene expression
- Large-scale forward and reverse genetics screening
- Genome maintenance and organization

SPECIFIC RESEARCH AREAS
- Rational redesign of corn starch composition
- Sugar accumulation in grass crops
- Genetic control of starch and protein digestibility in corn and sorghum
- Genetic modification of corn starch properties



Yuan Yao

GENERAL RESEARCH AREAS

- Biomaterials and carbohydrate chemistry
- Food nanotechnology

SPECIFIC RESEARCH AREAS

- Dendrimer-like polysaccharides
- Food nanotechnology for enhanced food quality and safety
- Genetic, enzymatic, and chemical modifications of carbohydrates
- Novel process to control starch digestibility
- Functional emulsion systems

ADJUNCT FACULTY

Yonas Gizaw, Ph.D., is a Principal Scientist at Procter & Gamble Global Research & Development.

GENERAL RESEARCH AREAS

- Polymers, colloids and surfactants
- Self-assembly biopolymers
- Nanotechnology

SPECIFIC RESEARCH AREAS

- Adsorption of polymers on colloids, vesicles, and emulsions
- Polyelectrolytes and surfactant interactions and functional properties of coacervates
- Surface modification and characterization
- Design, modification and application of starches in consumer products

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.

VISITING PROFESSORS

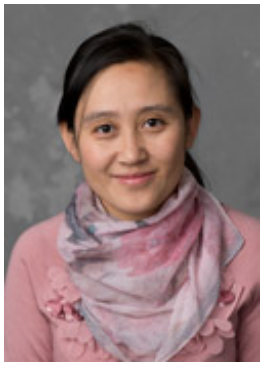
Edith Agama Acevedo is Associate Professor at the Center for Development of Biotic Products of the National Polytechnique Institute-Mexico. She was on sabbatical with her husband Dr. Arturo Bello-Perez and worked with Dr. Hamaker. Her work was on hydrothermal treatment of high-amylose starches to develop slowly digestible property.

Li Guo received a Ph.D. degree (2010) in the Key Laboratory of Tea Biochemistry and Biotechnology, Anhui Agricultural University, studying primarily tea polysaccharides, and has returned to her position as an Associate Professor in the School of Tea and Food Sciences of the same university in August.

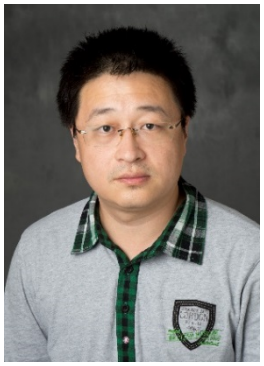
Wenbin Guo earned a Ph.D. from Inner Mongolia Agricultural University in 2009. He arrived to Purdue in August 2014 and is Lecturer at the College of Mechanical and Electrical Engineering Inner Mongolia Agricultural University Hohhot, Inner Mongolia Autonomous Region, 010018 P. R. of China. Wenbin is working on novel rheological methods to characterize the viscoelastic properties of vegetables and agricultural products and how they relate to the physical composition notably the water content of these materials.

Xiao Hua received his Ph. D in Material Science from Nanjing University of Science and Technology, and now is working in School of Food Science and Technology, Jiangnan University. His research mainly focuses on food hydrocolloids and oligosaccharides. He has been working with Dr. Hamaker's group since August 2014, researching the digestion of cellulose hydrolyzates by microorganisms from the human gut.

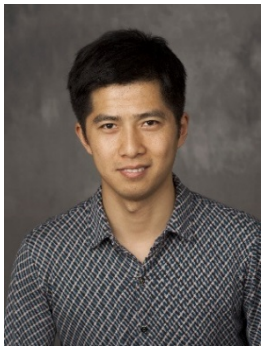
Kyeongyee Kim is a Professor in the Department of Food Science and Biotechnology of Seoul University in South Korea. Her research focuses on the rheological properties of polysaccharides and hydrocolloids and fractionation to evaluate chemical heterogeneity with varying structural parameter. Dr. Kim was a visiting professor in the labs of Drs. Hamaker and Campanella until August 2014.



Xiaolei Li is an Associate Professor in the Department of Food Science at Changchun University, China. She received her Ph.D. degree from Jilin University in 2009. Dr. Li joined Dr. Hamaker's group as a visiting faculty in September 2013. Her research focuses on the enzymatic modification of fructooligosaccharide for colon health.



Xiaoxi Li is an Associate Professor at South China University of Technology (SCUT; PR China). He received his Ph.D. degree from SCUT in 2004 and has been employed as a faculty member at SCUT since then. His research focused on the starch modification and the application of controlled release carriers. He remained in Drs. Hamaker and Campanella's group as a visiting professor until August 2014.



Ming Miao is an Associate Professor at the State Key Laboratory of Food Science and Technology in Jiangnan University. He received his Ph.D. in Food Science from Jiangnan University in June 2009. He joined Dr. Hamaker's group as a visiting faculty in April 2013 to stay for a year. His research focused on the modification of starch digestibility.

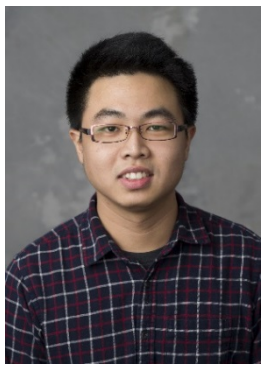
Luis Arturo Bello Perez is Professor at the Center for Development of Biotic Products of the National Polytechnique Institute-Mexico. He is well known and published in the area of starch chemistry, fine structure and functionality. He was on sabbatical with his wife, Edith Agama Acevedo, and was working on functional slowly digestible foods and was writing review articles and chapters in the field. He was a part of Dr. Hamaker's laboratory group.

VISITING SCIENTISTS

Laura Marcela Arango obtained her B.S. degree in Chemistry from Universidad del Valle, Cali, Colombia. Her senior thesis was titled "The nutritional benefits of the peach palm fruit". She joined the Hamaker group in February 2014, and works on the quantitative chemical analysis of starch and monosaccharide residues.

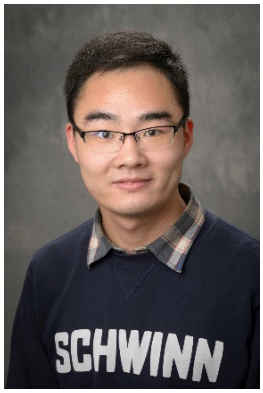
Mustapha Benmoussa received his Ph.D. degree from Laval University (Canada) in Plant Molecular Biology. His Ph.D. research project focused on potato flour viscoelastic proprieties improvement by expression of wheat glutenin in tubers. Mustapha spent two years working on corn storage proteins in the Pediatric Metabolism and Genetics Department, Indiana University as a post-doctoral research associate. Most recently, in his work at the Whistler Center for Carbohydrate Research, he has worked on non-food applications of modified starches such as for wastewater treatment and microalgae flocculation.

Bruna Castro Porto received her B.S. in Food Engineering from University of Ceará (Brazil) in December 2010, her M.S. in Food Technology from University of Campinas (Brazil) in February 2013, where her research was on the evaluation of oil-in-water emulsions using cashew tree gum as an emulsifying agent. She is currently a Ph.D. student at Food Technology from University of Campinas (UNICAMP) under the direction of Prof. Marcelo Cristianni. She arrived at Purdue University in August 2014 as a visiting scholar and has worked with Drs. Hamaker, Reuhs, and Campanella. Her research focuses on characterization of modified cashew tree gum.

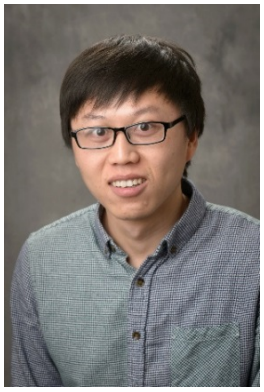


Wei-Jen (William) Chang received his B.S. degree in the Department of Food Science from Tunghai University, Taiwan June 2011. He has been in the M.S. program in the Department of Food Science, National Pingtung University of Science and Technology, Taiwan. Wei-Jen was awarded a government scholarship by the Ministry of Education in Taiwan to join Dr. Lin's group as a visiting scientist in October 2013. He later moved to Bi-State School of Food Science at University of Idaho (Moscow, ID) and Washington State University (Pullman, WA) with Dr. Lin and completed his study in October 2014 in Moscow, ID. William received his M.S. degree from Pintung University of Science and Technology in December 2014. His research focused on the measurement of starch digestion *in vitro*.

Fenglian Chen earned her Ph.D. in 2006 in Engineering focusing on intensive processing of wheat bran by using biotechnological techniques from Material Science and Engineering College, Northeast Forestry University, Harbin, China. She is an Associate Professor in the Department of Food Science and Technology, College of Food Engineering, Harbin University of Commerce (HUC). She arrived at Purdue in November 2014 and will stay until May 2015 working on the rheological evaluation of different kind of rice powders having different amylose/amylopectin ratios, starch and protein content, texture characteristics and microstructure.

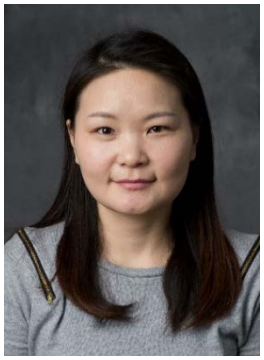


Yezhi Fu earned his B.S. in Food Quality & Safety in 2011 and received his M.S. in Food Engineering in 2014 from China Agricultural University. Now he is in Dr. Yao's research team and focuses on developing antimicrobial formulations with or without delivery systems for fresh and fresh-cut produce.

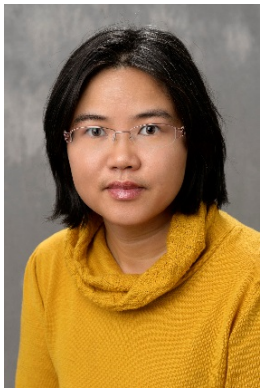


Zhen Fu is currently pursuing his Ph.D. degree in Food Science and Technology in the College of Food Science, Nanchang University, Nanchang, China. He joined Dr. BeMiller's lab as a visiting scholar in September 2014. His main research focuses on effects of hydrocolloids on starch retrogradation.

Dr. Lingxiao Gong obtained her Ph.D. Degree from the Department of Food Science and Nutrition of Zhejiang University in China. She worked in Dr. Yao's group to establish a high-throughput, single-kernel screening procedure for novel cereal starch and enhanced nutrients.

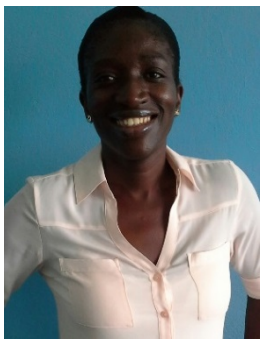


Sun-Young Lee received her B.S. degree in Polymer Science and Engineering from Dankook University in 2002 and received her M.S. degree in Chemical Engineering from Hanyang University in 2005. She worked in the Starch and Sweetener Division of Daesang Company in South Korea. She joined Dr. Hamaker's group in May 2013 as a Visiting Scholar and returned in April 2014. Her work focused on extracting pure xylose from palm empty fruit bunch and corn bran.

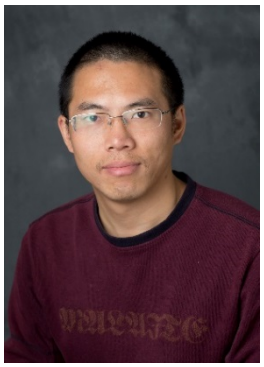


Dr. Xiaohui Li is an Associate Professor in the College of Food Science & Technology, Shanghai Ocean University, with her research focusing lysozyme antibacterial characterization. In Dr. Yao's group, she works on literature studies related to the delivery of antimicrobial compounds and encapsulation technology.

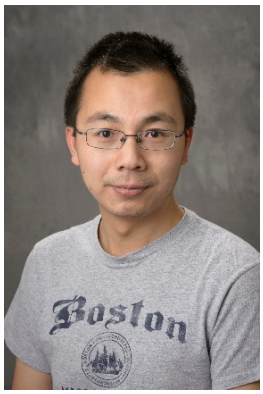
Alejandra Mencía graduated from Zamorano University, Honduras with a B.S. in Food Science and Technology where her research focused on inulin as a fat replacer in low sodium chicken frankfurters. She received her M.S. degree in Food Science from National Pingtung University of Science and Technology, Taiwan where her research focused on iron fortification of a fermented whey beverage for School Lunch Programs. Currently she is working as a visiting scholar in Dr. Yao's lab working on fluorescent labeling of carbohydrate nanoparticles.



Leticia Amoakoah Twum obtained her M.Phil. degree in Radiation Processing, Food Science and Post-Harvest Technology from the University of Ghana, School of Nuclear and Allied Sciences. She joined Dr. Janaswamy's lab group in in September of 2014. Her research interests are the use of cost effective biological means to preserving food for both industrial and household use, food microbiology and post-harvest technology. She currently works at Ghana Atomic Energy Commission as an Assistant Research Scientist.



Chengrong Wen is a Ph.D. student of Produce Processing and Storage in College of Food Science, Fujian Agriculture and Forestry University, Fuzhou, China. His thesis was on the crystallization process of konjac glucomannan with the action of salts. Chengrong joined Dr. Srinivas Janaswamy's lab as a Visiting Scientist in June 2013- January 2014. His research focused on the effect of salts and sweeteners on structure-function relationships of konjac glucomannan and its binary mixtures.



Fusheng Zhang is Associate Professor in the College of Food Science at Southwest University, China. He received his Ph.D. degree from China Agricultural University in 2011. Dr. Zhang joined Dr. Srinivas Janaswamy's lab as a visiting scientist in July 2014. His research focuses on the structure-function relationships of konjac glucomannan and its mixtures prepared through non-thermal processing and normal treatment.

Yongjun Zhang is a professor in the College of Life Sciences at China Jiliang University (CJLU; PR China). She received her Ph.D. degree from Southern Yangtze University in 2002. The research topic of her Ph.D. study is "Study on the screening and Identification of the Bioactive Blood Glucose Lowering Component in Pumpkin and its Hypoglycaemic Mechanism". She joined Dr. Hamaker's group as a visiting faculty in June 2014. Her research focused on the distribution of polysaccharides *in vivo* and the molecule mechanism on ameliorating pancreatic beta-cells from apoptosis.

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 earning his Ph.D. with Dr. Mauer. His main research focus is water-solid interactions involving crystalline and amorphous solids.

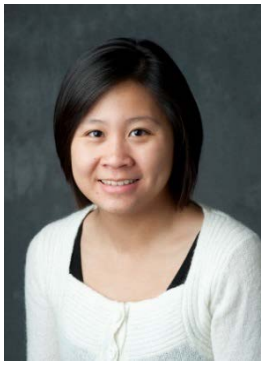
Jennifer Allen received her B.S in Food Science & Human Nutrition from the University of Illinois at Urbana-Champaign in 2004. She began her career at Michael Foods Inc. where she spent 5 years working in research and development. In 2012, she obtained a M.S in Food Science & Technology from Alabama A&M University where her research focused on the preventative effects of diets consisting of soy, flaxseed, and probiotics on colorectal cancer. Jennifer joined Dr. Ferruzzi's lab in 2012, where her research now focuses on the interactions of proteins with polyphenols and their subsequent effect on the protein's functionality as well as polyphenol bioavailability and bioaccessibility.

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. Afterwards, she joined the Nutritional Quality Laboratory (NQL) of the International Center for Tropical Agriculture (CIAT) (Palmira, Colombia) as Research Assistant in 2009. Her works focused in the development, implementation, and validation of analytical methodologies applied for evaluation of bioactive compounds and their antioxidant activity and *in vitro* bioaccessibility. Also, she participated in the development of different research projects in the cassava and bean breeding programs at CIAT, focused in 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 focuses on the nutritional and bioactive value of biofortified staple crops and native foods of Colombia.

Carlos Carter received his B.S. degree in Food and Nutritional Sciences at North Carolina Agricultural and Technical State University in Greensboro, NC. His undergraduate research focused on factors influencing greek yogurt in acid whey production. He joined Dr. Srinivas Janaswamy's Lab in fall 2014 as an Industry Fellow in the Department of Food Science. His Master's research is on developing polysaccharide-based essential oil carriers as antimicrobial inhibitors.

Mohammad Chegeni completed his B.S. in Biology from Ferdowsi University in 2002 in Iran. After that, he completed 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 maltose sensing of the small intestine enterocytes and sucrase-isomaltase maturation and trafficking. He has continued in B. Hamaker's lab as a post-doc.

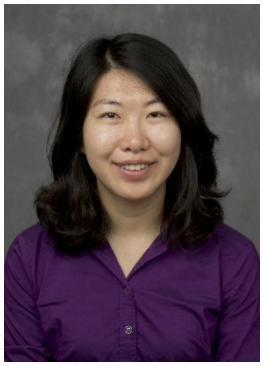
Tingting Chen received her B.S. and M.S. degree in Food Science and Technology from Nanchang University. Her M.S. study was about immunoassay development for small-molecular food contaminants. She joined the Dr. Hamaker's group and started her Ph.D. in August 2011 with a governmental scholarship from China Scholarship Council. Her Ph.D. research focuses on dietary fiber structure, gut microbiota, and colon health.



Belinda Christina is from Indonesia and graduated from Purdue University in 2011 with a B.S. in Food Science. After graduation Belinda worked as a Product Developer Intern in the Kellogg Company, Global Cereal Department. She then worked in PepsiCo, Quaker Group as a Product Development Contractor, developing new and improved cereal bars. Fall 2012 she returned to Purdue working with Dr. Mauer and received her M.S. degree in food chemistry in August 2014.

Fatimata Cisse received her M.S. degree in Food Science and Technology from the Department of Technology and Management of Production, Academy of State of Food Products of Moscow, Russia in 1997. After that she worked in the Food Laboratory of Rural Economic Institute of Mali. In January 2010 she joined Dr. Hamaker's group for her Ph.D. degree funded by USAID MALI. Her research mainly focused on the relationship between African porridges (thick and thin) and gastric emptying and satiety. More recently, her studies were supported by a grant from the Bill and Melinda Gates Foundation. She received her Ph.D. degree in December 2014.

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



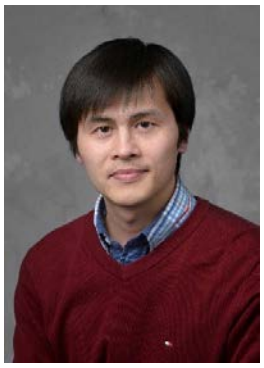
Juan Du received a B.S. in Food Science from Purdue University in 2009. She finished her M.S. in Food Science from University of Wisconsin-Madison in Dairy Chemistry. She came back to Purdue University in 2013 to pursue her Ph.D. degree in Food Science with Dr. Owen Jones. Her research focuses on interactions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

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

Necla Mine Eren received a B.S. degree in Food Engineering from Ankara University, Turkey in 2009. Necla came to Purdue in August 2010 as a M.S. student and completed her degree in May 2012. She is currently working on her Ph.D. with Dr. Campanella on physical-chemistry of colloidal nano-particle interactions with a focus on micro-microstructure relationship. For her research she has gained experience in rheological methods, laser scattering techniques (static and dynamic) and other molecular techniques such as Circular Dichroism (CD) and Isothermal Titration Calorimetry (ITC), the latter to characterize the binding of macromolecules into solid surfaces. Besides her research, she has taken leadership roles in different Student Organizations and served as the Symposium Chair of First Annual Graduate Student Research Symposium in the ABE department. Mine is planning to complete her Ph.D. work in the summer 2015.

Daniel Erickson earned his B.S. in Chemical Engineering from Iowa State University in May 2010. He arrived at Purdue University in August 2010 in pursuit of an M.S. degree in Food Science and is co-advised by both Dr. Hamaker and Dr. Campanella. His research focuses on functionalizing non-wheat cereal proteins to behave as viscoelastic aggregates for bread making and other applications within the gluten-free and functional protein areas. Daniel completed his Ph.D. in the summer 2014 and it is now working for Nestle in St Louis, MO.

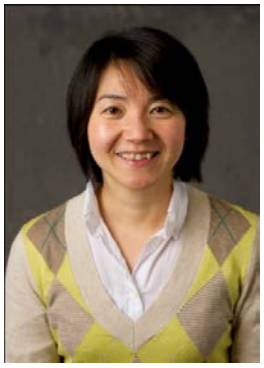
Fang Fang earned her B.S. in Bioengineering from Central South University of Forestry and Technology in 2009 and her M.S. in Food Science from Jiangnan University in 2012. Fang began her Ph.D. at Purdue in the fall of 2013 with support from the China Scholarship Council. She is co-advised by Drs. Campanella and Hamaker. Her research focuses on the relationship between rheology and digestion properties of starch with respect to molecular structure.



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 of tomato products processed under different conditions. Xing Fei is also working with the supervision of Professors Owen Jones and Bradley Reuhs in aspects related to the optimization of tomato processing and characterization of these products.

Amber Furrer received her Honors B.S. in Food Science with a minor in Foods and Nutrition from Purdue University in 2013. She is currently pursuing a M.S. degree in Food Science with a concentration in Foods for Health under Dr. Mario Ferruzzi. Her research focuses on content and process stability of phytochemicals in potatoes.

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 by-passed his M.S. degree and is directly working toward earning his Ph.D. He is advised by Dr. Owen Jones and his research focuses on the stability of protein fibrils for use in food, packaging, and pharmaceutical applications.



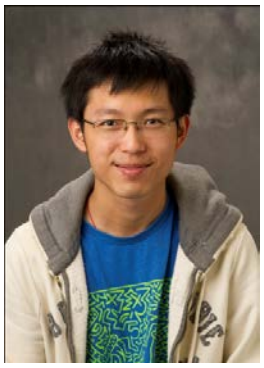
Like Yan Hasek graduated from Shanghai University of Science and Technology with a B.S. in Food Science and Technology, and from Iowa State University with M.S. degrees both in Food Science and Nutrition. Her food science thesis was on shelf life of toasted soyflakes and their application in bread making, tofu color prediction from the soybeans and soyflakes color. She worked with Dr. Hamaker's and received her Ph.D. degree in August 2014. Her research focused on slowly digestible starch and its physiologic and health effects. She worked on a collaborative project with faculty from Purdue's Department of Psychological Sciences (Drs. T. Powley, R. Phillips, and K. Kinzig), as well as with Dr. Buford Nichols at Baylor College of Medicine, Houston.

Anna Hayes received her B.S. in Food and Nutrition Science and her B.A. in Spanish from Saint Catherine University (Saint Paul, MN) in May 2014. Anna arrived at Purdue University in August 2014 and intends to bypass her M.S. degree and directly work toward earning 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.

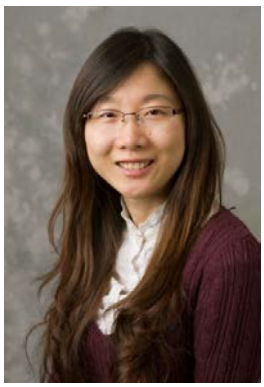
Chinmay Joglekar received his B.S. in Chemical Engineering from Institute of Chemical Technology, Mumbai, India in June 2011. After completing his M.S. in Chemical Engineering from Purdue University, he joined the Agricultural and Biological Engineering Department in August 2014 to pursue his Ph.D. degree. He is co-advised by Drs. Osvaldo Campanella, Bruce Hamaker, and Jim BeMiller. His research focuses on functionalization of corn protein zein.

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 in colon health.

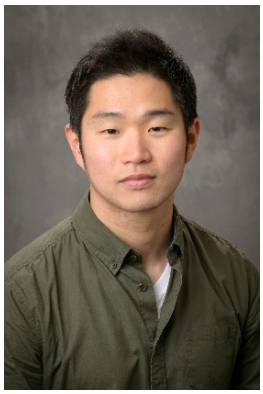
Lisa Lamothe received her B.S. degree in Food Science and Technology from Zamorano University in Honduras. She received her M.S. degree working with Dr. Hamaker's group and her research focused on the development of screening methods for breeder selection of popcorn lines. After receiving her M.S. degree, she worked for Cargill Meats Central America as a Quality Assurance and Food Safety supervisor. She completed her Ph.D. degree in September 2014 and now works at Nestle Research Centre in Lausanne, Switzerland. Her work focused on the design and modification of dietary fibers for improved colon health.



Kin Lau earned his B.S. degree in Biology from Davidson College in May 2010 where 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.

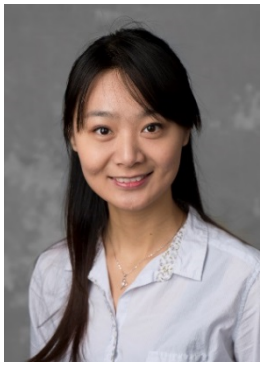


Na Li received her B.E. in Food Science and Engineering, from South China University of Technology, Guangzhou, China. She joined Dr. Mauer's group in August of 2009 in pursuit of a M.S. degree and by-passed to earn her Ph.D. degree which she received in the spring of 2014. Her research mainly focused on the physical and chemical stability of green tea catechins.

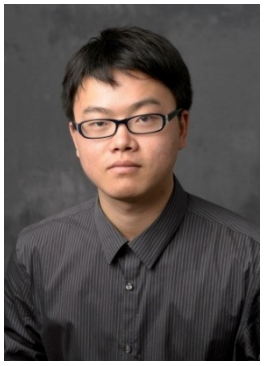


Jongbin Lim earned his M.S. degree in Food Science and Technology from Sejong University in South Korea. He joined Dr. Hamaker's lab group in August 2014 to begin his doctoral work. His research is on the moderation of starch digestion rate by inhibition of digestion enzymes and the development of glycemic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

Carl Littrell earned his B.S. in Biological Engineering with a concentration in Food Process Engineering from Purdue University in May 2012. He then decided to continue his education at Purdue by pursuing a M.S. in Engineering with a specialization in Food Process Engineering under the supervision of Dr. Osvaldo Campanella. His research involves the investigation of genetically-modified tomato fruit pectin as an alternative source of industrially-relevant pectins, and the structure-function relationship of genetically-modified pectins' chemistry and rheological properties. Carl completed his M.S. in the summer 2014 and now he is working at Frito-Lay, Plano, TX.



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 Jul 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 Aug 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 Degree 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. Dongdong is planning to complete his M.S. degree in the summer of 2016.

Krystin Marrs received a BSA in Food Science and a BSAB in Applied Biotechnology from the University of Georgia in May 2010. She arrived at Purdue University in August 2011and bypassed her M.S. degree and is directly working toward earning her Ph.D. in Food Science under Dr. Lisa Mauer. Her research focuses on the physical and chemical stability of amorphous and crystalline powders.

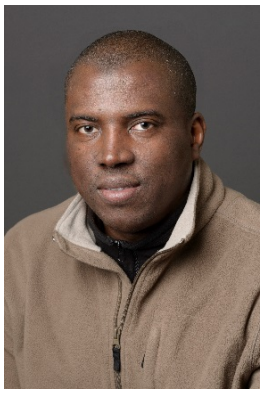
Moriah Massafaro completed her B.S. degree in Biochemistry at Purdue in 2010. She is currently pursuing a Master's degree in Agronomy with a focus on Plant Breeding and Genetics in the Weil lab. Her main project involves the mapping and identification of genetic determinants of increased protein digestibility in sorghum. The overall goal of the project is to improve sorghum as a food crop for human consumption by making it more digestible after being cooked in water.

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 has continued her studies in Dr. Ferruzzi's lab. Her research now involves 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 examines the ability of polyphenols in fruits and grains to modulate glucose release during digestion and subsequent intestinal transport.

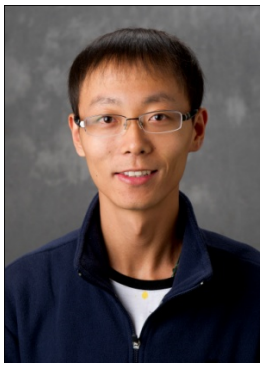
Anbuhkani Muniandy is an M.S. student with Dr. Amy Lin. She received her B.S degree from the Department of Food Science at Purdue University in May 2013. She joined Dr. Lin's group in August 2011 while she was a Junior. She later moved to Bi-State School of Food Science at University of Idaho (Moscow, ID) and Washington State University (Pullman, WA) with Dr. A. Lin and continues her M.S. program in Moscow. Her research focuses on structure of slowly digestible dextrins.

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 Dr. Jones and Dr. Farkas. His research focuses on emulsion stabilization using protein and polysaccharide-based nanoparticles. Ryan intends to bypass his M.S. degree and proceed directly to a 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.

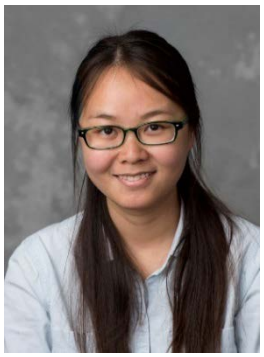
Lohit Myneedu received his Master's Degree in Food Science from JNTU - Oil Technological Research Institute, Anantapur, India. His thesis was on development of emulsion meat products from a combination of fish and chicken byproducts at the National Research Center on Meat, India. He joined Dr. Srinivas Janaswamy's lab as a M.S. student in May 2012. His Master's research is on developing hydrocolloid-based delivery vehicles for nutraceuticals, and possibly, probiotic applications.



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. The research theme was to reduce the cooking time of millet (*P. typhoides*) and sorghum (*S. bicolor*) flours and rolled flour products (*arraw*). In 2009, a M.S. in Food Science and Technology was obtained from Jiangnan University, China with a thesis' title, "Stabilization of cloudy mango juice using pectolytic and cellulolytic enzymes". 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. Recently, 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.



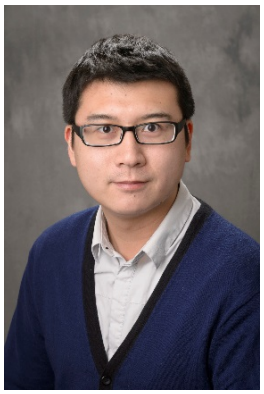
Xin Nie earned his B.S. and M.S. degree in the department of Chemistry from China Agricultural University, Beijing. He joined Dr. Hamaker's group as a Ph.D. student in August 2011 with support from the China Scholarship Council government scholarship. Xin's research project mainly focuses on dietary fiber's structure-function relationships related to colon and whole body health.



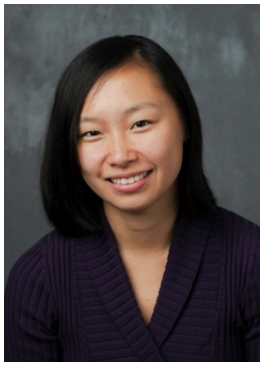
Xiang Ning earned her B.E. degree from the Department of Food Engineering of Hunan Agricultural University in July 2011. She obtained her M.S. degree from the Department of Food Science of Wageningen University in the Netherlands in June 2013. The research topic of her M.S study was "The relation between 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 β-conglycinin and pectin stabilized encapsulation system. She will continue her Ph.D. under Dr. Narsimhan with the research topic on pore formation in lipid bilayers by antimicrobial peptides.

Gabriella Mendes Candido de Oliveira received a B.S. in Food Engineering (5 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 was attending classes at the Food Science and Human Nutition 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.

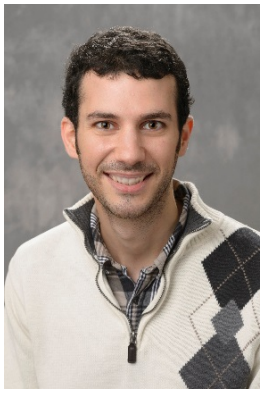
Darwin Ortiz is currently a Ph.D. candidate in Food Science at Purdue University. He holds a Bachelor's degree in Chemistry from Universidad del Valle in Colombia. He has worked in the International Center for Tropical Agriculture (CIAT) where he participated in the development of the nutritional quality laboratory of CIAT. 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). He joined Dr. Ferruzzi's lab in 2012, 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 the fall of 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 Champaign-Urbana in December 2011. She worked for Hillshire Brands Co. (formerly known as Sara Lee) until coming to Purdue University in August 2012. She by-passed her M.S. degree and is directly working toward earning her Ph.D. degree. She is studying under Dr. Hamaker on the physiological effects of glycemic carbohydrates.



Benjamin Redan earned a B.S. in Biochemistry from the University of Scranton, Pennsylvania in 2011. Afterwards, 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.

Rándol J Rodríguez obtained his B.S. Degree from the Food Science Department of Zamorano University, Honduras. In the graduate program of Food Science Department of Purdue University, he works with Dr. Yao on the structure and function of carbohydrate nanoparticles. He is pursuing his Ph.D. Degree.

Juan Sanchez is pursuing an 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 studies water-solid interactions and their effects on the chemical degradation of ascorbic acid in the amorphous solid state.

Preetam Sarkar received his M.S. in 2010 from California State University-Fresno. He joined Dr. Yao's lab in 2010 as a Ph.D. student. His thesis focused on the interaction between antimicrobial compounds and carbohydrate biopolymers in emulsion and non-emulsion systems. He completed his degree in October 2014 and is currently an Assistant Professor in the Department of Food Process Engineering of the National Institute of Technology, India.

Leigh C.R. Schmidt earned her B.S. Food Science from Purdue in 2003 and her M.S. in Food Science from UC Davis in 2009. She joined Dr. Hamaker's lab group in August 2013 to begin her doctoral work 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 research is on food protein matrices as a method to slow starch digestion.

Meric Simsek completed her M.S. degree in Food Engineering from Middle East Technical University in 2010 where she worked with the Microwave Processing Research Group. She received her B.S. degree in Food Engineering from Gaziantep University in 2007. She began working with Dr. Hamaker, supported by a scholarship from Ministry of National Education, Republic of Turkey in September 2010. She received her Ph.D. degree in the fall of 2014 focusing on the inhibition of human intestinal glucosidases for moderation of glycemic response.

Ana Steen received her B.S. in chemical engineering from Bucknell University. She began her M.S. in August of 2013 co-advised by Drs. Campanella and Hamaker. Her research is on a delivery system consisting of a food-based nanoscale, soft particle. Ana had an internship at Cargill during the summer of 2014 focusing on characterization of biomaterials through tensiometry and rheology. In addition to her experience with rheology, through her research Ana has acquired experience in chromatographic methods to characterize and separate macromolecules, microscopy techniques (e.g. TEM), and lately physicochemical methods to characterize biopolymers, specifically dynamic laser scattering. She will be finishing her Master's thesis in the summer of 2015 and is planning to work in the food industry.

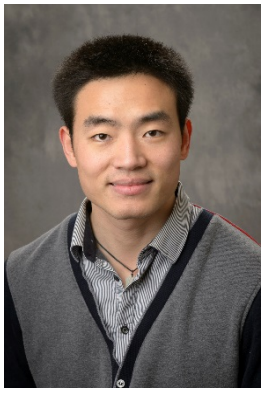
Pablo Torres-Aguilar received his M.S. in Nutritional Sciences from the University of Illinois at Urbana-Champaign where his research focused on food insecurity and the impact of environmental factors on the diet of underserved groups, both in the US and internationally. He joined Dr. Hamaker's group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

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

Yunus Emre Tuncil got 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. degree in the USA by the Turkish Government. He joined Texas A&M University Food Science and Technology Department as a M.S. student in 2010 in where he studied on the effects of wheat proteins on dough rheological properties. He arrived at Purdue University in August 2012 in pursuit of a Ph.D. and is advised by Dr. Hamaker. His research focuses on dietary fiber structures and their effect on the colon microbiota health. He works on a collaborative project with Dr. Eric Martens at University of Michigan Medical School.

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.

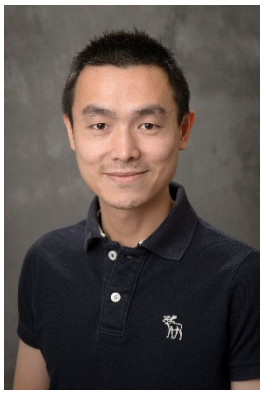
Ying Xie received her M. S. degree in Processing and Storage of Agriculture Products from China Agricultural University, Beijing. She joined Dr. Yao's group and started her Ph. D. study in August 2012. Her Ph.D. research focuses on modified carbohydrate nanoparticles and their functional properties,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



Xiaowei Zhang received his both B.S. and M.S. degrees from the Department of Food Science and Engineering from 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's structure-function relationships with the colon microbiota and relationship with health.

David Huizinga earned his B.S. in Biology from Purdue University in 1994, after which he worked in software quality assurance for several years. He completed his Ph.D. from Purdue in 2009, studying the effect of protein prenylation on abscisic acid signaling in arabidopsis. He then worked for Dow AgroSciences for 3 years, characterizing zinc finger nuclease expression in plants. He joined the Weil laboratory in September 2014 as a Post-Doc where his project is the mapping and eventual cloning of genes that control carbon partitioning in maize using SNP microarray and NextGen sequencing approaches.

Byung-Hoo Lee received his B.S. and M.S. in Food Science and Technology from Sejong University in Korea. His M.S research was characterization of carbohydrate-active enzymes and application to various corn starches. In August 2008, he joined Dr. Hamaker's group. His Ph. D. research was on structural changes of enzyme modified-starches and digestion patterns of the mammalian mucosal glucogenic enzymes with application to the area of slowly digestible carbohydrates. He was a Post-Doc in Dr. Hamaker's lab in 2014.

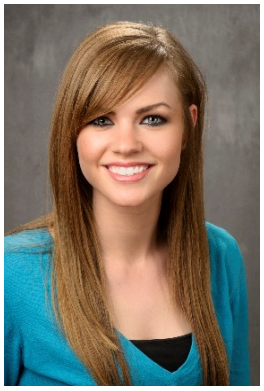


Min Li received his BS in ecology from Xiamen University in 2006. His MS was obtained from Xiamen University with a dissertation on characterization of plant polyphenols. In 2009, he continued his Ph.D. studies on plant polyphenols in Miami University (Oxford, Ohio). Under the guidance of Dr. Ann Hagerman, 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 Sept 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.

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 was 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, and has worked on fiber rheology and incorporation into processed foods and gel formation kinetics. Currently Dr. Patel is working in a project related to enzymatic conversion of complex polysaccharides into useful industrial and food products.

Maria Julia Spotti received her B.S in Biotechnology, Biochemistry and Biological Sciences Faculty, from the National University of Litoral, Santa Fe, Argentina in 2008 and a Ph.D. in Chemistry from the National University of Litoral, Santa Fe, Argentina in 2013 working on the study of the structure and mechanical properties of mixed protein-polysaccharide system gels. On completion of her Ph.D. she started post-doctoral studies at the same university focusing on products of the Maillard reaction between whey proteins and dextrans and the determination of antioxidant capacity and application in the microencapsulation of bioactive compounds. In May-December 2014 she worked in a project related to the modification of corn fibers in Professors Campanella, Jones, Reuhs, and Hamaker labs focusing on optimization of methods to modify corn fiber to make them more functional, as well as their structural and physicochemical characterization.

Ozgur Tarhan received her B.S. degree in Food Engineering from Gaziantep University (Turkey) in 1999. She worked in industry until she started her graduate education in 2001. She received her M.S. degree in Biotechnology (2004) and Ph.D. degree in Food Engineering (2013) from Izmir Institute of Technology in Turkey. She joined Drs. Campanella and Hamaker's group as a Post-Doc supported by The Scientific and Technological Research Council of Turkey (TUBITAK) in 2014. Her research is on the investigation of gelation phenomena of whey-based protein fibrils and nanotubes.



Mikaela Allan began working in the Whistler Center during the fall assisting with the annual Short Course and Research Focus Meeting. She is now the current Administrative Coordinator. 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 of 2014 from Purdue University.

Anton Terekhov joined Dr. Reuhs' group as a Research Assistant in 2005. He is proficient in analytical chemistry, molecular biology techniques and analytical instruments such as NMR, GCMS, LCMS and FTIR. Anton has seven years of experience in an interdisciplinary laboratory environment including the fields of analytical chemistry, microbiology, genetics, geology, chemical and civil engineering.

PROJECT SUMMARIES

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

P.I.: J.N. BeMiller

Researchers: Li Guo, Ph.D., Visiting Scientist, Zheng Fu, Visiting Scholar

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 have been used in the study: normal maize/corn starch (I), normal corn starch cross-linked with $POCl_3$ (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 $POCl_3$ (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 δ and η* 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: Determination of swelling power, dissolved amylose and total starch dissolved after heating starch suspensions at 65, 75 and 85 °C for V, VI and VII; determination of dissolved amylose and total starch dissolved after heating at 100 °C for IV and VIII. Data is being analyzed for indications of the mechanism(s) involved.

Status: Active.

2. Physical Chemistry of Colloidal-Nanoparticle Interactions

P.I.: O. Campanella

Researcher: Necla Mine Eren, Ph.D. Student

Collaborator: O. Jones

Objectives: 1) Understand the effects of colloidal nanoparticle interaction on the physicochemical properties of soft materials, 2) Application of these interactions to design engineered soft materials having targeted properties.

Progress: The objective of the current project is to investigate colloidal nanoparticle interactions with a view on both macroscopic and microscopic scales. Although molecular interactions are much more complicated at the nanoparticle-biopolymer interface, the use of basic model systems allows questioning basic fundamental principles of classical colloidal science, which enable that current unknowns in the nano-scale word could be explored to design and develop new biomaterials with targeted properties such as carriers for molecular transport and drug delivery, bioplastics, and biosensors.

Status: Complete, one manuscript submitted and second manuscript is under preparation.

3. A Soluble Self-Assembling Nanoparticle from Starch, Protein, and Lipid for Healthy Nutrient and Other Hydrophobic Compound Delivery

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

Researcher: Ana Steen, M.S. Student

Objective: The overall goal of the current research is to scale up lab production of our previously researched soft nano-sized particle to increase yield while maintaining control over particle parameters such as size and shape. One parameter that has been

investigated is cooling rate during formation. Differential scanning calorimetry is used to determine thermodynamic stability of particles formed under different cooling conditions. Size exclusion chromatography using refractive index (RI) and multi-angle laser scattering (MALS) detectors are used to evaluate changes in nanoparticle molecular weight and size.

Progress: The ability to deliver or mask flavor, enhance color, incorporate nutraceuticals or functional ingredients into a specific food would open numerous possibilities for the food industry. Currently a major hurdle to deliver many of these compounds is their solubility. Small colloidal particles and metal based nanoparticles have been shown to encapsulate and deliver small hydrophobic molecules but major drawbacks to these systems are stability and toxicity. This research focuses on an alternative delivery system, a food-based nanoparticle that is water soluble and self-assembling. This soft particle consists of amylose, β-lactoglobulin, and linoleic acid with the capacity to bind a fourth component. Previously, size-exclusion chromatography (SEC) coupled with MALS was used to estimate the particle dimensions as approximately 20 x 50 nm. Differential scanning calorimetry showed the formation of the particles to be a spontaneous process. The binding ability of a fourth component by the nanoparticle was demonstrated on three hydrophobic molecules, limonene, 1-naphthol, and 5-fluorouracil. Caco-2 BBe MTT cells treated with 5-FU bound nanoparticles demonstrated release of the small, hydrophobic molecule in a controlled manner.

Production of these nanoparticles takes place in a pasting cell on a rheometer. The overall goal is to scale up the current process to increase yield. Before this can be accomplished, it is desired to understand how processing conditions affect the formation of the nanoparticles, particularly in terms of size, shape, and batch yield. Furthermore, it is important to understand how changes in nanoparticles will affect bulk properties, for processing purposes as well as an application standpoint.

During production of the nanoparticles in the rheometer, it was observed that varying the rate of heat transfer to the system resulted in changes in viscosity profile only in the presence of nanoparticles. Furthermore, different heat transfer rates resulted in different viscosity profiles. It is not yet understood how varying the heat transfer rate gives different viscosity profiles but it believed that the structure of the nanoparticles plays a crucial role. Rheology is being performed to determine whether variations in heat transfer rate causes changes in the system that effect bulk properties, such as network strength and viscoelasticity. The effect of heat transfer rate on particle physical properties and structure is being observed by transmission electron microscopy (TEM). Nanoparticles are isolated by centrifugation after production in the pasting cell. Supernatant is run through a SEC, separating nanoparticles from uncomplexed protein and amylose. Nanoparticle fractions were collected and examined using TEM. Repeated images showed the presence of these particles and that they are approximately 20 x 50 nm in length. Differences in in nanoparticle shape were observed after different processing conditions. Interestingly, heat transfer rate was observed to affect the shape and size of the larger molecules eluting out in the void volume of the column as confirmed by TEM imaging. By further examining the effect of processing conditions on the void volume material as well as nanoparticles, insights into the mechanism of nanoparticle formation hope to be gained. Dynamic light scattering (DLS) is being used to determine particle size differences.

Status: Active, one manuscript submitted.

4. Industrial Processing Properties and Attributes of Genetically Modified Fruit Pectin

P.I.s: O. Campanella, A. Handa (Department of Horticulture, Purdue University)

Researcher: Carl Littrell, M.S. Student

Collaborators: B. Reuhs, O. Jones

Objectives: To determine the effects of altered degree of pectin methyl esterase (PME) activity present in tomato fruit on pectin molecular size, rheological properties, and processing efficiency of fruit crops.

Progress: Pectin is one of the major components of plant cell walls and is used extensively as a functional food ingredient in a large number of products. The molecular structure and sugar composition of pectins have profound effects on their functionality, thus limiting commercial pectin production to a few plant sources. Specifically the degree of methoxylation, degree of acetylation, pattern of methyl esterification, and molecular size determine the functional properties of pectins. Genetic engineering offers novel methods for producing a less expensive "source of pectins having desirable attributes through reducing PME activity, thus influencing the

biochemistry of endogenous plant pectins. Rheological measurements using steady shear conditions are of primary concern due to the importance of texture in assessing quality attributes of food products containing pectin.

Tomato fruits were collected from the greenhouse at the appropriate maturity stage, determined from either visually gathering immature or mature green, or based on the marked date of the fruits reaching breaker stage. The tomatoes were processed and the serum was collected, and then either 1) deionized distilled water was added back to original solids content, 2) deionized distilled water as added back to 18% solids content, 3) serum as added back to 18% solids content. Each of the reconstituted samples was run in the same fashion as the juice on the rheometer. The remaining serum was filtered this filtered serum is also run on the rheometer. The filtered serum was then dialyzed, frozen, freeze-dried, weighed out and dissolved in D_2O, freeze dried and dissolved in D_2O for a second time, and then analyzed using NMR. Once NMR spectra were recorded, the sample was freeze-dried once more, and then prepared using TMS for GC analysis of glycosyl residues.

Low PME transgenic fruit juice and serum exhibited markedly higher viscosity than high PME juice. Juice displayed a non-Newtonian (pseudoplastic) behavior, while serum showed purely Newtonian behavior. Measurements of the rheological steady-shear rates for whole juice and serum from transgenic fruits exhibited 11% and 100% of that of the WT parental fruit. These differences are indicative of the higher degree of methoxylation in pectin juice pulp due to reduced PME activity, yielding positive attributes for processing. Scanning electron microscopic (SEM) images displayed a noticeable difference in the plant cell structure and water-carrying capability between the wild type and transgenic fruits.

Status: Completed.

5. Industrial Processing Properties of Tomato Products

P.I.s: O. Campanella, Owen Jones, Brad Reuhs

Researcher: Xing Fei, Ph.D. Student

Collaborator: A. Handa (Department of Horticulture, Purdue University)

Objectives: This project is a continuation of project 3 and is aimed to optimize processing of tomato products to impact product quality, specifically viscosity. It is focused on the characterization of tomato products components that have an impact on their viscosity.

Progress: The viscosity of tomato products has long been thought to be attributed to the presence of soluble pectin present in the product serum. However, recent findings by our group have revealed that the contribution of tomato cell clusters may have a more significant role to impact viscosity. In this study, tomato suspensions with different particle morphologies (i.e. size, shape and distribution) were being prepared from tomato fruits at a laboratory scale using the two traditional employed by the tomato industry Hot Break (HB) and Cold Break (CB) combined with shear treatments of variable intensity (low and high shear). Tomato pulp was obtained from centrifugation of suspensions of tomato products processed by HB and CB. The viscosity of suspension and serum, as well as the viscoelastic properties of pulp are being investigated. Results showed that the viscosity of the serum was low and no significant difference among the samples were observed, which suggests that the contribution of soluble pectin on the product viscosity is limited. High viscosity of tomato suspensions reconstituted with different pulps and serum obtained from the different treatments were observed in systems derived from the HB and low shear treatments. The viscoelastic properties of the tomato pulp were positively correlated with the viscosity of the suspensions which indicated the viscosity of the tomato product suspension may be affected by the mechanical properties of tomato cell clusters. The treatments produced cluster particles with distinct particle morphologies. By a statistically supported comparison, the CB treatment produced cluster particles significantly larger than particles produced during the HB treatment. It was also inferred that the high shear treatment produced mainly cell fragments that produce weaker interaction between particles compared to cell clusters due to less deformability. The hypothesis being proved in this part of the project is that interaction of particles is affected by particle morphologies and strength, which plays an important role in determining the viscosity of tomato products. Cluster particle morphology and strength can be affected by processing conditions.

Status: Active, paper published.

6. Structure-Function Relationship of Highly Branched Starch

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

Researcher: Fang, Ph.D. Student

Collaborators: B. Reuhs, J. BeMiller

Objectives: This research project deals with novel glucan polymers and their physicochemical properties and physiological function. Research on the relationship between molecular structures of starches and their functional characteristics will contribute to the regulation of branching degree and chain length distribution of starches with desired properties. Objectives are: 1) Characterize highly branched starches in terms of their gelatinization and retrogradation properties, and rheological properties; 2) Characterize the digestibility of highly branched starches, 3) Interpretate structure-function relationship of highly branched starch by comprehensive analysis of molecular structure and characterization and digestibility.

Progress: In the past year, work has focused on the shear-thickening behavior of gelatinized waxy starches. After gelatinization, starch dispersions usually exhibit shear-thinning behavior; however, it was observed that gelatinized waxy corn and potato starch dispersions exhibit shear-thickening behavior around a shear rate of 20 s^{-1}. This behavior was not observed in gelatinized waxy wheat and rice starch dispersions, nor in normal starches. Rheological methods were utilized to further investigate this phenomenon. Shear-thickening was observed in gelatinized waxy potato starch for a temperatures range between 10 to 50°C, and in gelatinized waxy corn starch at temperatures lower than 15°C. After storage of gelatinized starch dispersions for 2 h, and 1, 2 and 7 days at 4 °C the shear-thickening behavior of the waxy corn starch sample, measured at 4°C, did not change significantly. Moreover, the shear-thickening behavior of waxy potato starch dispersions disappeared after 7d storage. Viscoelastic tests on waxy corn and waxy potato starches using increasing temperature ramps in the range 25-95 °C showed gradual increases in the phase angle indicating a transition to a more fluid behavior. The phase angle changed less for the waxy wheat starch dispersions and hardly changed for the waxy rice starch dispersions. Cryo-SEM images of the gelatinized starch dispersions suggested that there were no swollen granules or fractured granules embedded in the starch matrix; so all samples were well gelatinized. A new rheological method named *Shear Recovery Test* was developed to study the behavior of the starch dispersions under different shear rates. The method consists in subjecting samples at different shear rates (1, 20, 40 s^{-1} for 120 s) followed by two repeated cycles which were separated with 1 min period at 500 s^{-1} shear rate in order to detect the ability of starch molecule to recover the former structure. Results showed a decrease in viscosity at 1 s^{-1} and 40 s^{-1} shear rate for all waxy starch dispersions (waxy rice, corn, wheat and potato) and an increase of viscosity at 20 s^{-1} shear rate only for waxy corn and potato starch dispersions in a first shear cycle. That increase of viscosity was not observed in a second and third shear cycles, indicating that entanglements were not reformed in waxy corn and potato starch dispersions. The recovery properties were evaluated by comparing the viscosity at the beginning of the second shear cycle with the ending viscosity of the first cycle, and the initial viscosity of the third cycle with ending of the second cycle. The third shear cycle showed better recovery capability than the second one, indicated that altering this structure by using high shear leads to more stable molecular organization. Given the importance of the food viscosity on the digestion of foods, results of this research will help to understand how viscosity in the presence of shear may affect the digestion process of starchy foods.

Status: Active.

7. A Relationship between Rheology and Texture of Foods Having Complex Rheological Properties

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

Researcher: Dongdong Ma, M.S. Student

Collaborator: O. Jones

Objectives: The main objective of this project is to describe the flow of complex viscoelastic food materials in terms of deformations existing during consumption. Flows being analyzed involve shear and extensional flows in complex geometres. The effect of lubrication due to the presence of saliva and food phase separation is being examined taking into consideration the area of tribology. The project is envisioned to develop an experimental setup that allows for test food materials with a large range of rheological properties under different types of deformations (notably extensional and shear) including small and large deformations.

Experimentation will include relevant theoretical models.

Progress: Preliminary simple models (e.g. Newtonian) are being used to validate a numerical algorithm used. Models being solved to include the deformation of a Newtonian liquid in the presence of lubrication (tribology case) and without lubrication. The software Open Foam is being used.

Status: Active.

8. Use of Corn Zein Proteins as Functional Viscoelastic Polymers

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

Researchers: Daniel Erickson, Ph.D. Student, Stephanie Tandazo, M.S. Student

Collaborator: S. Keten, Northwestern University

Objectives: 1) To understand basic structure-function relationships of proteins such as corn zein and sorghum kafirin to create more functional proteins, 2) To study how plasticizers and co-proteins interact with zein in order to create viscoelastic structures.

Progress: In 2014, the Ph.D. thesis of D. Erickson was completed. The most noteworthy final contribution of his thesis research was from molecular dynamic simulation work done on zein peptides collaboratively with the Northwestern University Keten group. All-atom molecular dynamics simulations were performed to identify the key interactions that stabilize the β-sheet secondary structures connected with zein's elastic properties. Twelve model peptides were selected from three common α-zein variants and demonstrated a range of affinities for forming β-sheet structures. This behavior indicates that discrete regions of α-zein's primary structure have differing capacities for influencing system functionality, a property that appears to be contingent upon peptides forming a dense network of backbone hydrogen bonds. In the search to identify strategies to improve zein's versatility in various applications, these interaction types are a likely target for promoting or disrupting β-sheet associations and thus modify the protein's mechanical properties.

Status: Completed. Two manuscripts published, two more to be submitted.

This project is to be continued by Chinmay Joglekar, Ph.D. student in collaboration with J. Bemiller, and currently addresses a procedure developed by him to solubilize zein and to determine its functional properties.

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

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

Researcher: Tingting Chen, Ph.D. Student; Lisa Lamothe, Ph.D. Student

Collaborators: A. Keshavarzian (Rush Medical School, Chicago); L. Zhao (Shanghai Jiao Tong University)

Objectives: Fermentable dietary fibers have the potential to produce positive short chain fatty acid (SCFA) changes in the colon, such as specific 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 fermentable fibers, whether soluble or insoluble, and to understand their fermentative properties and effects; and to better understand differences in fiber effect among individuals with different microbiota compositions.

Progress: In a study by Tingting Chen, stools from 12 individuals were examined in *in vitro* fermentations using four soluble fibers and equal mixture of the four. Nearly all samples were found to increase in butyrate, some markedly so, at 12 h fermentation time, though no single fiber increased butyrate in all samples. Only the mixture of fibers showed increase in butyrate levels of 11 of the 12 samples suggesting that individual variation in fiber response must be considered in recommending fibers for potential therapeutic benefits.

In another study by Lisa Lamothe, dietary fibers from quinoa, amaranth, pearl millet, and sorghum were characterized for soluble/insoluble content, monosaccharide composition, and linkage structure. High pectic substance and xyloglucan contents of the quinoa and amaranth were found. Non-chemical, safe treatment methods were identified to increase solubility in some cases, and fermentability of insoluble fibers in others, of largely insoluble plant fiber sources. Microbiota changes were examined

after 24 h *in vitro* batch fermentations and, for fermentable insoluble fibers, increase in bacterial groups coincided with butyrate producing bacteria and perhaps clusters associated with colon health.

Status: Active, one manuscript submitted, four others in preparation.

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

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

Researchers: Yunus Tuncil, Ph.D. Student; Xin Nie, Ph.D. Student; Xiao Hua, Visiting Professor

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

Objective: To increase our understanding of how dietary fiber structures are utilized by colonic bacteria to create strategies to manipulate the microbiota for improved health.

Progress: With Prof. Eric Martins at UM Medical School, we have expanded our collaborative work to better understand the interaction of dietary fiber structures and colonic bacteria using pure *Bacteriodes* strains. In a way, we are trying to define basic rules of how bacteria use dietary fiber structures, in the highly competitive environment of the gut, and how dietary fibers (oligosaccharides and polysaccharides) can be used to favorably affect the colon microbiota for reasons of health.

In the last few years, we reported in various annual reports of work related to the polysaccharide arabinoxylan and bacterial growth response to structure. Arabinoxylans are found in significant amounts in monocot plant cell walls and we have looked in particular at the one in corn bran. In our previous study, Haidi Xu found that the corn arabinoxylan polymer alone has different repeating structural components that favor different bacteria. Its orderly complex and simple branched structural regions make it a good model polysaccharide to examine specificity of structural areas to different xylanolytic *Bacteroides* from E. Marten's lab. Haidi most notably found that, out of eight xylanolytic pure Bacteriodes strains, there are bacteria that best compete on both complex branched portions of the polymer with high density of diverse sugars and linkages, and on simple loosely branched portions composed of only arabinosyl units with two linkage types. It seems reasonable to speculate from this work that even simple fiber structures, such as those soluble fibers used to fortify processed foods, in the long-term would promote certain colon bacteria that are able to compete best on such fibers.

As an extension of the above work, Xin Nie has examined in a more detailed way fine structural details of corn arabinoxylan hydrolyzates and how specific the gut bacteria are in terms of structure. Last year, we reported that different discrete structures of hydrolyzed and modified arabinoxylan products affect strains *B. ovatus* 3-1-23 and *B. cellulosilyticus* DSM 14838. The study showed high fiber substrate specificity, down to minor differences in branched sugar and linkage structure. In newer work, Xin has shown using another strain of B. xylanosolvens that small changes in fiber structure can be made that even more pronouncedly shifts growth patterns, and in competitive experiments. Such high specificity of gut bacteria to fiber structures perhaps could be used to drive differences in a broader way in the even more highly competititve and complex gut microbiota ecology.

In another study, Yunus Tuncil has worked on the hierarchical preference of usage of dietary fibers by gut bacteria. This is important because there is previous evidence from the Marten group that bacteria use substrates, of which they have the encoded genes to digest, in a prescribed order. If trying to effect change in growth of a strain or bacterial group in the colon, one should understand which substrates it/they utilize in order, and in the competitive environment how this affects substrate utilization. In Yunus's study, responses of two human gut symbionts, *Bacteroides thetaiotaomicron* (Bt) and *B. ovatus* (Bo) were examined during growth on a mixture of different dietary fibers. The fibers used were rhamnogalacturonan I (RGI), arabinan (Ara), chondroitin sulphate (CS), amylopectin (AP), pectic galactan (PG), and polygalacturonic acid (PGA). In both, CS and PG were utilized first, and in a competition study with the two strains the bacteria were shown to change preferences. Further work is being done to understand whether changes in fiber structures or properties (e.g., molecular size, fine structure) changes the hierarchical ranking. This fundamental information is helping us to understand how specific fiber structures might be used to favor certain gut bacteria or bacterial groups.

In a third study, Prof. Xiao Hua from Jiangnan University, is developing methods to make cellulose-

based oligosaccharides and larger hydrolyzates for a study with Marten's group on effect of molecular size on hierarchical preference and competition or favoring growth of certain *Bacteroides*.

Status: Active, four manuscripts in preparation.

11. Investigations on Slowly Digestible Glycemic Carbohydrates

P.I.: B. Hamaker

Researchers: Byung-Hoo Lee, Post-doctoral Research Associate; Meric Simsek, Ph.D. Student; Edith Agama-Acevedo, Visiting Professor; Arturo Luis Bello-Perez, Visiting Professor; Mario Ferruzzi, Professor

Collaborators: A.H.M Lin (Whistler Center and 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); M. Pinto (Simon Fraser University, Canada); 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 α-glucosidase enzymes.

Progress: Our current interest in glycemic carbohydrate research is to better understand how to achieve slowly digestible carbohydrates that may have the potential to effect physiological changes through ileal or colonic triggers to affect 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.

In a study completed in 2014, Edith Agama-Acevedo worked out a process to have significant slowly digestible starch (SDS) and resistant starch (RS) in a pre-gelatinized powder. Pre-gelatinized high-amylose maize starches (50 and 70% amylose) were subjected to hydrothermal treatments (40% of moisture, 100°C and 4°C for 5 and 24 h) to increase the total amount of SDS/RS. Because normal starches did not respond similarly, it is speculated that the higher "intermediate" starch fraction present in these starches retrogrades under these conditions to form SDS, while amylose forms RS. The advantage of such starches is that they are cold pasting and, without thermal treatment, retain relatively high levels of SDS/RS.

Byung-Hoo Lee was involved in a number of studies, but most notably on *in vitro* methodology to understand natural compound α-amylase and α-glucosidase inhibitors, and development of test materials to reach and digest at least partially in the ileum to use in *in vivo* studies to test hypotheses related to triggering the ileal brake and gut-brain axis feedback mechanisms. We expect to begin conducting with collaborators *in vivo* studies in 2015.

Meric Simsek successfully defended her PhD thesis work in 2014 with, with co-PI Roberto Quezada-Calvillo, finished her final work on phenolic inhibitors of the mucosal α-glucosidases. Rat intestinal acetone powder and human intestinal tissue to investigate the inhibitory effects of selected phenolics on α-glucosidases. Chlorogenic acid and EGCG showed high inhibitory potency for maltase, sucrase and isomaltase activities using rat intestinal acetone powder. Also, chlorogenic acid notably inhibited the sucrase activity of human immunoprecipitated SI, while EGCG inhibited the maltase activity of human immunoprecipitated MGAM. Overall, results suggest that there is a potential to change the rate of digestion of starches, starch products, and other saccharides like sucrose by phenolics present in the die through differential or selective inhibition of the different intestinal α-glucosidase activities.

Status: Active, six manuscripts in preparation.

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

P.I.: B. Hamaker

Researchers: Mohammad Chegeni, Ph.D. Student; Beth Pletsch, Ph.D. Student; Like Yan Hasek, Ph.D. Student; Marwa El-Hindaway, Ph.D. Student; Choon Young Kim, Ph.D. Research Associate

Collaborators: H. Naim (University of Veterinary Medicine Hannover, Germany); T. Powley, R.

Phillips, K. Kinzig (Department of Psychological Sciences); G. Zhang (Jiangnan University, China)

Objectives: To understand the cellular and physiological responses to slowly digestible carbohydrates with controlled digestion profiles.

Progress: In these studies, we have interest in the sensing and response to dietary glycemic carbohydrates both at the cellular and physiological levels related to appetitive response and sustained energy. In cell culture work, Mohammad Chegeni, who successfully defended his doctoral thesis in December, showed with collaborator Prof. Naim that small intestine enterocytes sense α-amylase degradation products (represented by maltose) to more rapidly process, traffic to the apical surface, and activate in lipid rafts the α-glucosidases sucrase-isomaltase. This implies that there is a repository of glucogenic enzyme within the enterocyte that is activated for digestion and glucose production by luminal dietary carbohydrates, and that the ileal brake in particular may be a way the body has to hold food (in the stomach) for distal small intestine cells in the ileum to prepare for efficient digestion. In further work by Marwa El-Hindaway, it was shown using a enteroendocrine L-cell line that maltose triggers greater GLP-1, the gut incretin hormone that also signals the hypothalamus appetite control center in the brain, than does glucose or short chain fatty acids from carbohydrate fermentation by gut bacteria. This is an interesting finding and suggests the importance of small intestine luminal dietary carbohydrates in signaling the brain and stomach (to control emptying rate).

Like Yan Hasek successfully completed her Ph.D. in late spring, and her work has provided us an impetus to focus on the relationship between glycemic carbohydrate digestion rate, signaling cellular and physiological effects, and feeding behavior. She previously showed that starch digestion occurring ileally in the small intestine promotes lower food intake and results in a hypothalamic response of lower gene expression of the appetite-stimulating neuropeptides, and perhaps delayed gastric emptying. In 2014, Beth Pletsch conducted *in vitro* and a human study on digestion and gastric emptying of white and brown rice. Increased amylose content, SDS, and RS have all been associated with slower *in vitro* digestion rates and lower glycemic responses, which are closely related to slower gastric emptying rates. In this study, cooked white rice with a moderately high amylose content (~24 – 29% amylose) was temperature-cycled to increase *in vitro* SDS and RS fractions, and compared to low amylose (~17%) and medium amylose (~24%) white and brown rice. Rice (50 g available carbohydrate) was then fed to human subjects (n=10) to measure gastric emptying rates using the ^{13}C-labeled octanoic acid breath test method. When higher amylose white rice varieties were temperature-cycled, SDS and RS fractions increased, with some rice samples showing a similar *in vitro* starch digestion profiles to low amylose brown rice. In the human study, while both low and high amylose brown rice delayed gastric emptying to a greater extent than all white rice treatments ($p<0.05$), the lag phase, a parameter related to the breakdown of a food inside the stomach, remained the same among treatments, suggesting that factors other than physical degradation, such as slow starch digestion, may trigger a feedback control to slow gastric emptying. Defining the mechanisms of whole grain digestion would help determine how refined grains with good carbohydrate quality can be used in products to delay gastric emptying for slower meal digestion and a sustained energy effect.

Status: Active, five manuscripts in preparation.

13. Starch Digestion in Stunted Children in Mali

P.I.: B. Hamaker, B. Nichols (Baylor College of Medicine)

Researcher: Fatimata Cisse, Ph.D. Student

Collaborators: A. Rahmanifar (Nutrition Advisor); M. Grusak (USDA Children's Nutrition Research Center, Houston)

Objectives: To test the hypothesis that stunted children are α-amylase insufficient and that starch-based sorghum and millet thick porridges can be prepared that are better digested, particularly by the existing mucosal α-glucosidases.

Progress: This was a project funded by the Bill and Melinda Gates Foundation and was carried out in Mali, West Africa, and Fatima Cisse successfully defended and completed her Ph.D. work in the Fall. Starch is also a dominant source of dietary energy in complimentary feeding of growing toddlers. After weaning, dietary glucose is generated mostly from starch which is the main component of most complementary foods. A new, non-invasive modified 13C breath test was used to assess pancreatic α-

amylase activity, and the ability to digest sorghum porridge starch in healthy and moderately stunted toddlers from 18 – 30 months of age in Bamako, Mali. α-Amylase insufficiency was present in both Malian healthy and stunted toddlers. However, children with α-amylase insufficiency digested, absorbed, and oxidized the released glucose from normal sorghum porridge starch at least as well as, and in some cases even better, than the healthy group, indicating that the α-glucosidases compensate for the α-amylase insufficiency, and particularly well in the stunted group. A thicker porridge and its α-amylase thinned counterpart were also digested well by the stunted group. The clinical study suggests that thick energy dense porridges supply digestible carbohydrates to stunted children, and that pending further study might be considered for supplemental feeding programs.

Status: Completed, two manuscripts in preparation.

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

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

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

Objective: 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 coming year additional insights will be developed into how such models will be applicable to whole food systems and potentially correlate to *in vivo* data.

Status: Active.

15. Carbohydrate-Based Antimicrobial Carriers

P.I.: S. Janaswamy

Researcher: Carlos Carter, M.S. Student; Atul K. Singh, Ph.D. 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 (EOs) possess antimicrobial properties. However, EOs 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 EOs from volatilization and oxidation.

Progress: Eugenol and sodium iota-carrageenan (IC) have been chosen as the model EO and carbohydrate, respectively. Antimicrobial activity was tested against the foodborne pathogen *Listeria innocua F4248*. The results suggest that eugenol-encapsulated in IC fibers are effective in controlling its growth.

Status: Active, available for sponsorship.

16. Phase Stability of β-Lactoglobulin Fibrils in the Presence of Chitosan and Methyl Cellulose

P.I.: O. Jones

Researcher: Jay Gilbert, Ph.D. Student; Monica Jiulianti, B.S. Student (prior)

Objective: Determine physical stability and solution recovery of protein fibrils assembled from β-lactoglobulin as a function of added polysaccharide (chitosan, methylcellulose), fibril concentration, and pH value.

Progress: Physical integrity of protein fibrils at higher pH values was preserved in the presence of chitosan and other strongly charged cationic polymers. High concentrations of chitosan and methylcellulose led to observed structures that indicated thermodynamic incompatibility. These techniques are to be further developed for an improved method to selectively separate protein fibrils or form composites with synergistic properties.

Status: Active, one manuscript published.

17. Amyloid-Like Protein Fibril Networks within Polysaccharide Composite Films

Co P.I.s: O. Jones, O. Campanella

Researcher: Jay Gilbert, Ph.D. Student

Objective: Identify structural and mechanical attributes of protein fibrils alone or within composite polysaccharide-based films that contribute to improved macro-scale behavior. As a secondary objective, this project seeks to establish a fundamental framework detailing the contributions of both mechanical properties and architecture among fibrous structures to the ultimate macro-scale behavior of composite materials.

Progress: Initial experiments have demonstrated the capability of forming pure and methylcellulose-composite films with protein fibrils. A recently developed multifrequency atomic force microscopy method has been used to characterize the mechanical behavior of films and will soon be applied to characterize heterogeneous mechanical behaviors within such composite film systems.

Status: Active.

18. Effects of Specific Ions and Reducing Agents on Molecular Interactions and Microgel Formation of β-Lactoglobulin

P.I.: O.G. Jones

Researcher: Ryan Murphy, Ph.D. Student; Stacey Hirt, M.S. Student (prior)

Objective: Determine interactions among β-lactoglobulin and carboxylated polysaccharides in the presence of specific ions and reducing agents at varying pH and temperature in order to describe their influence on the ultimate architecture of protein-based microgels.

Progress: Turbidimetry and light scattering were utilized to study the electrostatic interactions between β-lactoglobulin and pectin at neutral and low-pH conditions. A significant specific ion effect has been observed for the pH of complex formation and the pH of coacervation for unheated protein and pectin. Specific ion effects were also observed on the size of microgels formed from heated complexes. Specific ion effects and reducing agents significantly influenced the structure and size of microgels formed without pectin, yet the most significant factor was the solution pH.

Status: Completed, three manuscripts published.

19. Stabilization of Oil-in-Water Emulsions by β-Lactoglobulin Microgels

P.I.: O.G. Jones

Researchers: Ryan Murphy, M.S. Student (current); Laura Zimmerer, M.S. Student (prior)

Objective Determine the interfacial activity and physical stability of oil-in-water aqueous emulsions using (a) microgels of β-lactoglobulin with or without pectin or (b) nanoparticles of zein; determine influence of particle size, particle swelling ratio, and environmental conditions on interfacial properties.

Progress: Emulsions of corn oil or limonene were successfully prepared with β-lactoglobulin microgels using high- pressure homogenization. Size of the microgels greatly influenced the capacity to stabilize emulsions, as larger microgels were poorly adsorbed

to the small droplet interface. The largest droplets flocculate rapidly and form a dense cream layer. Emulsions stabilized by zein nanoparticles were relatively prone to flocculation. Current research is developing discrete size populations from microgel and nanoparticle dispersions to determine the influence of size and swelling ratio on interfacial energy and rheology.

Status: Active, one manuscript published.

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

Progress: Chitosan and dextran molecules have been successfully modified to form block ionomers. Interactions between dextran block ionomer and a milk protein, forming a block ionomer complex, have been successfully characterized. Current research is investigating the formation of block ionomer complexes between a milk protein and a chitosan block ionomer with variable chitosan molecular weight.

Status: Active, manuscript in preparation.

21. Architecture of Internal Amylpectin Molecules and Starch Digestibility at Mucosal α-Glucosidase Level

P.I.: A. Lin

Researcher: Anbuhkani Muniandy, M.S. student

Objective: To understand how starch branch structure drives digestibility differently at the mucosal α-glucosidase level.

Progress: To produce sufficient amounts of glucose from starch, both α-amylase and mucosal α-glucosidases are required. We found previously that the digestion rate of starch is influenced by its susceptibility to mucosal α-glucosidases (Lin et al., 2012, Journal of Biological Chemistry 284 (44) 369170-369217). We later reported that the distance between branches and the amount of branches of the internal amylpectin influence glucose production by mucosal α-glucosidase (Lin et al., 2014, Carbohydrate Polymers 111:33-40). In this project, we characterize amylpectin structure of commonly used starches and examine it susceptibility to mucosal α-glucosidase. Knowledge gained from this project could be utilized by the food industry to design slowly digestible ingredients or starchy foods to better manage glucose release in humans. The project is continued at the University of Idaho.

Status: Active.

22. Starch Digestion *In Vivo* in Sucrase Deficient Shrew Model

P.I.: A. Lin

Collaborators: B. Nichols [¥], R. Quezada-Calvillo[¥€], D. G. Burrin[¥], S. K. Chako[¥], S.-I. Oda (Okayama University of Science, Okayama, Japan)

Researchers: S. E. Avery[¥], B.E. Hodges[¥] , A. Johnson[§]
[¥] USDE ARS Children's Nutrition Research Center at Baylor College of Medicine, Houston TX
[€] Universidad Autonoma De San Luis Potosi´, San Luis Potosi´, Mexico
[§] Research Associate, University of Idaho, Moscow ID

Objective: To understand the digestion role of individual mucosal α-glucosidases *in vivo* using sucrase deficient shrew model; examine oral enzyme supplements for Congenital Sucrase-isomaltase Deficiency (CSID) patients in order to receive enough carbohydrate-sourced energy with lower abdominal pain.

Progress: While luminal α-amylase (AMY) is recognized as a major starch digesting enzyme, the products require further digestion from the non-reducing ends of the oligosaccharides to produce glucose for absorption. Two mucosal enzyme complexes are required for glucogenesis: maltase-glucoamylase (MGAM) is a fast and sucrase-isomaltase (SI) is a slow α-glucosidase. Previously, we used Mgam knocked-out mice to study starch digestion and the digestion role of individual mucosal enzyme *in vivo*

(published in J Pediatric Gastroenterology and Nutrition, 2013, 57(6) 704-712). In current project, we use sucrase mutant (*suc/suc) Shrew, Suncus Marinus,* which have known sucrase deficiency, as an animal model to investigate starch digestion *in vivo* and an oral enzyme supplement as a potential solution for improving starch digestion in CSID. We hypothesized that starch digestion is reduced due to SI deficiency and oral glucosidase enzyme supplement can safely correct the starch maldigestion of CSID patients.

Sucrase mutant (suc/suc) and heterozygous (+/suc) shrews were fed with 13C enriched starch diets. Glucogenesis derived from starch was measured and oral recombinant C-terminal MGAM (Mgam N20) was provided to improve starch digestion. An inactive Ct-MGAM (Mgam N13) was provided as a control. The Sucrase deficiency was characterized; we examined carbohydrate intolerant, mucosal enzyme activity phenotyping and sucrase genotyping. After two joint feeding experiments, total blood glucose and dietary sourced glucose were measured. The small intestine was collected for enzyme activity and residual carbohydrate analysis. Our current findings have demonstrated that sucrase deficiency, in this model of CSID, reduced blood glucose response to starch feeding, and the supplementing the diet with oral recombinant Mgam N20 significantly increased starch digestion in the sucrase deficient shrew model of CSID.

Status: Active, manuscript is in preparation; part of project is still on-going at Lin's lab at the University of Idaho and is open for sponsorship.

23. Improving Measurement of Starch Digestibility *In Vitro*

P.I.: A. Lin

Researcher: Wei-Jen (William) Chang, Visiting Scientist

Objective: Provide the food industry with an improved method to evaluate starch digestibility *in vitro;* measuring the sustainable dietary glucose released from slowly digestible starch molecules.

Progress: We have been working on designing an *in vitro* assay based on digestive reactions *in vivo*, and developing a mathematical model to present the digestion information including changes in digestion rate, to show in a more precise way the slow or extended digestion period, and total releasable glucose amount. The conventional *in vitro* and *in vivo* (glycemic response) does not well measure the sustained dietary glucose that is released from slowly digestible starch molecules, which may be associated with physiological benefits. The outcome will be to provide the food industry an easy assay to evaluate the digestibility, especially to develop products that potentially provide sustained energy benefits. This project is continued at the University of Idaho and is open for sponsorship.

Status: Active.

24. Water-Solid Interactions

P.I.: L. Mauer

Researchers: Na Li, Ph.D. Student; Krystin Marrs, Ph.D. Student; Matthew Allan, Ph.D. Student

Objective: To determine the effects of the 5 modes of water-solid interaction on the chemical and physical stability of 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 amorphous components. In collaboration with a researcher in the Industrial and Physical Pharmacy Department, 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. Effects of temperature on deliquescence and deliquescence lowering were modeled. We have also demonstrated synergistic moisture sorption in blends of crystalline and amorphous solids, wherein the co-formulation of crystalline and amorphous ingredients has the potential to lower both the deliquescence RH and Tg of the blend rendering the blend of ingredients more sensitive to environmental RH than the individual ingredients. This has importance for the formulation, sequencing, blending, storage, packaging, and stability of dry ingredient mixtures and final food products.

Status: Active.

25. Amorphous Solid State Dispersion (Amorphization) of Crystalline Ingredients

P.I.: L. Mauer

Researchers: Na Li, Ph.D. Student; Seda Arioglu Tuncil, M.S. Student; Belinda Christina, M.S. Student; Juan Sanchez, M.S. Student

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

Progress: We are investigating the differences in stability and delivery traits between crystalline and amorphous forms of both poorly water soluble and highly water soluble inherently crystalline ingredients. A variety of dispersion techniques and matrices were explored to document crystallization inhibition properties of different polymers. 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 polyphenols were stabilized in amorphous dispersions. Physical and chemical stability differences between crystalline and amorphous states of a compound were monitored. Interesting insights into molecular assembly and crystalline/ amorphous behaviors were developed during these studies.

Status: Active.

26. Identification of Antimicrobial Peptides from Soy Protein

P.I.: G. Narsimhan

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

Objectives: 1) Development of methodology for identification of desirable peptide sequences from soy β-conglycinin, 2) Characterization of antimicrobial activity of selected peptide segments against *L. monocytogenesis* and *E. Coli*.

Progress: Antimicrobial peptides (AMPs) kill microbial cells through insertion and damage/permeabilization of the cytoplasmic cell membranes and have applications in food safety. Soy protein may be an attractive, cost-saving candidate for commercial consideration because the protein subunits have amino acid sequences that contain several α-helix or 3-10 helix domains which possess characteristics of AMPs. A methodology for identification of AMPs from soy protein is proposed. They were identified from soy β-conglycinin (7S) and glycinin (11S) based on (i) number of amino acids, (ii) positive charge, (iii) hydrophobicity and (iv) hydrophobic moment. Explicit solvent molecular dynamics (MD) simulation was employed to assess the secondary conformation of these peptides in POPC/POPG bilayers to mimic their permeation action on the cell membrane of microorganisms. The effects of number of peptides, their orientation and hydrophobic moment on the deformation of membrane and formation of water channel were investigated. A mathematical model accounting for free energy of formation of a pore by an aggregate of peptides for the prediction of minimum inhibitory concentration for deactivation (antimicrobial activity) has been proposed. The antimicrobial activity was tested against *Listeria monocytogenes* and *E. coli* by using synthetic selected peptides and compared with predictions.

Status: Active.

27. 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.

28. High-Value Corn Starch

P.I.: C. Weil

Collaborators: L. Mauer, Y. Yao

Researcher: Sean Tague, undergraduate student

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.

29. 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.

30. Genetic Interactions That Impact Starch Quantity and Quality

PI: 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.

31. Genetics of Carbohydrate Transport and Partitioning in Maize

PI: C. Weil

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

Progress: We have now mapped ten new mutations impacting carbohydrate transport and distribution in maize, have identified over 350 more, and have now developed F2 mapping populations for 320 of these. In summer 2015, we will map another 40 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.

32. Genetics of Sugar Accumulation and Distribution in Maize and Sorghum

PI: 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.

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

PI: 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. Carbohydrate-Based Colloidal Assemblies to Adsorb and Deliver Antimicrobial Peptide

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

Researchers: Preetam Sarkar, Ph.D. Student, Yezhi Fu, Visiting Scholar

Objective: To study the delivery of an antimicrobial peptide using carbohydrate-based colloidal assemblies.

Progress: In this work, carbohydrate-based colloidal assemblies are used to interact with antimicrobial compounds, in particular the peptide nisin. It was found that while nisin can inhibit Gram-positive bacteria, the mixture of nisin with other compounds may prohibit the growth of both Gram-positive and Gram-negative bacteria with possibly reduced doses compared with those of individual compounds. Currently, we are using carbohydrate colloidal assemblies to realize an enhanced antimicrobial effect, using several pathogens as model systems. This study will allow us to identify new approaches to mitigate the growth of pathogens.

Status: Active.

35. Synergistic Effects among Antimicrobial Compounds to Inhibit Pathogenic Bacteria

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

Researcher: Yezhi Fu, Visiting Scholar

Objectives: to evaluate the synergistic effects among synthetic and naturally occurring antimicrobial compounds against food pathogens

Progress: Synergistic effects among antimicrobial compounds not only reduce the total amount (and cost) of active compounds needed to achieve targeted reduction of microbial load, but also create new potentials for industrial applications. In this project, a number of antimicrobial compounds are either simply mixed or combined in carbohydrate-based colloidal systems (as carriers), and their efficacies to inhibit the model pathogens are evaluated. The model pathogens include *Listeria monocytogenes*, *Salmonella*, and *E. coli 0157*. Once the basic understanding is established, the formulations will be applied to real food systems, such as deli meat and fresh-cut produce, to test their protective effects against food pathogens.

Status: Active.

36. Carbohydrate-Based Biomaterials to Improve Quercetin Water Solubility

P.I.: Y. Yao

Researcher: TBD (graduate student or visiting scholar)

Objective: To isolate and characterize soluble carbohydrate-quercetin complexes.

Progress: Quercetin is one of the most abundant flavonoids found in plants used as foods, with potential protective effects against coronary heart disease, cancer, inflammation, and tumor growth. The absorption of quercetin is low and variable, partly due to its poor water solubility. Various techniques have been used to increase the solubility of quercetin, including complexation with cyclodextrin, hydrophobic proteins, liposomes, solid lipid nanoparticles, nanoemulsions, and nanoparticles. However, these methods have individual limitations in terms of loading capacity, cost effectiveness, and suitability for food systems. In our lab, we are using carbohydrate biomaterials to increase the solubility of quercetin. Caco-2 cell monolayer tests showed substantial increase of quercetin permeability.

Status: Available for sponsorship

37. Carbohydrate-Based Biomaterials to Improve Curcumin Water Solubility

PI: Yuan Yao

Researcher: Randol Jose Rodriguez Rosales, Ph.D. Student

Objective: To improve the water solubility and permeability of curcumin.

Progress: Curcumin is the principle curcuminoid extracted from turmeric, a popular ingredient in Indian food. Studies have shown potential health benefit of curcumin, including antioxidant effects, anti-inflammatory, anti-gastric ulcer, and anti-cancer effects. However, curcumin is poorly soluble in water with low bioavailability. A number of methods have been proposed to improve curcumin solubility, including micelles, nanoemulsions, cyclodextrin complexation and the formation of solid dispersions. However, these methods have various limitations on loading capacity, cost, and suitability for food applications. In our lab, we use carbohydrate-based biomaterials to improve the solubility and *in vitro* permeability of curcumin.

Status: Available for sponsorship

38. Carbohydrate-Based Biomaterials to Improve the Solubility of Active Pharmaceutical Ingredients (API)

PI: Yuan Yao

Researchers: Ying Xie, Ph.D. Student

Objective: To improve the water solubility of APIs.

Progress: It is estimated that roughly 40% of new drug molecules present drug delivery challenges due to their low solubility. The Biopharmaceutics Classification System (BCS) was developed as a systematic approach 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 drug delivery problem. In this project, a number of carbohydrate-based biomaterials have been prepared and tested using model APIs. The results showed that both the stability and solubility of APIs can be improved through complexation with carbohydrate biomaterials.

Status: Active.

39. 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 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.

PUBLICATIONS AND OTHER SCHOLARLY ACTIVITIES

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

BeMiller

1. C.A. Bello-Flores, M.C. Nunez-Santiago, M.F. San Martin-Gonzalez, **J.N. BeMiller, L.A. Bello-Perez**. Preparation and characterization of octenylsuccinylated plantain starch. *International Journal of Biological Macromolecules* 70: 334-339.

2. **J.N. BeMiller.** Essentials of carbohydrate chemistry. In *Functionalizing Carbohydrates for Food Application*, M.E. Embuscado, ed., DEStech Publications, pp. 1-39.

3. **J.N. BeMiller.** Plant gums. In *Encyclopedia of Life Sciences*, John Wiley. DOI: 10.1002/9780470015902. a0000698.pub2.

4. **J.N. BeMiller.** Polysaccharides. In *Encyclopedia of Life Sciences,* John Wiley. DOI: 10.1002/ 978047001-5902. a0000693.pub3.

Campanella

5. **M. Abiad**, **O.H. Campanella**, M. Carvajal. Effect of spray drying conditions on the physicochemical properties and enthalpy relaxation of alpha-lactose. *Journal of Food Properties* 17: 1303-1316.
6. **L.A. Bello-Perez,** P.C. Flores-Silvam, **E. Agama-Advedo**, J. de Dios Figueroa-Cardenas, J.A. Lopez-Valenzuela, **O.H. Campanella**. Effect of the nixtamalization with calcium carbonate on the indigestible carbohydrate content and starch digestibility of corn tortilla. *Journal of Cereal Science* 60: 421-425.

7. J.M. Bouvier, **O.H. Campanella**. Extrusion Processing Technology: Food and Non-Food Biomaterials. Wiley-Blackwell, 530 pp.

8. E. de la Pena, F.A. Manthey, **B.K**. **Patel, O.H. Campanella.** Rheological properties of pasta dough during pasta extrusion: Effect of moisture and dough formulation. *Journal of Cereal Science* 60: 346-351.

9. **I. Demirkesen**, S. Kelkar, **O.H. Campanella**, G. Sumnu, S. Sahin, M. Okos. Characterization of structure of gluten-free breads by using X-ray microtomography. *Food Hydrocolloids* 36: 37-44.

10. **I. Demirkesen**, **O.H. Campanella**, G. Sumnu, S. Serpil, **B. R. Hamaker**. A study on staling characteristics of gluten-free breads prepared with chestnut and rice flours. *Food and Bioprocess Technology* 7: 806-820.

11. **D.P. Erickson,** S. Renzetti, A. Jurgens, **O.H. Campanella, B.R. Hamaker.** Modulating state transition and mechanical properties of viscoelastic resins from maize zein through interactions with plasticizers and co-proteins. *Journal of Cereal Science* 60: 576-5783.

12. C. Yoon, S.D. Heister, **O.H. Campanella.** Modeling gelled fluid flow with thixotrophy and rheological hysteresis effects. *Fuel* 128: 467-475.

13. **B.K. Patel, O.H. Campanella.** Dough processing: Sheeting, shaping, flattening and rolling. In "Conventional and Advanced Food Processing Technologies". Ed. S. Bhattacharya. John Wiley and Sons.

See Jones paper 35

Hamaker

14. E.A. Cameron, K.J. Kwiatkowski, N.M. Koropatkin, E.C. Martens, **B.-H. Lee, B.R. Hamaker.** Multifunctional nutrient-binding proteins adapt human symbiotic bacteria for glycan competition in the gut by separately promoting enhanced sensing and catalysis. *mBio* 5:e01441-14.

15. **M.W. Cheng**, **M. Chegeni**, K.H. Kim, G. Zhang, M. Benmoussa, R. Quezada-Calvillo, B. Nichols, **B.R. Hamaker**. Different sucrase-isomaltaseresponse of Caco-2 cells to glucose and maltose suggests dietary maltose sensing. *Journal of Clinical Biochemistry and Nutrition* 54: 55-60.

16. **B.R. Hamaker,** A. Keshavarzian, M.D. Cisneros, **A. Kaur**, H. Rasmussen. Methods of improving digestive health. U.S. Pat. Appl. Publ. US 20140212494 A1 20140731.

17. **B.R. Hamaker. Y.E. Tuncil.** A perspective on the complexity of dietary fiber structures and their potential effect on the gut microbiota. *Journal of Molecular Biology* 426: 3838-3850.

18. **M. Kale**, **B. Hamaker**, **N. Bordenave**. Oat β-glucans: physicochemistry and nutritional properties. In *Oats Nutrition and Technology*, Y. Chu, ed., Wiley-Blackwell, pp.123-169.

19. **P. Kittisuban**, **B.H. Lee**, M. Suphantharika, **B.R. Hamaker**. Slow glucose release property of enzyme-synthesized highly branched maltodextrins differs among starch sources. *Carbohydrate Polymers* 107: 182-191.

20. **B.H. Lee**, **A. Lin**, B.L. Nichols, K. Jones, D.R. Rose, R. Quezada-Calvillo, **B.R. Hamaker**. Mucosal C-terminal maltase-glucoamylase hydrolyzes large size starch digestion products that may contribute to rapid postprandial glucose generation. *Molecular Nutrition & Food Research*. 58:1111-1121.

21. G.T. Spear, D. Gilbert, M.R. Zariffard, P. Mirmonsef, T.H. Sullivan, W.W. Spear, A. Landay, A.L. French, S. Micci, **B.-H. Lee, B.R. Hamaker**. Human α-amylase present in lower-genital-tract mucosal fluid processes glycogen to support vaginal colonization by lactobacillus. *The Journal of Infectious Diseases* 210: 1019-1028.

See Campanella papers 10, 11

See Ferruzzi paper 22

See Lin papers 39, 40

Ferruzzi

22. **N. Bordenave, B.R. Hamaker, M.G. Ferruzzi.** Nature and consequences of non-covalent interactions between flavonoids and macronutrients in foods. *Food & Function* 5:18-34.

23. R.S. Bruno, J.A. Bomser, **M.G. Ferruzzi.** Antioxidant capacity of green tea (*Camellia sinensis*). *Processing and Impact on Antioxidants in Beverages,* V.R. Preedy, ed., Academic Press, pp.33-39.

24. M.L. Failla, C. Chitchumronchokchai, **M.G. Ferruzzi**, S.R. Goltz, W.W. Campbell. Unsaturated fatty acids promote bioaccessibility and basolateral secretion of carotenoids and alpha-tocopherol by Caco-2 cells. *Food & Function* 5:1101-1112.

25. **M.G. Ferruzzi**, S.S. Jonnalagadda, S. Liu, L. Marquart, N. McKeown, M. Reicks, G. Riccardi, C. Seal, J. Slavin, F. Thielecke, J.-W. van der Kamp, D. Webb. Development a standard definition of whole-grain foods for dietary recommendations: summary report of a multidisciplinary expert roundtable discussion. *Advances in Nutrition* 5: 164-176.

26. T.E. Lipkie, D. Banavara, B. Shah, A.L. Morrow, R.J. McMahon, Z.E. Jouni, **M.G. Ferruzzi.** Coco-2 accumulation of lutein is greater from human milk than from infant formula despite similar bioaccessibility. *Molecular Nutrition & Food Research* 58: 2014-2022.

27. **S. Moser, M. Chegeni, O.G. Jones,** A. Liceaga, **M.G. Ferruzzi.** The effect of milk proteins on the bioaccessibility of green tea flavan-3-ols. *Food Research International* 66:297-305.

28. J.W. Pawlowski, B.R. Martin, G.P. McCabe, **M.G. Ferruzzi**, C.M. Weaver. Plum and soy aglycon extracts superior at increasing bone calcium retention in ovariectomized Sprague dawley rats. *Journal of Agricultural and Food Chemistry* 62: 6108-6117.

29. R.S. Sharma, R.C. Joy, C.J. Boushey, **M.G. Ferruzzi,** A.P. Leonov, M.A. McCrory. Effects of para-aminobenzoic acid (PABA) form and administration mode on PABA recovery in 24-hour urine collections. *Journal of the Academy of Nutrition and Dietetics* 114: 457-463.

30. K.E. Strathearn, G.G. Yousef, M.H. Grace, S.L. Roy, M.A. Tambe, **M.G. Ferruzzi,** Q.-L. Wu, J.E. Simon, M.A. Lia, J.-C. Rochet. Neuroprotective effects of anthocyanin- and proanthocyanin-rich extracts in cellular models of Parkinson's disease. *Brain Research* 155:60-77.

31. Y. Xu, J.E. Simon, C. Welch, J.D. Wightman, **M.G. Ferruzzi,** L. Ho, G.M. Pasinetti, Q. Wu. Survey of polyphenol constituents in grapes and grape-derived products. *Journal of Agricultural and Food Chemistry* 62: 3010.

32. J. Wang, W. Bi, A. Cheng, D. Freire, P. Vempati, W. Zhao, B. Gong, E.M. Janle, T.-Y. Chen, **M.G. Ferruzzi**, J. Schmeidler, L. Ho, G.M. Pasinetti. Targeting multiple pathogenic mechanisms with polyphenols for the treatment of Alzheimer's disease-experimental approach and therapeutic implications. *Frontiers in Aging Neuroscience* 6: DOI: 10.3389/fnagi.2014.00042.

Janaswamy

33. **S. Janaswamy**. Encapsulation altered starch digestion: Toward developing starch-based delivery systems. *Carbohydrate Polymers* 101: 600-605.

34. A.K. Singh, P. Sarkar, **S. Janaswamy, Y. Yao,** A.K. Bhunia. Encapsulation and delivery of antimicrobial compounds. In *Novel Food Preservation and Microbial Assessment Techniques*, I.S. Boziaris, ed., CRC Press, pp.218-236.

Jones

35. **J. Gilbert, O.H. Campanella, O.G. Jones.** Electrostatic stabilization of β-lactoglobulin fibrils at increased pH with cationic polymers. *Biomacromolecules* 15:3119-3127.

36. **S. Hirt, O.G. Jones.** Effects of chloride, thiocyanate and sulfate salts on β-lactoglobulin-pectin associative complexes. *International Journal of Food Science and Technology* 49:2391-2398.

37. **S. Hirt, O.G. Jones**, M. Adijanto, **J. Gilbert.** Influence of sulphate, chloride, and thiocyanate salts on formation of β-lactoglobulin-pectin microgels. *Food Chemistry* 164: 63-69.

38. **L. Zimmerer, O.G. Jones.** Emulsification capacity of microgels assembled from beta-lactoglobulin and pectin. *Food Biophysics* 9: 229-237.

Lin

39. J.D. la R.-Millan, **A. Lin**, P. Osorio-Díaz, **E. Agama-Acevedo**, **B.R. Hamaker**, **L.A. Bello-Perez.** Influence of annealing flours from raw and pre-cooked plantain fruit on cooked starch digestion rates. *Starch-Stärke*, DO-10.1002/star.201400136.

40. **A. Lin,** Z. Ao, B. Quezada-Calvillo, B.L. Nichols, C.T. Lin, **B.R. Hamaker.** Branch pattern of starch internal structure influences the glucogenesis by mucosal Nt-maltase-glucoamylase. *Carbohydrate Polymers* 111:33-40.

See Hamaker paper 20

Mauer

41. I.-H. Cho, **L.J. Mauer,** J. Irudayaraj. In-situ fluorescent immunomagnetic multiplex detection of foodborne pathogens in very low numbers. *Biosensors & Bioelectronics* 57:143-148.

42. I.-H. Cho, A.D. Radadia, K. Farrokhzad, E. Ximenes, E. Bae, A.K. Singh, H. Oliver, M. Ladisch, A. Bhunia, B. Applegate, **L.J. Mauer,** R. Bashir, J. Irudayaraj. Nano/micro and spectroscopic approaches to food pathogen detection. *Annual Review of Analytical Chemistry* 7:65-88.

43. M.K. Ghorab, **K. Marrs,** L.S. Taylor, **L.J. Mauer.** Water-solid interactions between amorphous maltodextrins and crystalline sodium chloride. *Food Chemistry* 144:26-35.

44. M.K. Ghorab, S. Toth, G. Simpson, **L.J. Mauer**, L. Taylor. Water-solid interactions in amorphous maltodextrin-crystalline sucrose binary mixtures. *Pharmaceutical Development and Technology*. 19:247-256.

45. **N. Li**, L.S. Taylor, **L.J. Mauer.** The physical and chemical stability of amorphous (-)-epi-gallocatechin gallate: Effects of water vapor sorption and storage temperature. *Food Research International* 58:112-123.

46. L.A. Wegiel, **L.J. Mauer**, K.J. Edgar, L.S. Taylor. Mid-infrared spectroscopy as a polymer selection tool for formulating amorphous solid dispersions. *Journal of Pharmacy and Pharmacology* 66:244-255.

47. L.A. Wegiel, Y. Zhao, **L.J. Mauer**, K. Edgar, L. Taylor. Curcumin amorphous solid dispersions: the role of intra and intermolecular bonding on physical stability. *Pharmaceutical Development and Technology* 19:976-986.

Narsimhan

48. **G. Narsimhan**, A mechanistic model for baking of leavened aerated food. *Journal of Food Engineering* 143:80-89.

49. P.Y. Phoon, L.N. Paul, J.W. Burgner, M.F San Martin-Gonzalez, **G. Narsimhan.** Effect of cross-linking of interfacial sodium caseinate by natural processing on the oxidative stability of oil-in-water (O/W) emulsions: *Journal of Agricultural and Food Chemistry* 62:2822-2829.

50. P.Y. Phoon, M.F. San Martin-Gonzalez, **G. Narsimhan.** Effect of hydrolysis of soy B-conglycinin on the oxidative stability of O/W emulsions. *Food Hydrocolloids* 35:429-443.

51. L. Zhou, **G. Narsimhan, X. Wu**, F. Du. Pore formation in 1, 2-dimyristoyl-sn-glycero-3-phosphocholine/cholesterol mixed bilayers by low concentrations of antimicrobial peptide melittin. *Colloids and Surfaces, B: Biointerfaces* 123:419-428.

Reuhs

52. H.H. Chong, S. Simsek, **B.L. Reuhs**. Chemical properties of pectin from industry hot and cold break tomato products. *Food and Nutrition Sciences* 5:1162-1167.

Weil

53. B.W. Penning, R.W. Sykes, N.C. Babcock, C.K. Dugard, M.A. Held, J.F. Klimek, J.T. Shreeve, M. Fowler, A. Ziebell, M.F. Davis, G.B. Turner, N.S. Mosier, N.M. Springer, J. Thimmapuran, **C.F. Weil,** M.C. McCann, N.C. Carpita. Genetic determinants for enzymatic digestion of lignocellulosic biomass are independent of those for lignin abundance in a maize recombinant inbred population. *Plant Physiology* 165:1475-1487.

54. N.B. Best, J.S. Budka, B. Schulz, **C.F. Weil**, B.P. Dilkes. (2014) New EMS-induced allele of *terminal ear 1 (te1)* in the B73 background. *Maize Genetics Newsletter* Volume 88.

55. **C. F. Weil.** Transposable controlling elements step out onto the broader scientific stage *In* Perspectives on Nobel Laureate Barbara McClintock's publications (1926-1984): A Companion Volume, L. B. Kass (ed) Cornell University Press, Ithaca.

Yao

56. **N. Bordenave**, **S. Janaswamy**, **Y. Yao**. Influence of glucan structure on the swelling and leaching properties of starch microparticles. *Carbohydrate Polymers* 103: 234-243.

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

February

1. **Bruce Hamaker.** The potential of dietary fibers to be used for targeted function in the colon. Immunology/Microbiology seminar series, Rush University Medical Center, Chicago, IL.

March

2. **Bruce Hamaker, Amy H.-M. Lin.** A different approach to design food carbohydrates for health-based endpoints. General Mills Inc., Minneapolis, MN.
3. **Kin Lau, Clifford Weil.** The *Clumped Tassel1* gene and its modifiers, Maize Genetics Conference, Beijing, China.
4. X. Ma, Y. Wang, M. Ahearn, L. Miranda, D.M. Braun, **Clifford Weil.** Mapping genes involved in carbon partitioning Maize Genetics Conference, Beijing, China.

April

5. **Mario Ferruzzi.** 100% Juice Going Beyond Sugar and Calories. Presented at Experimental Biology. San Diego, CA.
6. Elsa Janle, Tzu-Ying Chen, Janice Kritchevsky, Katherine Hargett, Kathryn Feller, Ryan Klobusnik, Olivia Tabaczyk, **Mario Ferruzzi**, Zeina Jouni. Pharmacokinetics and brain distribution of polyphenols from fruit extracts in young pigs. Experimental Biology annual meeting, San Diego, CA.
7. Tristin Lipkie, Brian Song, Matt Probst, Ardythe Morrow, Yongmei Peng, Maria Guerrero, Guillermo Ruiz-Palacios, Robert McMahon, Zeina Jouni, **Mario Ferruzzi.** Carotenoids and flavonoids in human milk: longitudinal patterns from China, Mexico, and the USA. Experimental Biology annual meeting, San Diego, CA.
8. **Amy Hui-Mei Lin**, **Anbuhkani**. **Muniandy,** M. Diaz-Sotomayor, S. Avery, S. Chacko, L.-K. Yan R. Quezada-Calvillo, **Bruce Hamaker**, B. Nichols. Slower in vivo glucogenesis from starch oligomers by mucosal sucrase-isomaltase. Experimental Biology annual meeting, San Diego, CA.
9. **Sydney Moster, Mohammad Chegeni,** Andrea Liceaga, **Owen Jones**, **Mario Ferruzzi** The effect of individual milk proteins on bioaccessibility of green tea flavan-3-ols. Experimental Biology annual meeting, San Diego, CA.
10. **Benjamin Redan, Mario Ferruzzi.** Chronic flavan-3-ol exposure induces changes in metabolism and transport kinetics in differentiated Caco-2 cell monolayers. Experimental Biology annual meeting, San Diego, CA.
11. **Meric Simsek.** R. Quezada-Calvillo, B. Nichols, **Bruce Hamaker.** Inhibition of individual subunits of maltase-glucoamylase and sucrase-isomaltase by polyphenols. Experimental Biology annual meeting, San Diego, CA.
12. **Byung-Hoo Lee,** B. Nichols, **Bruce Hamaker.** Hydrolytic properties of the four small intestinal mucosal α-glucosidases on disaccharides with different linkages and compositions. Experimental Biology annual meeting, San Diego, CA.
13. **Tingting Chen, Choon Young Kim, Bruce Hamaker.** Impact of dietary fiber-based SCFA mixtures on colon epithelial barrier function. Experimental Biology annual meeting, San Diego, CA.

14. **Mohammad Chegeni, Choon Young Kim,** H. Naim, **Bruce Hamaker.** Elucidating a mechanism for maltooligosacchride sensing at the small intestine enterocyte. Experimental Biology annual meeting, San Diego, CA.

15. **Fatimata Cisse,** H. Diall, A. Rahmanifar, M. Sylla, A. Opekun, M. Grusak, **Amy Hui Mei Lin**, B. Nichols, **Bruce Hamaker.** Sorghum starch is well digested in developmental pancreatic α-amylase insufficient children in Mali. Experimental Biology annual meeting, San Diego, CA, Mexico.

May

16. **Matthew Allan, Lisa Mauer.** Common-ion effects on deliquescence lowering of crystalline ingredient blends. 8th International Conference on Water in Food, Timisoara, Romania.

17. **Matthew Allan, Lisa Mauer.** A comparison of analytical techniques used to determine the deliquescence point of crystalline ingredients. 8th International Conference on Water in Food, Timisoara, Romania.

18. **Bruce Hamaker, Amy Hui-Mei Lin, Byung-Hoo Lee, Like Yan Hasek.** Starch structural variability leading to distal intestine digestion and fermentation. Iowa State University Resistant Starch Symposium, Ames, IA.

19. **Lisa Mauer, Matthew Allan, Seda Arioglu, Belinda Christina, Na Li, Krystin Marrs.** The five mechanisms of water-solid interaction: measurement and case studies. 8th International Conference on Water in Food, Timisoara, Romania.

20. **Amy Hui-Mei Lin, Bruce Hamaker.** Idea for moderating glycemic carbohydrate digestion rate for physiologic benefit. Technical Conference, Whistler Center for Carbohydrate Research, Purdue University, West. Lafayette, IN.

21. **Amy Hui-Mei Lin.** Small intestine mucosal α-glucosidase: a missing feature of in vitro starch digestibility. 12th International Hydrocolloid Conference, Taipei, Taiwan.

June

22. **Bruce Hamaker, Amy Hui-Mei Lin, Byung-Hoo Lee, Like Yan Hasek Haidi Xu, Amandeep Kaur.** Carbohydrate Quality, What It Means for Health Benefit. Conferéncia Internacionál de Alimentos Functionales y Nutraceuticos, Monterrey University of Technology, Monterrey, Mexico**.**

23. **Belinda Christina**, L.S. Taylor, **Lisa Mauer.** Vitamin C amorphous solid dispersions: Crystallization inhibitor properties of polymers and effects on the chemical and physical stability of ascorbic acid. Institute of Food Technologists annual meeting, New Orleans, LA.

24. **Matthew Allan, Lisa Mauer.** Relative humidity-temperature phase diagrams of hydrate forming deliquescent crystalline ingredients. Institute of Food Technologists annual meeting, New Orleans, LA.

25. **Seda Arioglu, Lisa Mauer.** Particle type and morphology effects on moisture adsorption, capillary condensation, and powder flowability. Institute of Food Technologists annual meeting, New Orleans, LA.

26. **Yuan Yao.** Dendrimer-like polysaccharides for food applications. Invited talk at Institute of Food Technologists annual meeting, New Orleans, LA.

27. **Jennifer Allen, Osvaldo Campanella,** Andrea M. Liceaga and **Mario Ferruzzi.** Effects of Grape Seed Extract and the Primary Green Tea Polyphenol, EGCG, on Functionality of Select Dairy Proteins. Institute of Food Technologists annual meeting, New Orleans, LA.

28. **Bruce Hamaker.** How slowly digestible carbohydrates slow gastric emptying for sustained energy release. Institute of Food Technologists annual meeting, New Orleans, LA.

29. **Meric Simsek**, B.L. Nichols, R. Quezada-Calvillo, **Bruce Hamaker**. Maltase activity of individual subunits of recombinant maltase-glucoamylase and sucrase-isomaltase is inhibited differentially by polyphenols. Institute of Food Technologists annual meeting, New Orleans, LA.

30. **Darwin Ortiz**, Torbert Rocherford, **Bruce Hamaker,** Dominique Dufour, **Mario Ferruzzi.** Changes in the carotenoid profiles of biofortified corn cultivars at pre-harvest and storage stages. International Carotenoid Conference, Park City, UT.

31. Massimiliano D'Imperio, Angela Cardinali, Isabella D'Antuono, Vito Linsalata, Fiorenza Minervini**, Benjamin Redan, Mario Ferruzzi.** Stability-activity of verbascoside, a known antioxidant compound, at different pH conditions. 8th World Congress on Polyphenol Applications, Lisbon, Portugal.

July

32. **Mario Ferruzzi.** From Farm to Cell: *Integrating agriculture, food and nutrition sciences to develop improved food products delivering nutritional quality*. Presented to the National Coalition for Food and Agricultural Research. Lunch and Learn Capitol Seminar Series, Washington, DC.

33. **Osvaldo Campanella.** Advancing the core curriculum in biological engineering. American Society of Agricultural and Biological Engineers annual meeting, Montreal, Canada.

August

34. **Yuan Lyu, Xiang Ning, Ganesan Narsimhan.** Prediction of pore formation in cell membranes by aggregate of peptides from soy protein. 248th ACS Meeting & Exposition, San Francisco, CA.

35. L. Zhou**, Xi Wu, Ganesan Narsimhan.** Pore formation in DMPC bilayers and *Listeria monocytogenes* by antimicrobial peptide melittin. 248th ACS Meeting & Exposition, San Francisco, CA.

September

36. **Lisa Mauer.** Water-solid interactions. Presented at the American Association of Candy Technologists National Technical Seminar, Lincolnshire, IL.

37. M. Busche, H. Edmondson, **Clifford Weil.** Investigation of genes influencing high protein digestibility in *Sorghum bicolor.* Presented at the Undergraduate Research Symposium*,* Rice University, Houston, TX.

October

38. **Lisa Mauer.** Keynote/Plenary speaker - Food safety, quality, and security: Challenges and opportunities from farm to fork to cell. Nanosensor Networks and Exabyte Analysis from Farm to fork (NEAFF) Symposium, University of Illinois at Urbana-Champaign, Champaign, IL.

39. R. B. Cunningham, **Lisa Mauer**. Panel Discussion: Nanosensors for food safety. Nanosensor Networks and Exabyte Analysis from Farm to fork (NEAFF) Symposium, University of Illinois at Urbana-Champaign, Champaign, IL.

40. B. Brackett and **Lisa Mauer**. Talks & Panel Discussion: Big data in food safety. Nanosensor Networks and Exabyte Analysis from Farm to fork (NEAFF) Symposium, University of Illinois at Urbana-Champaign, Champaign, IL.

41. **Srinivas Janaswamy.** Molecularly ordered polysaccharide systems for protecting bioactive compounds in food formulations. Presented at the State Key Laboratory of Food Science and Technology, Jiangnan University, Wuxi, China.

42. **Srinivas Janaswamy.** Molecularly ordered polysaccharide systems as novel carriers of bioactive compounds. The 3rd Starch Science Conference of China, Xi'an, China.

43. **Clifford Weil.** 2nd Workshop on Crop Improvement and Bioinformatics, WACCI, Accra, Ghana.

44. **Daniel Erickson,** E. Hamed, S. Keten, **Osvaldo Campanella, Bruce Hamaker.** Atomistic modeling of maize α-zein peptides and their propensities for aggregation and β-sheet structuring. American Association of Cereal Chemists International annual meeting, Providence, RI.

45. **Edith Agama-Acevedo, Byung-Hoo Lee, Bruce Hamaker.** Slowly digestible enriched starch powder from gelatinized high-amylose starch by hydrothermal treatment. American Association of Cereal Chemists International annual meeting, Providence, RI.

46. **Xin Nie, X.**, E. Martens, **Bruce Hamaker.** Exploring the relationship between corn arabinoxylan structure and gut bacterial growth behavior. American Association of Cereal Chemists International annual meeting, Providence, RI.

47. **Meric Simsek**, R. Quezada-Calvillo, B. L. Nichols, **Bruce Hamaker**. Polyphenols have multiple effects on the intestinal α-glucosidases. American Association of Cereal Chemists International annual meeting, Providence, RI.

48. **Osvaldo Campanella.** Twelve hours course on Extrusion. Molinos Rio de la Plata, Buenos Aires, Argentina.

November

49. **Srinivas Janaswamy.** Molecularly ordered polysaccharide systems for protecting bioactive compounds in food formulations. National Engineering Research Center of Seafood, School of Food Science and Technology, Dalian Polytechnic University, China.

50. **Srinivas Janaswamy.** Puzzling polysaccharides – Past, Present & Future. State Key Laboratory of Food Science and Technology, Jiangnan University, Wuxi, China.

51. **Srinivas Janaswamy.** Molecularly ordered polysaccharide systems for protecting bioactive compounds in food formulations. Department of Food Science and Technology, Shanghai Jiao Tong University, Institute of Edible Fungi, Shanghai Academy of Agricultural Sciences, and School of Perfume and Aroma Technology, Shanghai Institute of Technology, Shanghai, China.

52. **Ning Xiang, Yuan Lyv, Ganesan Narsimhan.** Antimicrobial peptide segments from Soy Protein for Use in Food Safety, American Institute of Chemical Engineers annual meeting, Atlanta, GA.

53. **Yuan Lyv, Ning Xiang, and Ganesan Narsimhan.** Pore formation in DOPC/DOPG bilayers by antimicrobial peptide melittin, American Institute of Chemical Engineers annual meeting, Atlanta, GA.

54. **Osvaldo Campanella.** Eighteen hours course on Advanced Rheology, Instituto Tecnologico Monterrey, Monterrey, Mexico.

55. **Kin Lau, Clifford Weil.** The *Clumped Tassel1* gene and its modifiers, AFRI, Purdue University, West Lafayette, IN.

December

56. **Mario Ferruzzi.** Exploring the value of processed foods: What is the role of "Food Technology" in delivery of safe and nutritious food? Presented at the 2014 IFIC Processed Food Roundtable on Improving the Quality of the Dialogue on Processed Foods: Working Together to Achieve a Nutritious, Safe, and Affordable Food Supply. National Harbor, MD.

57. **Bruce Hamaker, Haidi Xu, Yunus Tuncil, Brad Reuhs,** Eric Martens. How dietary fiber discrete structures may favor colonic bacteria. Presented at the Korean Federation of Science and Technology Society (KOFST) Dasan Conference, Alpensia, South Korea.

C. GRADUATE DEGREES AWARDED

1. **Na Li, Ph.D.**, *Stability of bioactive ingredients: degradation mechanisms and kinetics,* May.
2. **Tristan Lipkie, Ph.D.,** *Bioaccessibility and tissue distribution of carotenoids and vitamin D from fortified foods*, May.
3. **Daniel Erickson, Ph.D.,** *Functionalizing maize zein as viscoelastic polymers through β-sheet-rich protein networks*, August.
4. **Matthew Allan, M.S.**, *Characterization of water-solid interactions in crystalline ingredients and development of deliquescence measurement recommendations*, August.
5. **Belinda Christina, M.S.,** *Crystallization inhibitor properties of pectin and effects on chemical and physical stability of vitamin C,* August.
6. **Like Yan Hasek, Ph.D.,** *Dietary approach to modulate postprandial glucose absorption, gastric emptying, and long-term food intake using starch-entrapped microspheres,* August.

7. **Carl Littrell, M.S.,** *Physical and chemical attributes of a genetically modified fruit pectin,* August.
8. **Preetam Sarkar, Ph.D.,** *Interaction and protection of antimicrobial compounds with carbohydrate-based colloidal systems for improved food safety*, December.
9. **Lisa Lamothe, Ph.D.,** *Fermentable carbohydrate substrates generated from cereal and pseudocereal insoluble dietary fibers and their in vitro fecal fermentation*, December.
10. **Fatimata Cisse, Ph.D.,** *African starchy foods, gastric emptying, and starch digestion in Malian stunted children*, December.
11. **Meric Simsek, Ph.D.,** *Inhibition of activities of individual subunits of intestinal Maltase-Glucoamylase and Sucrase-Isomaltase by dietary phenolic compounds for modulating glucose release and gene response*, December.
12. **Seda Arioglu Tuncil, M.S.**, *Crystallization inhibitor properties of polymers and effects on physical stability of curcumin and thiamin,* December.

D. RECOGNITIONS, AWARDS, AND HONORS

1. **Lisa Mauer** received the Marcel Loncin Research Prize at the Institute of Food Technologists (IFT) Annual Meeting.
2. **Jay Gilbert** is current the President of the IFT Student Association.
3. **Jay Gilbert, Anna Hayes,** and **Ryan Murphy** each received the IFT Feeding Tomorrow Graduate Scholarship this year.
4. **Matthew Allan** and **Juan Sanchez** won first place at the Next Generation Scholars poster competition. This event showcases exciting Science, Technology, Engineering, and Math (STEM) related research to local junior high students.
5. **Srinivas Janaswamy** has been invited to join the Editorial Board of Carbohydrate Polymers.
6. **Srinivas Janaswamy** was appointed on the council member of Food Science Matters, FMC Corporation Health and Nutrition Division.
7. **Clifford Weil** received the USAID Sorghum and Millet Innovation Lab, (M. Tuinstra PI) Platform for gene identification and sorghum improvement, ($1,206,782 for four years).
8. **Clifford Weil** received Bill and Melinda Gates Foundation, (C. Weil, PI) Use of intrinsic volatile compounds for bird resistance in sorghum ($298,216 for two years).
9. **Sushil Dhital's (advisor Amy Hui-Mei Lin)** publication "Mammalian mucosal α-glucosidases coordinate with α-amylase in the initial starch hydrolysis stage to have a role in starch digestion beyond glucogenesis. PLoS One 8(4), e62546"was adjudged as the was best paper published in a peer review journal in 2013 by the Australian Institute of Food Science.
10. **Amy Hui-Mei Lin/Bruce Hamaker's** visiting student, Sushil Dhital, received the Australian Jack Kefford Award for 2014
11. **Mario Ferruzzi** received the 2014 Purdue University Faculty Scholar award.
12. M. Busche, H. Edmondson, and **Clifford Weil** were presentation winners for their paper, "Investigation of genes influencing high protein digestibility in *Sorghum bicolor"* at the Undergraduate Research Symposium, at Rice University.
13. **Bruce Hamaker** was appointed an Institute of Food Technologists Fellow, June.
14. **Bruce Hamaker** and **Mario Ferruzzi** received the USAID Sorghum and Millet Innovation Lab, Expanding markets for sorghum and millet farmers in West Africa through strengthening of entrepreneur processors and nutrition-based promotion of products ($812,000 for four years).

15. Purdue University International Food Technology Center, Department of Food Science received the USAID Food Processing Innovation Lab ($5,000,000 for five years), **Bruce Hamaker** and **Mario Ferruzzi** received two of the four principal projects.

16. **Osvaldo Campanella** and **Ganesan Narsimhan** received a USDA NIFA grant, Prediction of Pasting Behavior of Cross Linked Starch ($465,694 for three years).

E. SPECIAL EVENTS

Whistler Center Short Course, October 21-23, 2014

We were pleased to include three guest speakers in this year's Short Course:

Dr. M. Kale, from the USDA-ARS Eastern Regional Research Center in Wyndmoor, PA, taught "*Basic principles in rheology*" and "*Rheology of polysaccharides: concepts and experimental techniques*"

Dr. J. Keller, a Food Industry Consultant specializing in hydrocolloids, taught "*Hydrocolloids and functionality*"

Dr. Stefano Renzetti, a senior scientist at TNO in the Netherlands within the expertise group of functional ingredients, taught *"Approaches in food reformulation for products with healthier composition"* and *"Physical and textural shelf-stability of food products: from powders to multi-component food"*

As is our tradition, the course was designed to provide one-day on carbohydrate fundamentals followed by two days 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 4 advanced topic sessions of their choice.

1. Introduction to structures and properties of polysaccharides, J. BeMiller
2. Polysaccharide architecture, R. Chandrasekaran and S. Janaswamy
3. Starch granule structure and properties, J. BeMiller
4. Basic principles in rheology, M. Kale
5. Enzymatic and physical modification or conversion of starch, Y. Yao
6. Polyols and high-intensity sweeteners, Y. Yao
7. Chemical modification of polysaccharides, J. BeMiller

Wednesday and Thursday Breakout Sessions

Carbohydrate nutrition, B. Hamaker

1A/1B - Advances in chemical and physical modifications of starch, J. BeMiller

2A - Beverage emulsions, encapsulation, G. Narsimhan and S. Janaswamy

3A - Approaches in food reformulation for products with healthier composition, S. Renzetti

4A - Rheology of polysaccharides: Concepts and experimental techniques, M. Kale

5A - Complex carbohydrate structure analysis (non-starch), B. Reuhs

6A/6B - Hydrocolloids and functionality, J. Keller

7A - Polysaccharide –protein interactions, O. Jones

8A - Polysaccharide architecture and functionality including starch, R. Chandrasekaran and S. Janaswamy

9B - Physical and textural shelf-stability of food products: from powders to multi-component food, S. Renzetti

10B - Extrusion and industrial products, O. Campanella

11B - Physical property testing of carbohydrates, L. Mauer and O. Jones

12B - Phenolics and CHOs in food and nutrition, M. Ferruzzi

13B - Predictive modeling of multicomponent systems, G. Narsimhan

14B – Carbohydrate digestion and sustained energy, B. Hamaker

"Some food factors of importance for glycaemia in the acute phase and beyond"

2014 Belfort Lecturer
Dr. Inger Björck
Functional Food Science Centre, Lund University

Dr. Inger Björk is a professor of applied nutrition on and managing director of the Functional Food Science Centre at Lund University, Sweden. One important area of research has involved evaluation on of food factors of importance for the glycaemic and hormonal responses to carbohydrate rich foods, and possibilities to tailor glycaemia by choice of ingredients and/or food processing conditions. More recently she has been engaged in research related to the potential of food proteins to modulate post-prandial blood glucose. Other research topics deal with the potential of prebiotic carbohydrates in regulating metabolism and appetite. Within the frame of a national centre of excellence in research and innovation, the Antidiabetic food centre, she is also involved in semi-long term interventions in healthy subjects exploiting the anti-inflammatory properties of low glycaemic index foods and other food concepts, aiming at reducing risk factors linked to the metabolic syndrome. Dr Björck is a member of several national and international expert committees such as the Royal Swedish Academy of Science (Food and nutrition group), the International Carbohydrate Quality Consortium and ILSI.